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Dear reader,

Croatian Academy of Engineering celebrated 15 years of successful activities in 2008. It was founded in 1993 at the time of the formation of Croatia, at the moment when the awareness of the independence of Croatia as an internationally recognized country and full member of the United Nations was on highest level, if we looked back on several centuries ago right to the VII century. And those are the reasons for each year in the existence of the Academy to have their successful beginning and the end. Foundation of the Academy at the time of the struggle for survival of young Croatian nation could have its ups and downs, disorientations in insufficiently precise legislation, but could nevertheless achieve necessary consensus of different professions, experiences and views about the formation of an association of engineers with doctor's degrees and important international know-how of scientists and university professors who would, for the first time in history, take an important part in reverting technological decline of Croatia. For the first time and among the first in the world experts from technical and biotechnological professions have been united in the same association willing to take over important role in Croatian society by being active participants of the creation of modern Croatian state with highly developed technology and internationally recognized members in their ranks.

Today we can say that due to the alternations of the presidents beginning with the Academician Josip Božićević, Ph.D. from 1993 – 1997, then Prof. Juraj Božičević, Ph.D. from 1997 – 2003 and today myself, Prof. Zlatko Kniewald, Ph.D. from 2003-2009 the Academy has undergone three different phases, but each one necessary for the following to be recognized, not by the president as head of the Academy, but for ever growing activities and mobility of all members of the Academy. Therefore, I would kindly ask you not to recognize and remember the Academy by its presidents, but by the shifts the Academy has made owing to its members at home and abroad in promoting Croatian knowledge, European tradition and international cooperation with all technical and biotechnological professions in Croatia and abroad, and full support of international organizations of the kind.

However, at the moment when we are facing the end of the so called third period of the Academy, it is necessary to summarize the results and leave its success to the evaluation of future heads of the Academy who will present their results by the end of their mandate.

I will consequently start with the first prerequisite for each institution, the premises. At the beginning of my mandate on July 1st, 2003 the Academy signed a contract with the Faculty of Food Technology and Biotechnology of the University of Zagreb and the University of Zagreb about the cession of a neglected place in Kačićeva 28. State of the location could be best described by the fact that the office of the Academy, which has by then occupied only one room on the address of Hercegovačka 25, has been moved for a year to Kačićeva 30 so that all the activities regarding adaptation, arrangement of the exterior and equipping of the present "House of the HATZ", Kačićeva 28, could be monitored from the vicinity. Major roles belong to our members Prof. Jure Radić, Ph.D., Prof. Hildegard Auf-Franić, Ph.D. and Prof. Mladen Obad-Šćitaroci, Ph.D. who have built their knowledge and experience in the exterior and interior of the "House of the HATZ", as well as its surroundings. Funds for the building have been provided by the Ministry of Science, Education and Sports of the Republic of Croatia and thus conditions have been fulfilled for the Academy to function freely for five years on the new premises owned by the University of Zagreb. The University of Zagreb, the Faculty of Food Technology and Biotechnology and the Ministry of Science, Education and Sports have not only substantially contributed to the functioning of the Academy by these activities, but have also visually changed the appearance of this part of town center which has been the mockery of Zagreb for decades. Interior decoration and the gift of a ceiling projector by the Faculty of Electrical Engineering and Computing in Zagreb, as well as the funds for library donated by the Croatian Electrical Company (HEP) have contributed to the functionality. By all means a part of the funds has been provided by the contributions of our supporting members, as well as by the membership fees of the members of the Academy themselves. In 2008 a prolongation of the Agreement with the University of Zagreb was signed for the next five years up to 2013 with the possibility of further prolongation, so we would express our gratitude to all those who enabled us to operate successfully and fulfill our programs in the years to come. Although there have been some personnel changes due to the illness of the secretary lately, the office of the Academy functioned properly including transparent financial, legal and administrative activities. The success of the Academy is also attested by the decision of CARNet to elect it its full member so that the requirements are met for a faster and better communication of all the members of the Academy with their colleagues at home and abroad. Reorganization has been made by the new Statute of the Academy and from 2003 Governing Board has been constituted as an operative body consisting of the president, two vice presidents, secretary general and former president of the Academy. In the mandate of 2003-2005 the Governing Board constituted of Prof.

Zlatko Kniewald, Ph.D., Prof.Tomislav Filetin, Ph.D., Prof. Stanko Tonković, Ph.D., Prof. Miljenko Lapaine, Ph.D. and Prof. Juraj Božičević, Ph.D., while from 2005 – 2009 Prof. Zlatko Kniewald, Ph.D., Prof. Branka Zovko-Cihlar, Ph.D., Prof. Stanko Tonković, Ph.D., Goran Granić, Ph.D. and Prof. Juraj Božičević, Ph.D. So far the Governing Board has held 54 sessions and by the end of the mandate on July 1, 2009 their number is expected to be around 60.

At the beginning of the 2003 mandate the Academy was a member of CAETS to which it was first elected in Peking, China in 2000. Former presidency of the Academy and the Committee for International Cooperation received a delegation of CAETS in Zagreb in 1998 and thus enabled the HATZ to become full member of CAETS. Successful cooperation began on the Annual Meeting of CAETS in Prague in 2002 when our delegation consisted of Prof. Juraj Božičević, Ph.D. and Prof. Jasna Kniewald, Ph.D. as chairlady of the Committee for International Cooperation of the HATZ who also actively participated in later meetings of CAETS with her lectures. In 2001 member of the Board of Directors of CAETS was the then president of the HATZ Prof. Juraj Božićević, Ph.D., a special recognition to the Academy in the implementation of common programs of CAETS. Successful cooperation with CAETS has continued up to now by a series of discussions on global technological problems. In 2005 Prof. Zlatko Kniewald, Ph.D. was elected member of the Board of Directors of CAETS and in 2009 next president of the Academy (2009-2013) Prof. Stanko Tonković, Ph.D. was also elected member of the highest body of world association of academies of engineering. By active participation on annual meetings in Hollywood (2003), Stavanger (2004), Cairns (2005), Brussels (2006), Tokyo (2007) and The Hague (2008) the Academy continued its international activities. In 2009 the CAETS meeting will be held in Calgary and in 2021 Croatia should be the host. From 2003 several documents were drawn up and accepted, such as “CAETS Strategy 2006 – 2010” and “Statement on Oceans and the World`s future” at Cairns in 2005, “Statement on the Role of Hydrogen in our Energy Future” in Brussels in 2006, as well as “Environment and Sustainable Growth Strategy” in Tokyo in 2007.

On the other hand the European Council of Applied Sciences, Technologies and Engineering, Euro-CASE was established in 1993 to which our Academy sent a membership application, but was rejected with the explanation that we were not the member of the European Union. We accepted the fact and waited up to 2001 when Croatia received invitation to join the EU. Then we renewed the application and the HATZ was invited to become associated member of Euro-CASE up to the full membership of

Croatia in the EU when our status would automatically change and the Academy would become full member of Euro-CASE. Due to historical truth it should be mentioned that the HATZ is the only member in both associations out of all ex-Yugoslav republics. Slovenia entered Euro-CASE in 2008 when it also activated its frozen member status in CAETS. Consequently, with the support of the Ministry of Science, Education and Sports of the Republic of Croatia for membership fees and occasional reimbursement of expenses for the participation in international meetings of CAETS and Euro-CASE, the Academy has actively promoted knowledge and technology from our region in the world.

Promotion of the HATZ activities throughout the world has also been accomplished by web pages at the address www.hatz.hr which convey all interesting events of the Academy both in Croatian and in English. Modern web pages nonexistent at the beginning of my mandate have been set up by the efforts of Prof. Miljenko Lapaine, Ph.D. and, from the introduction of the visits' monitoring in August 2005, 340,000 visits (i.e. more than 350 per day) have been recorded so far. At the beginning of 2008 web pages were extended by a series of new information about the activities of Departments and Centers, as well as individual members of the Academy. Another activity is the Annual, a yearly report about the work of the Academy which, in its present form, has been included in the ISI data base so that the papers published there are regularly being referred to in international data bases. Editing of our periodical bulletins "Tehničke znanosti" in Croatian and "Engineering Power" in English has been resumed and all editions can also be found on our web pages.

At the beginning of this mandate the Academy had only two Centers, i.e. the Center for Development Studies and Projects (head Prof. Juraj Božičević, Ph.D.) and the Biotechnical Center (head Prof. Zlatko Kniewald, Ph.D.). Today there are also the Center for Lifelong Education (head Prof. Tomislav Filetin, Ph.D.), the Center for Geoinformation and Cartography (head Prof. Miljenko Lapaine, Ph.D.), the Center for Graphical Engineering (head Prof. Vilko Žiljak, Ph.D.) and the Center for Environmental Protection and Development of Sustainable Technologies (head Prof. Đurđa Vasić-Rački, Ph.D.). Formation of new Centers is specially encouraged since through them the Academy directly cooperates with the industry.

In the past few years the Academy organized annual thematic conferences the results of which were included in the Annuals, i.e. "Current Approaches to the Education of Engineers" (2004), "Development of New Technologies and Products in Croatia (2005), "Life and Work of Nikola

Tesla" (2006), "Tesla in Croatia" UNESCO Paris (2006), "With Tesla to the Progress of Croatia" (2006), "Marie Curie Workshop" EU Conference Zagreb – Belgrade (2006), "Knowledge-based Croatia – Possible Contribution of Croatian Scientists" (2006), "Engineering Education – Bologna Process 3 Years Later" (2007), Water Management in Croatia (2008) held in 2009. Therefore, not only has former rate of scientific and professional conferences been retained, but it has overcome all earlier conferences in importance, international participation and response. Most of the conferences have been coorganized or sponsored by CAETS or Euro-CASE. Such is the obligation taken over by the Academy from the Government of the Republic of Croatia to organize the 300th anniversary of the birth of of Rugjer Boscovich in Croatia in 2011 the importance of which has also been recognized by CAETS and Euro-CASE.

On the occasion of taking over the mandate in 2003 due to unfavourable finances the Academy had no funds for awards, although they were stipulated by the Statute. Complete financial set-up was critical and cash flow irregular. By introducing financial discipline and strictly dedicated spending in the last mandate annual budgets have been substantially increased and security achieved so that invoices could be settled on time in some 7 days or less from their issue.

Owing to the donation of our honorary member from Canada, Prof. Branko Ladany and sponsorship agreements of Zagrebačka pivovara, PLIVA, Končar Institute and later on Croatian Center for Vehicles and Belupo nowadays we have Foundation of the Academy supplying the funds for annual awards "The Power of Knowledge", "Rikard Podhorsky" and "Vera Johanides" for young scientists. Even though the awards are humble, they represent certain recognition to scientists, businessmen and young scientists for their achievements. On this occasion I would like to thank all donators of the Foundation, as well as all other supporting members and all the members of the HATZ for their contributions. As it is already well-known, but never emphasized enough, no member of the Academy receives any fee for his/hr taking part in the program of the Academy including members of the Governing Board.

At the incentive of the Ministry of Science, Education and Sports of the Republic of Croatia the Academy participated in the organization of the 1st Congress of Croatian Scientists from Homeland and Abroad held in Zagreb and Vukovar in 2004 where we gathered more than 600 young researchers and we also contributed to the organization of the 2nd Congress held in Split in 2007.

And when we are talking about young scientists from the field of technical and biotechnical sciences, we should not forget that in recent years by the negligence of the legislator the title of engineer has been omitted, although it is the basis of the higher education system throughout the world. In collaboration with the Ministry of Science, Education and Sports we have pointed out to the default and also obtained opinion from some of the members of CAETS who have supported the proposal of returning the title of graduate engineer into the system of the Bologna Process reorganization of higher education. In the second half of 2007 the Croatian Parliament adopted amendment of the law so that the title of engineer was returned to the Croatian system of higher education. The HATZ has been involved in the project of Engineering Education through CAETS from 2005 and through Euro-CASE from 2006.

At the invitation of the organizer I have been the only representative from Croatia at the biggest world forum of science and technology entitled “Science and Technology in Society” held in Kyoto the recommendations and conclusions of which are already being carried out.

The Academy is also being occupied with the activities regarding the Law on the Foundation of Croatian Chamber of Engineers and Technologists, draft of the Law on the Croatian Academy of Engineering and coordination of documents of the Ministry of Science, Education and Sports with the registration of the HATZ as a scientific organization, since the Ministry has included the Academy among the 4 most important organizations (implementation of program 2002 – 2007) and 4 important (Development Strategy up to 2010) in the Republic of Croatia.

I would personally like to thank all members of the Governing Board, Presidency, secretaries of Departments, heads of Centers and all operatives engaged in expert and administrative tasks and I would like to point out that I have been honoured I could serve you members of the Croatian Academy of Engineering as president in two mandates. I believe that our joint activities have shown that we want to cooperate, and in such cooperation there are problems which should be solved in the spirit of understanding, mutual tolerance and appreciation. To the next president Prof. Stanko Tonković and his team elected according to the highest standards of developed society I wish every success in their work and I will deliver him the Academy to run free of charges, financial liabilities and unfulfilled obligations.

President of the Academy
Prof. *Zlatko Kniewald*, Ph.D.

Symposium with International Participation “Water Management in Croatia”

Selected papers

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Water Management Strategy

Summary

The paper describes the Water Management Strategy (OG 91/08), the basic strategic document of water management which defines legislative, organizational, financial, technical, scientific/research, and IT frameworks for water management activities under present socio-economic circumstances of the EU accession process of the Republic of Croatia and under future circumstances of its full EU membership.

Key words: Water Management Strategy, protection against floods and other adverse effects of water, public water supply and other forms of water use, collection and treatment of urban wastewater, protected areas.

1. Introduction

Based on the provisions of the Water Act (OG 107/95, 105/05), the Water Management Strategy (OG 91/08), enacted on 15 July 2008 at the 5th Session of the Parliament of the Republic of Croatia, is the long-term planning document that defines the vision, mission objectives and tasks of state policy in the field of water management. It provides strategic directions and guidelines for development of water management, starting from existing state in the water sector, development needs, economic potentials, international obligations and needs for preservation and improvement of water status, aquatic and water-dependent ecosystems. Its contents are harmonized with relevant directives of the European Union and it is thus the basic document for preparation of negotiation documents for the accession negotiations and also one of the documents for preparation of applications for utilization of funds from the EU pre-accession funds. The Water Management Strategy is a document on the basis of which reforms of the water sector will be carried out, so that the European standards in water management could be reached, and as such is also the basic document for gradual amendments to the Water Act and Water Management Financing Act and associated by-laws, whose final enactment, according to the dynamics of accession negotiations with the European Union, is expected at the end of 2009. The Water Management Strategy is also the framework for preparation of strategies and plans in the fields of physical planning, environmental protection, nature protection and development of other sectors which depend on waters or have impact on water status (agriculture, forestry, fishery, industry, power generation, transport, tourism, public health, etc.). It will be in force as long as the conditions of its enactments are valid, under the consideration of the period of legal adaptation by the end 2009 and the duration of two fifteen-year investment cycles by the end of 2038.

2. Status of water resources

Croatia belongs to the group of relatively water-abundant countries, in which problems with water or surrounding water are not yet intense and whose water resources are presently still not a limiting factor to development. According to research done by the UNESCO in 2003, Croatia is ranked as a high 5th country in Europe and as 42nd in the world in terms of availability and abundance of its water resources. The total length of all natural and artificial watercourses in Croatia is estimated at about

32,000 km. Groundwater as one of the components of total water balance is of particular significance, since it is the most important source of public water supply. Renewable groundwater resources in the Republic of Croatia are estimated at 9 billion m^3/year.

The balances of surface waters (Fig. 1) and groundwater (Fig. 2) show that Croatia disposes of large quantities of surface waters and groundwater with uneven spatial and temporal distribution; therefore, efficient and ecologically acceptable water management requires systematic investments into development and regular maintenance of the functionality of water management systems.

Fig. 1 – Spatial distribution of inland waters

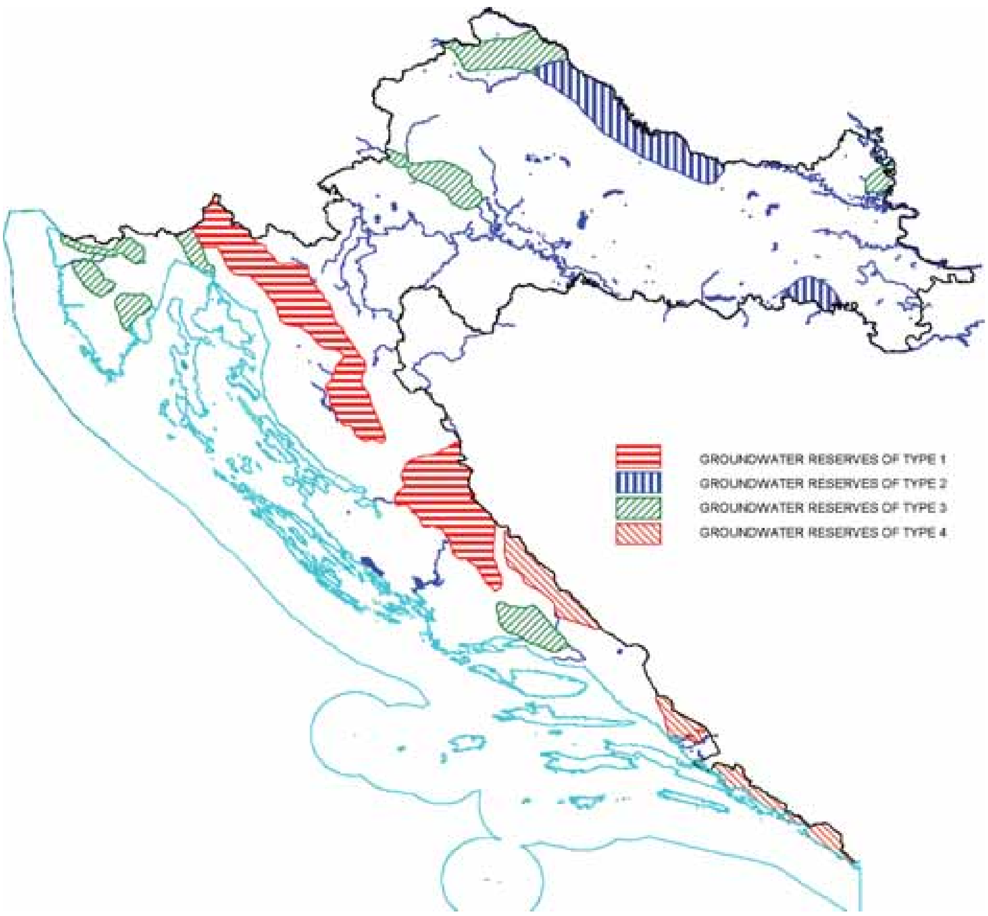

Fig. 2 – Strategic groundwater reserves

3. Status and strategic goals of water management

Water management tasks include numerous activities, from enactment of legislation to development and maintenance of water management systems and systematic monitoring of status of waters and systems. Institutions which are authorized and responsible for these activities are the Parliament of the Republic of Croatia, National Water Council, Government of the Republic of Croatia, Ministry of Regional Development, Forestry and Water Management and other state administration bodies, Hrvatske vode as the national agency for water management and units of local and regional (counties) self-government. Organized water management in Croatia, which is based on regulated water right, has a very long tradition. It started in 1876 in Osijek, when the Society for Regulation of the Vuka River, headed by Bishop Strossmayer, was established.

The basic goal of water management emphasized in the Water Management Strategy is the achievement of integrated, harmonized water regime on the state territory and in each of the four river basin districts (Sava river basin district, Drava and Danube river basin district, Littoral-Istrian river basin district and Dalmatian river basin district), which includes the following:

- provision of sufficient quantities of quality drinking water for water supply of the population,
- provision of necessary water quantities of suitable quality for different economic uses,
- protection of people and material assets from floods and other forms of adverse effects of water,
- achievement and preservation of good water status for protection of aquatic and water-dependent ecosystems.

The strategic goal of protection from floods and other forms of adverse effects of water is the increase in functionality of the flood protection system on waters of ranks I and II from the present 75% (Fig. 3) to 87% by the end of 2023 and to 100% by the end of 2038. This goal will be achieved by gradual implementation of rehabilitation and reconstruction works and implementation of development projects. The detailed canal network for drainage and irrigation will be brought to functional state by the end of 2013. The functional systems will be regularly maintained, both in economic and technical sense.

The strategic goal of public water supply is the increase in the level of supply of population with water from public water supply systems from the present 80% (Fig. 4) to 85 to 90% by 2023, which corresponds with the European standards. Intensification of activities on the determination of sanitary protection zones of water abstraction sites and implementation of suitable protection measures are also anticipated as well as intensification of activities on the improvement of conditioning of drinking water according to the provisions of the EU Drinking Water Directive and intensification of activities on the restoration of losses from distribution water supply networks. With regards to problems related to existing state of the water sector, intensive activities on its grouping i.e. determi-

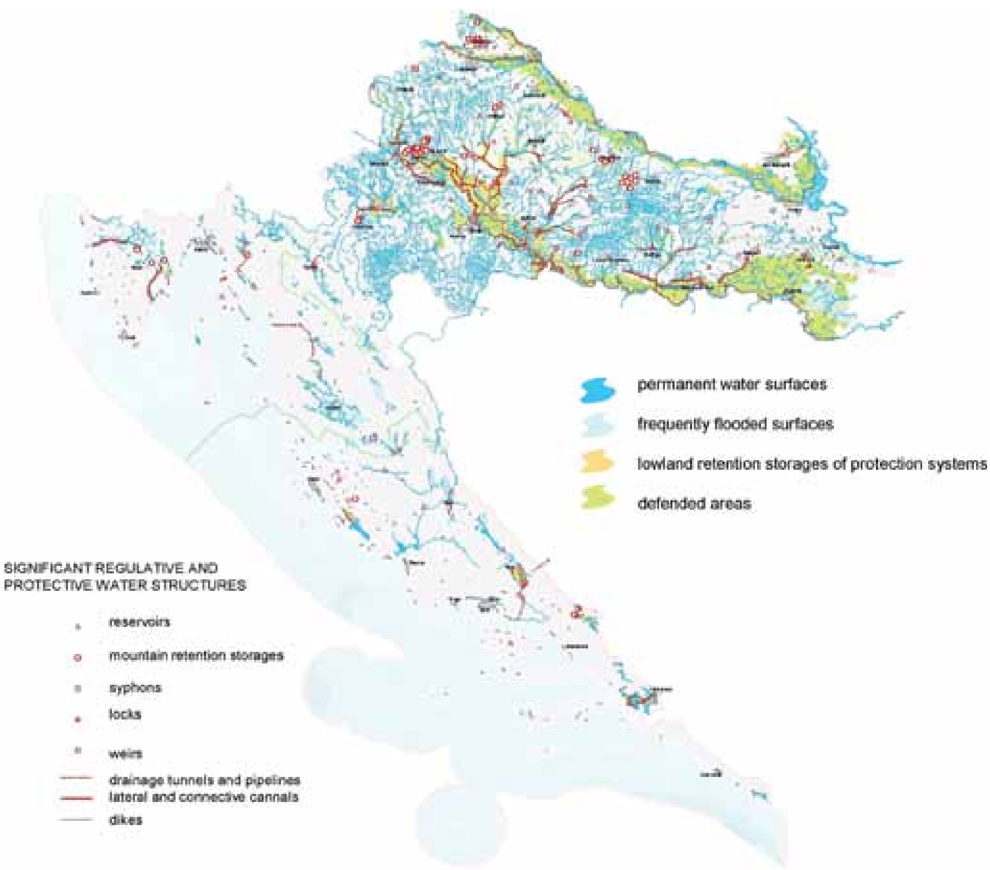

Fig. 3 – Status of flood protection

nation of distribution/service areas as sustainable units in technological and economic sense will be also carried out.

The strategic goal of water protection is intensive construction and reconstruction of public systems for urban wastewater collection and treatment, which will by 2023 completely solve the mentioned issues for:

• about 70% of systems to which 2,000 to 10,000 inhabitants gravitate,

• about 77% of systems to which 10,000 to 15,000 inhabitants gravitate,

• about 100% of systems to which over 15,000 inhabitants gravitate.

In this manner, the level of population connection to public wastewater collection and treatment systems will increase from the present 43%

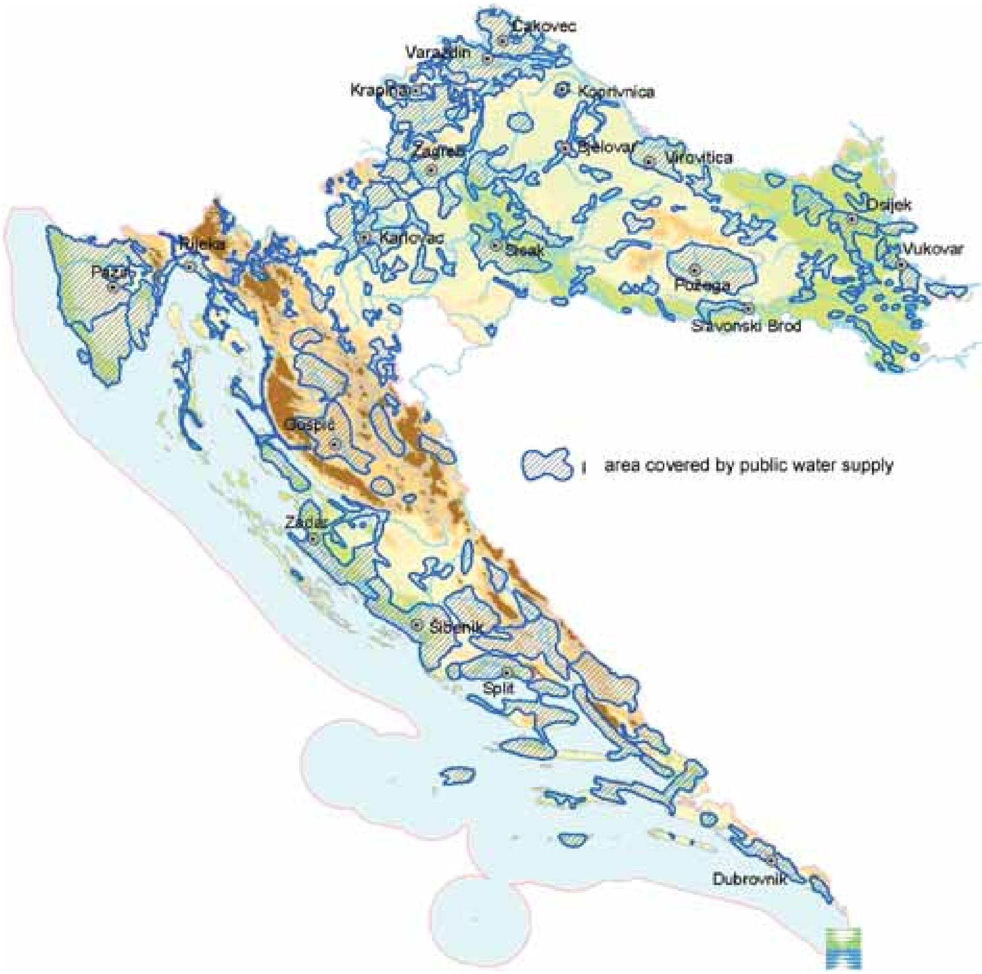

Fig. 4 – Status of public water supply

(Fig. 5) to 60%, which will fulfil key requirements from the EU Urban Wastewater Directive. The remaining requirements from this Directive, which relate to smaller systems, will be fulfilled after 2023.

The Water Management Strategy anticipates areas of special water protection, i.e. protected areas:

- areas intended for abstraction of water for human consumption,
- waters (areas) intended for cultivation of economically important aquatic species,
- waters intended for recreation, including areas intended for bathing,

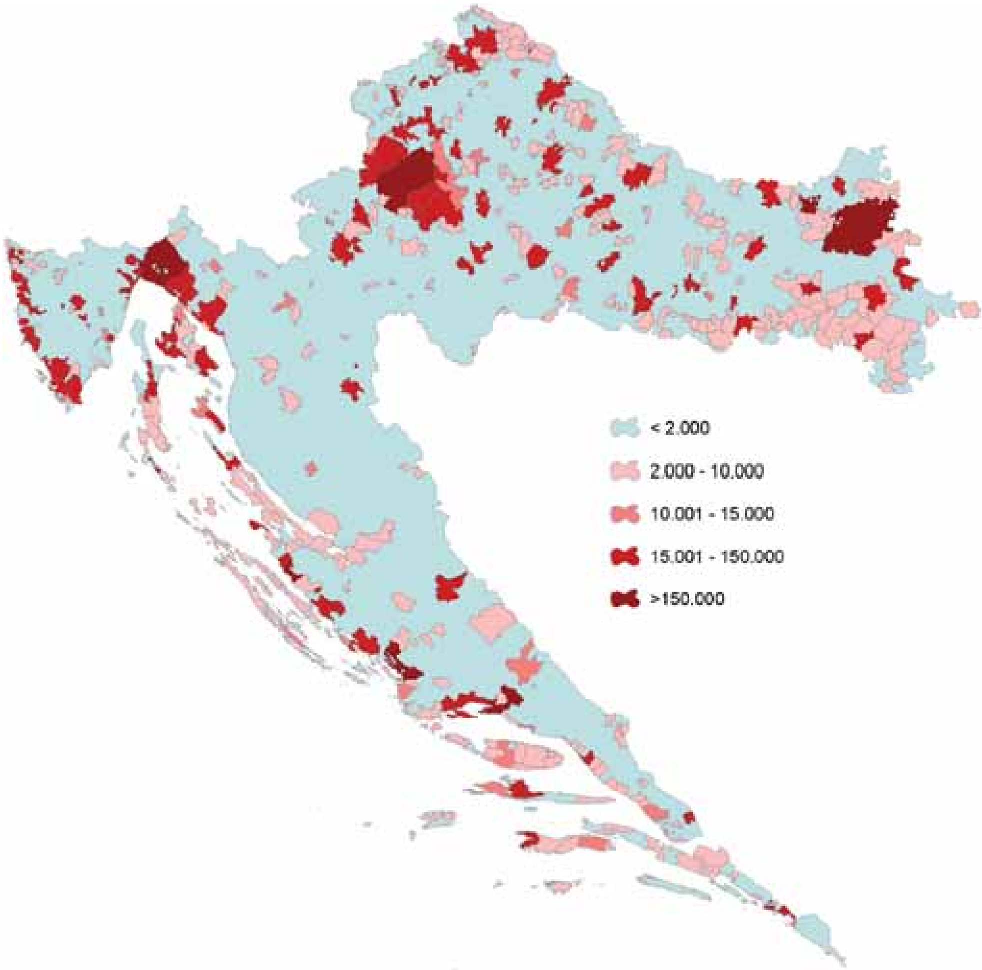

Fig. 5 – Physical scope of existing and planned urban wastewater collection and treatment systems

- “vulnerable” areas and “sensitive” areas,
- areas intended for protection of habitats and species (NATURA 2000),
- strategic groundwater reserves.

Its total surface is relatively large and is estimated at about 47% of the county's inland territory. Although the existing state of these areas is relatively favourable, their adequate protection also requires significant investments.

4. Strategic national projects

"**The Coastal Cities Water Pollution Control Project (Adriatic Project)"** is a project of protection of transitional (inland surface waters under sea influence) and coastal waters (coastal sea) from pollution. It includes construction, rehabilitation and extension of urban wastewater collection and treatment systems, wastewater treatment plants and submarine outfalls in numerous settlements along the Adriatic coast and on the islands and is cofinanced by funds of a World Bank loan. The project is implemented in three phases within the period of about ten years. The total cost of its implementation is estimated at about 280 million Euro. The fist phase was completed (2005 – 2008) in four years (80 million Euro), while the second phase (120 million Euro) and the third phase (80 million Euro) will each last three years. The project included in its first phase the following towns and municipalities: Novigrad, Pula, Lovran, Opatija, Matulji, Rijeka, Zadar, Sveti Filip i Jakov, Biograd na moru, Pakoštane, Rogoznica, Dugi Rat, Omiš, Makarska and Opuzen, whereas the second and third phase will also include some other towns and municipalities (agglomerations) from which urban wastewater is discharged into transitional and coastal waters.

"**The Inland Waters Project"** has the goal of development of systems for flood protection, public water supply and urban wastewater collection and treatment in the river basins of the Sava, Drava and Danube, and is also cofinanced by funds of a World Bank loan. The project is implemented in a five-year period (2008 – 2012) and its total value equals about 105 million Euro. The project includes the development of the flood protection system of Central Posavina, development of public water supply systems in the area of Northern Baranya, Central Posavina (regional system Davor – Nova Gradiška) and Slavonska Podravina (regional system Slatina – Orahovica – Donji Miholjac and system Pitomača) and also development of urban wastewater collection and treatment systems in Ogulin, Virovitica, Southern Baranya (Darda and Bilje), Našice, Vukovar, Ilok, Ivankovo, Cerna, Otok and Komletinci.

Since 2004 to date, the Government of the Republic of Croatia has approved **22 development programmes of public water supply and water protection in 15 counties** in the total value of about 2.44 billion Kuna. For each adopted programme, a Cofinancing Agreement was signed, which marked the beginning of their implementation. Among adopted programmes are the following:

- 11 programmes of public water supply in the total amount of 1.56 billion Kuna,
- 8 programme of water protection in the total amount of 0.6 billion Kuna,
- 3 combined programmes in the total amount of 0.63 billion Kuna (public water supply –0.27 billion Kuna and water protection – 0.36 billion Kuna).

"The National Project of Irrigation and Land and Water Management in the Republic of Croatia (NAPNAV)" was adopted on 17 November 2005 by the Government of the Republic of Croatia. On the national level, it offers integrated approach to irrigation issues and defines rights, obligations and competences of all participants in the process of irrigation. Based on directions from this document, the implementation of the National Irrigation Project started in phases:

- development and adoption of county irrigation plans (conclusively with 2008, these plans will be completed and adopted in 19 of 21 counties),
- national pilot irrigation projects (four pilot areas – Lovas, Biđ Bosutsko polje, Kaštela and the Neretva),
- project documents for irrigation systems (about eighty projects in all Croatia),
- rehabilitation of existing and construction of new irrigation systems (about ten rehabilitated projects and two new projects under construction).

Through implementation of the National Project of Irrigation and Land and Water Management, irrigated surfaces in Croatia were increased in two years by over 50%, so that conclusively with 2007, about 15,000 ha of agricultural land are irrigated. The designs for irrigation systems at all levels of technical documentation (from conceptual designs to implementation designs) cover about 40,000 ha of agricultural land. The National Project of Irrigation and Land and Water Management anticipates by 2010 the construction of irrigation systems for additional 35,000 ha of agricultural land, for which it is necessary to annually provide about 70 million m^3 of water, and for 65,000 ha by 2020, for which it is necessary to annually provide about 130 million m^3 of water. The total value of the investment by 2010 is 2.5 billion Kuna, and 4.5 billion Kuna by 2020.

The Decision on the preparations for construction of the **Multi-purpose Canal Danube – Sava** was passed by the Government of the Republic of Croatia on 19 March 1991. The Government Decision defines the tasks in the preparation of canal construction, the basis for its implementation and the bodies responsible for individual tasks. The main functions of the Multi-purpose Canal Danube – Sava are amelioration drainage, raising of low water levels, navigation and irrigation. The construction of the canal will facilitate the following:

- regulation of surface drainage on about 173,000 ha of agricultural land,
- extension of subsurface drainage to about 62,000 ha of agricultural land,
- reduction of damage caused by floods,
- regulation of water regime in the Spačva basin according to the needs of forest vegetation,
- implementation of technical conditions for raising of low water levels in parts of river beds of the Bosut, Spačva and Vuka rivers with water from the Sava and Danube,
- shortening of navigation from the Sava in the direction of western Europe by 417 km and in the direction of eastern Europe by 85 km,
- intensive irrigation of about 33,000 ha of agricultural land.

The Multi-purpose Canal Danube – Sava will be about 50 km long, 30 m wide and 3 m deep. It is estimated that total costs of its construction will equal about 4.5 billion Kuna.

5. Implementation costs

The total implementation costs of the Water Management Strategy for water management development projects is estimated at about 52.8 billion Kuna, of which about 13 billion Kuna for public water supply projects, about 20 billion Kuna for urban wastewater collection and treatment projects and about 10.8 billion Kuna for projects of protection from floods and other forms of adverse effects of water. About 4.5 billion Kuna will be invested into irrigation development and also about 4.5 billion Kuna in the construction of the Multi-purpose Canal Danube – Sava. The total costs of regular economic and technical maintenance of watercourses, water estate and regulative and protective water facilities, which is the responsibility of water management, are estimated at about 915 million Kuna per year, while the total costs of the performance of expert works is estimated at about 270 million Kuna per year. A part of necessary funds for implementation of this Strategy will be obtained from the present pre-accession and later structural and cohesion funds of the European Union. It is estimated that planned investments are maximal with regards to financial possibilities of Croatian citizens and economy.

6. Institutional setup

The institutional setup of water management will be based on the decentralization principle, with clear competences of national, regional and local water management. National water sector has competences in management of waters (protection of water quality, redistribution of available water quantities for different uses and protection from adverse effects of water), management of public water estate, development and maintenance of system of basic amelioration drainage and implementation of national investment policy into regional and local water sector. Regional water sector (i.e. counties) has competences in development and management of irrigation systems and detailed amelioration drainage. Local water sector (i.e. associated towns and municipalities) has competences in development and maintenance of water supply systems, collection of wastewater and storm water and wastewater treatment.

The Strategy anticipates exclusion of possibility of privatization of right to a water resource in public water supply. Concessions for water abstraction for public water supply will be awarded exclusively to local authorities in the service area and exclude possible privatization of existing water utilities infrastructure (public water supply systems and urban wastewater collection and treatment systems), which will be transferred to the ownership of local government and self-government units. Providers of water services (licensed operators) will exercise right to water abstraction on the basis of mandatory legal contract with the concession grantor.

Municipal sector will be reformed in the sense of the definition of public water supply and collection and treatment of wastewater as supramunicipal activities (activities performed by several self-government units) for purposes of institutional integration of municipal systems to a technically, technologically and economically sustainable level. In each distribution/service area, a supramunicipal operator for public water supply and collection and treatment of wastewater will be established, which will be a separate legal entity, different from legal entities performing municipal activities (maintenance of public surfaces, maintenance of unclassified roads, municipal solid waste disposal, public lighting, etc.).

An independent regulator of water services will be established in the form of council for water services. The main task of the regulator will be to secure the local component of the water tariff intended for the system maintenance (service price) in terms of implementation of the full cost recovery principle to the maintenance in the service area and the social affordability of the water tariff for local population. The task of the regulator will be to arbitrate between the operator and the local authorities, both in cases where the local authorities pursue underrated water pricing policy or where the operator proposes overrated tariffs, thus ensuring expert assessments of the requirements for service price corrections.

In compliance with the requirements of the EU water policy, the Strategy promotes the "user/polluter pays" principle, according to which economic water price is gradually introduced. In the course of introduction of economic water price, both local authorities and state authorities, each from the aspect of the water price component which presents their revenue, will develop such forms of water pricing which will ensure gradualness and social affordability of price for local population. They will aspire to a uniform tariff within the service area, while respecting the right of local communities to also develop multi-tariff models, depending on the social or other needs.

7. Conclusion

The draft proposal of the Strategy of Water Management was developed by Hrvatske vode, with participation of eighteen relevant scientific and expert institutions and nine renowned consultants and in collaboration with employees of the Ministry of Regional Development, Forestry and Water Management – Directorate of Water Policy and International Projects and Water Management Directorate.

In the enactment procedure for this document, special attention was paid to public participation, since proposed measures and activities relate to all citizens, all economic and other subjects, i.e. general public. In this sense, a series of public hearings, topical discussions, presentations at expert events, public insights and discussions in the media with the purpose of informing the general public about the document and encouraging all interested persons to share their comments, suggestions and opinions.

The main partners of water management in the implementation of this Strategy will be the municipal sector, physical planning, environmental protection, nature protection, agriculture, forestry, power industry, tourism, water transport, other economy, science, education and media. According to the provisions of the Water Framework Directive of the European Union, it is expected that different interested non-governmental organisations will also get significantly involved in the implementation of the Strategy.

Priority, permanent tasks of water management, local self-government units and utilities companies are intensive project preparation, strengthening of institutional capacities, implementation of necessary organisational adaptations and development of adequate applications in order to raise to the highest possible level the absorption capacities for utilization of means from the European funds, later from cohesion and structural funds; in other words, to utilize to the highest extent the available non-refundable funds for development of water infrastructure and thus accelerate the achievement of development goals defined in this Strategy.

The necessary conditions for implementation of the Water Management Strategy are gradual organisational adaptation and systematic strengthening of expert capacities on the national, regional and local levels. The performance of scientific and expert tasks on the national level will be advanced by the establishment of a scientific – expert institution for waters.

Through the implementation of the Water Management Strategy, the Republic of Croatia will, the same as all member-states of the European Union, gradually achieve the proscribed standards in water management, which is of great significance to its population and economy.

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Hydraulic Aspects of Cross-Border Cooperation in River Restoration Project

Abstract

Presented project was elaborated in frame of the INTERREG IIIA Initiative between the Hungarian and Slovak Republic. It was concentrated on the region among the Latorica River from the North, the Tisa River from the South, Bodrog River from the West and the Slovak-Ukraine border from the East (Fig.1). The confluence point of the Tisa and Bodrog rivers is the famous Tokaj town. The initiative came out from the Water Board enterprises in both countries – in Hungary as well as in Slovakia. The main reason for the project proposal was that in this region five flowing rivers were "alive" in this region fifty years ago. Except of the above mentioned Latorica, Bodrog and Tisa rivers there were another two rivers – Tice and Krčava – which were due to water management measures in the years 1946-64 more or less dried out. The reason for that is very simple – it was the construction of protection dykes on the Latorica and Tisa rivers and the consequent groundwater level decrease in the region between these two rivers due to decreased recharge of groundwater from surface flows. The goal of the project is the feasibility study of possibilities and design of possible technical measures for revitalisation of Tice and Krčava rivers.

Due to research work the Slovak University of Technology in Bratislava, Water Research Institute as well as Institute of Hydrology of Academy of Sciences has been involved into the project. After several discussions and consultations Ekövizig (North-Eastern Direction on Water and Environmental Issues in the River Basin in Miskolc) as the principal project proposer has been established – on the Hungarian side and the Slovak University of Technology in Bratislava on the other side.

Introduction

The project had more very important goals to be solved, but the most important can be characterised shortly as follows:

- water management – ecological (with appropriate technical solution),
- landscape (depending on water management solution),
- socio-economic (close connected with previous two).

The concentration was given on the first – for us the main and most important goal – the solution of water management control – from quantitative as well as from qualitative point of view.

The first task for the working team was to analyse the recent hydrological state of surface-, ground- as well as soil water in the given area and to find the water source for the water management solution for revitalisation of the old river bed and branches of the Tice River. The interregional and "the joint" point, as well, was the water source which is located mostly on the Slovak side.

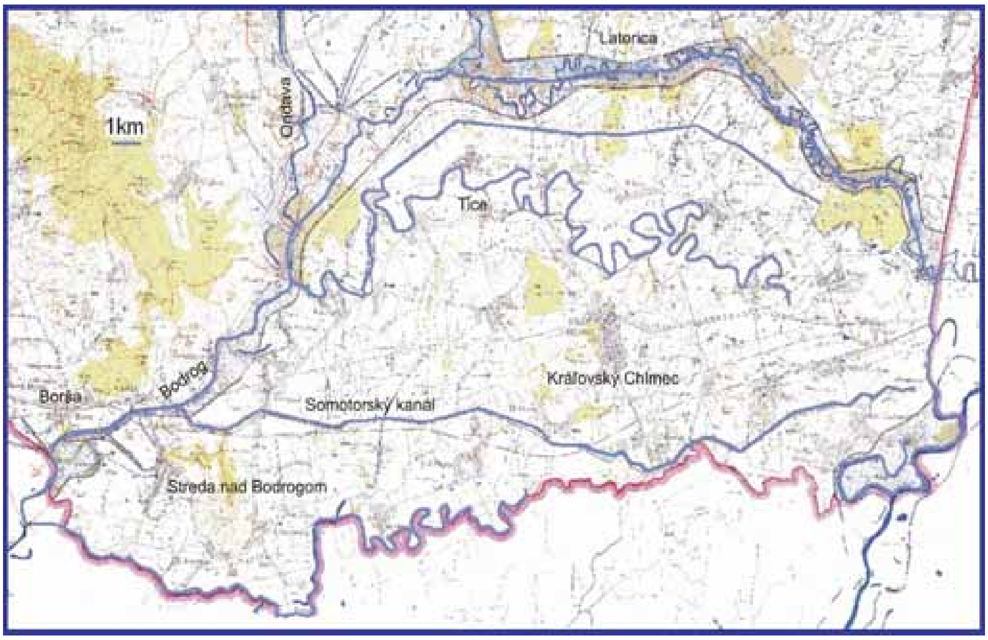

Fig. 1 – Illustration of the Medzibodrožie region with natural hydrological boundary conditions – Latorica, Bodrog and Tisa rivers (Slovak side).

The next specific point of the project is the already done water management measures on both sides of the Medzibodrožie region. They are completely other and do not coincide but utilising the proposed water management achieved in the project it could be possible to achieve the symbiosis in water management on both sides.

The project itself was divided into seven phases of solution, which involve in the water management part of the project a detailed analysis of hydrological conditions of the whole Medzibodrožie region, hydraulic and morphological conditions of surface flows (last passports have been elaborated almost 40 years ago), hydro-geological conditions of the whole region as well as hydro-pedological conditions of the Medzibodrožie region. It has to be considered that the "inter-regional" means that the water knows no political or regional constructions and it is flowing with no respect.

Present state of the research results

All types of analytic works are finished now and the working team is closely concentrated on modelling of hydrological and hydraulic processes in surface- and subsurface flow. These works are, of course, closely connected and they are waiting for the results of the airborne scanning to achieve the digital terrain model (DTM) of the investigated area. Several modelling situations have been elaborated. Although the region was once scanned, results of the scanning were for our purposes not utilisable because they were realised in the vegetation period for the detection of agricultural vegetation cover in the region. It means that the mentioned DTM is very rough for morphological analysis in the floodplain regions of rivers as well as not precise enough for mathematical modelling of hydraulic processes and the most important item – not precise enough for designing technical measures which are involved in the project as well as the environmental impact assessment. The border between the Slovak and Hungarian Republics can be seen in the Fig.1, although the water management in this region was elaborated as one hydrological unit. All important water bodies on the Slovak side of the Medzibodrožie region are shown there, as well.

The technical solution for the revitalisation of the Tice river is assumed to be realised through outlets in the left hand-side protection dyke of the Latorica river (Fig.2). The problem is that the overflowing can be realised

Fig. 2 – The outlet structure in the left hand-side protection dam of the Latorica river.

at the discharge Q= 55 $m^3.s^{-1}$ in the Latorica river, which is appearing approximately 30 days per year. It would not be so unfavourable but the problem is that it appears mostly in such period when the watering of the Tice river is not necessary or unreasonable from water quality in the Latorica river point of view (flood situation).

To obtain more information about the Latorica river bed in planned realisation of technical measures detailed geodetic measurements in the floodplain have been performed in July 2006 with recent discharge measurements in the Latorica River, as well (Fig. 3). Results of the measurements have been compared with the river passport information from 1969 and been used at modelling the water level regime in the Latorica river for different discharges to recommend an optimum water level regime in the river. Mathematical model of the Latorica River has been elaborated on input data based on longitudinal and cross-section profiles. For surface water modelling purposes the HEC-RAS 1-D computational program as well as MIKE-11 (in GIS environment) for flood-mapping.

Fig. 3 – Measurement of cross-sections and discharge in the Latorica river (July, 2006).

Model contained (Fig.4):

- section from Kapušany bridge to state border with Ukraine (km 21.615 – km 31.493), the total length of model was 9.878 km,
- 57 cross sections.

The first part of model (16 cross sections) was taken from recent measurements (from the year 2006) and the second part (41 profiles) came out from the Latorica river passport from the year 1969. Calibration of this hydraulic model was made on water level regime drawn in passport and measured in September 1969. As boundary conditions – the water level in the first profile (the Kapušany bridge) and the corresponding discharge (31 $m^3.s^{-1}$) from the rating curve in Veľké Kapušany profile were used. Calibrated values of Manning roughness coefficient are extra for floodplain (this part of Latorica River is strongly covered by vegetation) and different values are for particular river bed sections:

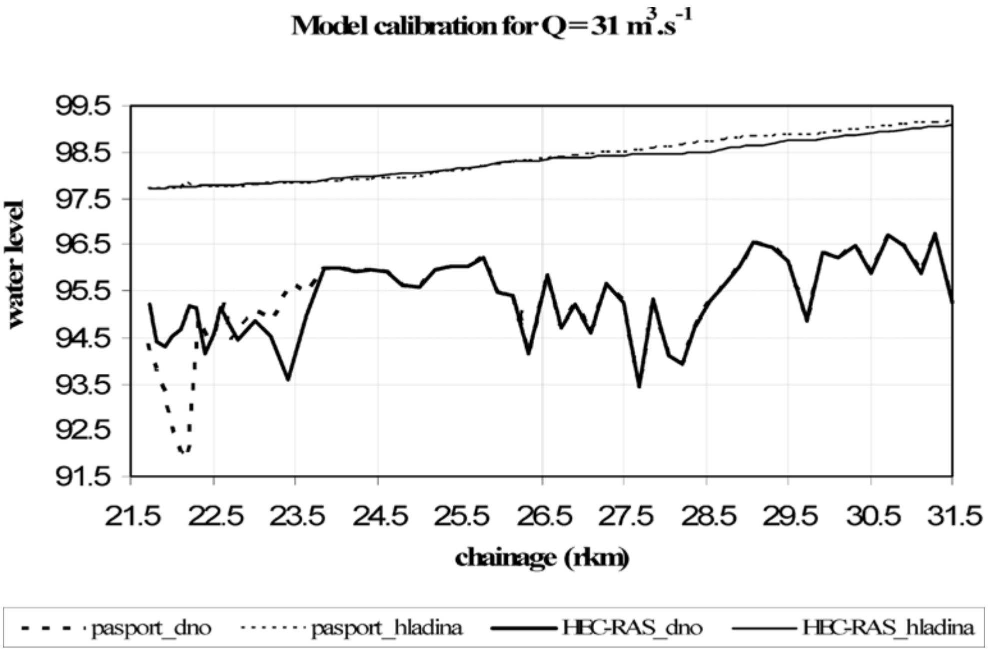

Fig. 4 – Calibration of the modelled section of the Latorica River for discharge (31 $m^3.s^{-1}$).

- floodplain n = 0.7 – forest, trees and bushes,
- river bed
  - n = 0.045 – rough surface, irregular profile (rkm 21.615 – 22.015; rkm 23.022 – 27.681; rkm 30.116 – 31.493),
  - n = 0.038 – natural channel, covered by vegetation (rkm 22.111 – 22.798),
  - n = 0.048 – channel with bushes on banks (rkm 27.858 – 29.922).

These calculations were followed by analyses and prognoses of groundwater level regime at this time on the Slovak part of the Medzibodrožie region. Several results of groundwater level regime have been achieved for different discharges in the Latorica River as well as for proposed surface water level regime after introducing technical measures in the Latorica river bed. Numerical modelling of the groundwater flow was realised by means of TRIWACO (Royal Haskoning Software) using finite element method. The basic finite element mesh is illustrated in the Fig.5. There were different modifications undertaken (Fig.6) to achieve a most proper computation finite element mesh with most important surface flows – rivers, drainage channels as well as proposed surface flows which connect the natural flows with artificial channels to supply the Tice river on Slovak side by means of

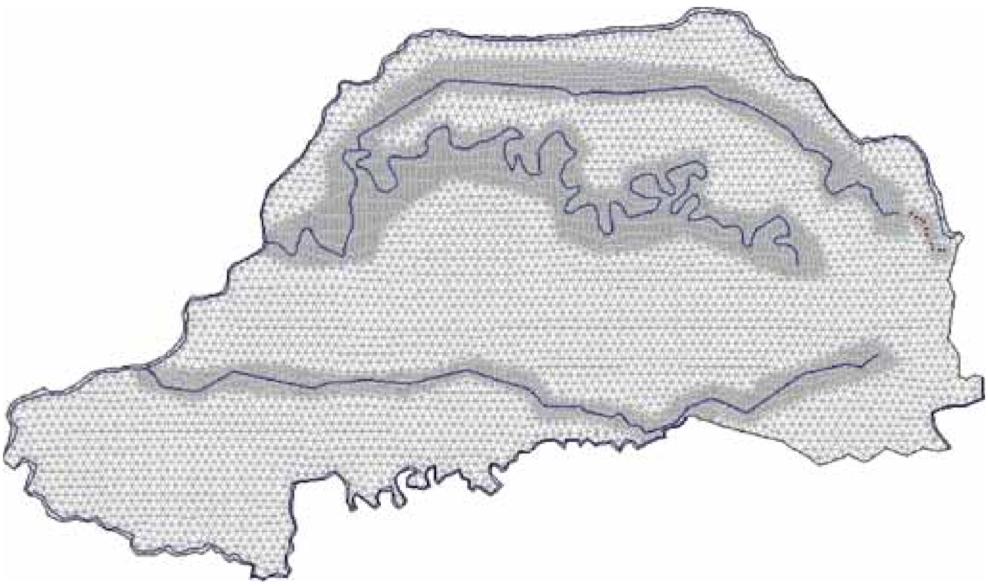

Fig. 5 – Illustration of the basic finite element computational mesh for 2-D groundwater flow in TRIWACO software.

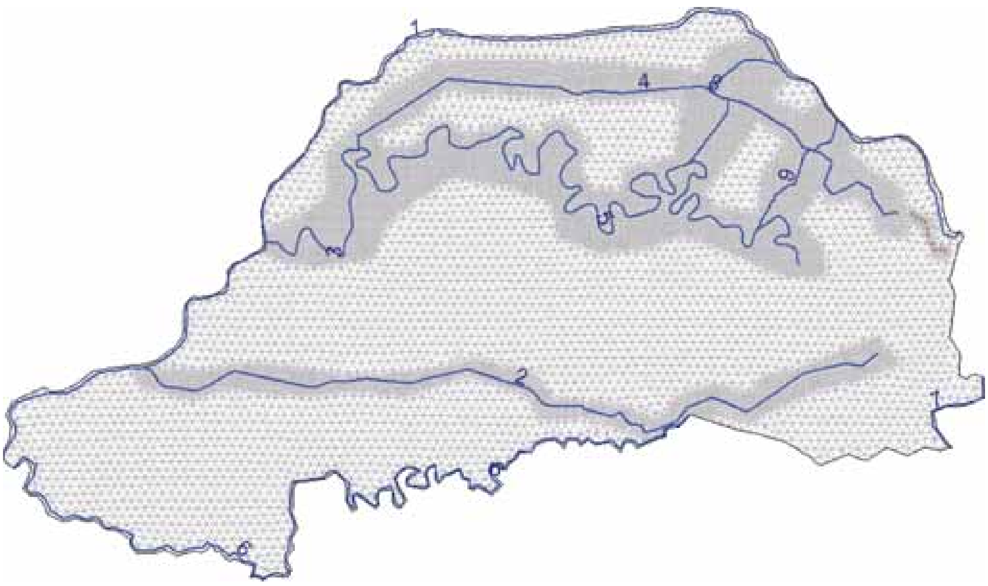

Fig. 6 – Illustration of the 2-D finite element computational mesh for groundwater flow after introducing technical measures in TRIWACO software.

outlets in the left hand-side protection dyke of the Latorica river and the Krčava river on the Slovak-Hungarian border. All other activities as calibration, verification and sensitivity analysis have been realised already and first prognoses are shown in the Fig. 7. The situation shown in this figure is the groundwater level regime after realising technical measures in the Latorica river bed and watering the Tice river bed.

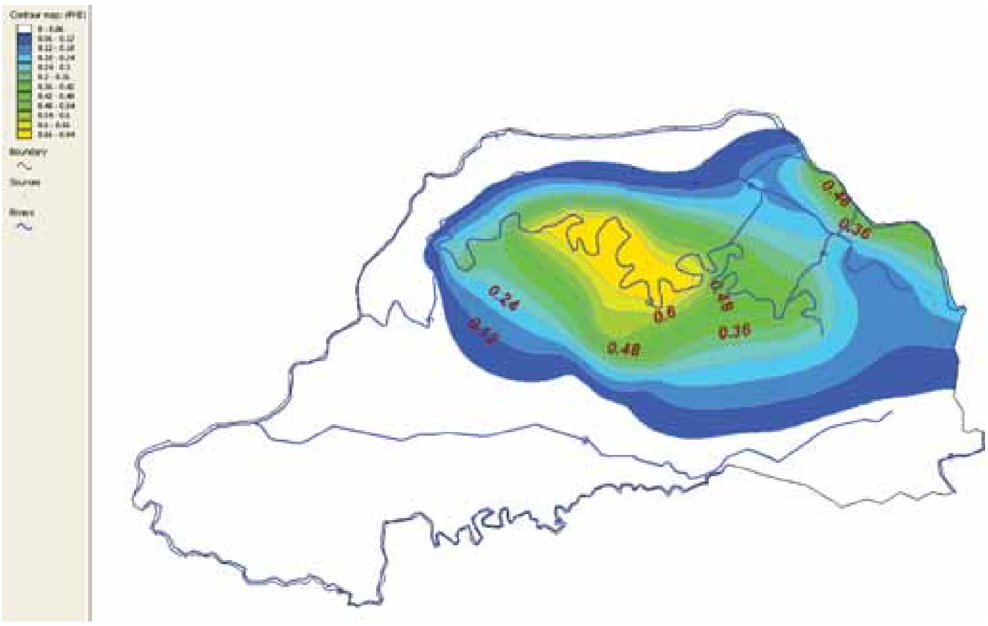

Fig. 7 – Course of groundwater level differences (m) after introducing technical measurements in the Latorica river bed with contemporary watering of the Tice river by means of artificial channels No.8 and No.9 (Fig. 6).

These modelling calculations of surface and groundwater level regime have been accomplished by soil moisture measurements in the Medzibodrožie region and modelling in the unsaturated zone realised by Institute of Hydrology, Slovak Academy of Sciences in Bratislava.

TECHNICAL SOLUTION

Proposed technical solution has after put into operation to secure in the 44,4 km long Tice River and in some parts of its branch system the creation of a relative steady discharge regime with possibility of certain water level control due to requirements and needs of the ecosystem and population of individual touched villages. For this reason it was necessary to solve following hydrologic, hydraulic and technical problems:

- hydraulic solution and technical proposal of a gravitational uptake of required water quantity from the Latorica River in such way that even in dry periods will be enough water for creation of convenient water level regime in revitalised Tice River,
- hydraulic proposal and relevant technical solution of necessary measures in the Latorica River for securing the required water take-off into the Tice River,
- hydraulic solution and technical proposal for gravitational discharge take-off from the Tice River into the border Veľká Krčava River,
- flood protection securing in the vicinity of the revitalised Tice River by means of controlled inflow into the Tice River,

Fig. 8 – Northern branch of connection of the Latorica water through Leleský channel into the Tice river bed.

Fig. 9 – Southern branch of water connection from the Tice through Northern and Southern Radský channel into the Veľká Krčava River.

- hydraulic solution and technical proposal of measures and objects in revitalised Tice River to enable water control possibility for relatively stable discharges in the Tice River,
- utilisation of existing channel system in the region for solving the inflow into the Tice River and proposal of necessary measures in the channel system and needed gates,
- determination of marginal operation discharges Q_{min} and Q_{max} and determination of minimum and maximum operation water levels in the Tice River and in the channel system, as well,
- review of evaporation impact from water level and seepages into the groundwater on discharge balance in the Tice River and need for water supply from the Latorica River.

Description of the system and its operation

System which will secure during operation the required function of restored Tice flow in the nature consists from relatively separate parts:

- ***Weir construction*** in the Latorica River is a component of the technical solution. It is situated in rkm (river kilometer) 21,680 of the Latorica flow, in profile approx. 60 m above the bridge on road connecting towns Veľké Kapušany – Kráľovský Chlmec, which will secure backwater level behind it on operation level 99,5 m n.m., whereby conditions for gravitational inflow into the Tice River will be created even at minimum discharges in the Latorica River at consequent securing of hydrodynamic conditions of flood discharges.
- ***Channel 1*** is created by using parts of existing channels – Leleský, Kaponský and Bačka with some corrections and completion by a new channel situated from outlet object in the left protection dam of Latorica in rkm 24,751 up to Leleský kanál. The total length of channel 1 is 4 617 m and its discharge capacity at most unconvenient hydrodynamic conditions is approx. 1,0 $m^3.s^{-1}$.
- ***Channel 2*** consists of existing channels Pri prameni, Leleský, Veľký les IV and no-named channel. Its total length is 5 800 m and it is connected with Latorica through outlet structure in the left hand-side protection dam in its river chainage rkm 21,750. This channel enables to bring water gravitationally into the Tice River and its discharge capacity at most un-convenient hydrodynamic conditions is approx. 1,25 $m^3.s^{-1}$.
- ***Revitalised Tice River*** is 44,4 km long and its route is untouched without any corrections in the width and length. Revitalised flow will be supported by Latorica water by means of both mentioned channels. The water level regime will be controlled by sluices on tubes at six damming profiles on the river. These are designed to be situated in following cross-sections:
  - 1. damming in rkm 0,000 at mouthing into Northern Radský channel,
  - 2. damming in rkm 4,940 when crossing the field road on the eastern part of the Rad village,
  - 3. damming in rkm 11,030 at crossing the state road from Zatín to Svinice,
  - 4. damming in rkm 17,910 at crossing the state road from Kráľovský Chlmec to Boľ on the southern part of the Boľ village,
  - 5. damming in 26,100 in taper part of the flow in meander northerly from the Kráľovský Chlmec town,
  - 6. damming in rkm 38,170 at crossing the field road in south-western direction from the Leles village (Fig.10).

Fig. 10 – Damming profiles on the Tice River.

- ***Channel 3***, which secures gravitational water flow from the Tice River down to the Veľká Krčava River, is 8479 m long and is created by connected channel system – Northern Radský, Somotorský and Southern Radský channels. Its discharge capacity is 2,3 $m^3.s^{-1}$.

RIVERS, CHANNELS AND STRUCTURES ON THEM

For obtaining the determined goals and for watering of former river bed of the Tice River is necessary to execute in individual rivers and channels following technical measures and correct the operation rules on rivers and their structures.

The Latorica River

On the Latorica River it is necessary to build over the bridge on state road from Veľké Kapušany to Kráľovský Chlmec a weir structure which will secure at even minimum discharges the required water level in the vicinity of two above mentioned outlets in the left hand-side protection dam of the Latorica River. The weir was designed as a bag weir with operation water level on 99,50 m a. s. l. It will be a two-field weir with the width of 12,0 m. The height of the backwater will be 3,30 m. Due to operation on the weir appropriate water level will be secured.

Tice

Recently the Tice River presents a system of wetlands which are connected and sometimes flown through. The river bed is fully grown with water flora and trees. The width of the river varies from 20 to 100 m , locally up to 150 m. The bottom is clogged with mud and several contaminants. The whole head of the river bed bottom is on 44,4 km long river approx. 3,51 m, what presents a mean longitudinal slope of the bottom $i_0 = 0{,}000079 = 0{,}079$ ‰.

Revitalisation of the river presents at the minimum technical measures of the river bed including cleaning and creation of conditions for securing a permanent discharge in the river and reconstruction as well as building of six dammings where the water levels in front of and behind are connected with two pipes (diameter D = 1000 mm) with sluices for the water control. These damming profiles are used for crossing the roads of local importance and field roads, as well.

Fig. 11 – The hydro-ecosystem of the Tice River.

The total area of the water level in revitalised 44,4 km long Tice River is approx. 2,8 mil. m^2 and the whole water volume in the Tice River at maximum operation levels in individual reaches is 2,95 mil. m^3 of water.

The discharge regime in revitalised Tice River is given mostly:

- by possibilities of water uptake from the Latorica River in low-water periods and at discharges close to values of minimum discharges when the uptake should not exceed the $0,5\ m^3.s^{-1}$value,
- by discharge capacity of transport channels No.1 and No.2, which should be at most unconvenient hydrodynamic conditions – minimum head at the beginning and at the end of the channel – for channel 1 $1,0\ m^3.s^{-1}$ and for channel 2 $1,25\ m^3.s^{-1}$,
- at discharge capacity of connecting pipes on individual damming profiles utilising the control capability of sluices on these pipes, which will be used mainly during the first fulfilling of the system as well as during low discharges in the Latorica River.
- at discharge capacity of the channel 3 which is $2,3\ m^3.s^{-1}$.

Discharge and water level regime in the system

The discharge regime in the Tice River is detemined by possibilities of the water uptake from the Latorica River and by capacity possibilities of the transport channel No.3. Discharge in the Tice River will vary in limits from

$$0{,}5\ m^3.s^{-1} \leq Q_T \leq 2{,}3\ m^3.s^{-1}$$

The mean operation discharge which will be supported from the Latorica River is $Q_{oper,T} = 2,25\ m^3.s^{-1}$.

Water losses from revitalised Tice are given by seepage of the water into groundwater and by evapotranspiration. Determined losses were computed for the maximum evapotranspiration and were evaluated by the value $Q_{evap} = 0,13\ m^3.s^{-1}$.

Losses due to seepage from the Tice river bed into groundwater were calculated by means of mathematical modelling and were determined after watering of the Tice river bed at the value $Q_{seep} = 60\ l.s^{-1} = 0,06\ m^3.s^{-1}$.

Discharge in the Tice River will be after estimation of water losses

$$Q_{prev,Tice} = Q_{prev,T} - Q_{pries} + Q_{výp} = 2{,}25 - 0{,}06 - 0{,}13 = 2{,}06\ m^3.s^{-1}$$

Water level regime for individual reaches of the system was determined by numerical modelling by means of mathematical modelling of steady non-permanent flow.

Evaluation of solution scenarios

In presented contribution a proposal of water supply into the Tice River and its prospective watering is given using two alternative technical solutions.

1. scenario of the solution considers the construction of weir with operation water level on 99,50 m a.s.l. in the Latorica River (Fig.12) above the

Fig. 12 – Situation of the bag weir on the Latorica River for damming the surface water.

bridge on state road from Veľké Kapušany to Kráľovský Chlmec with water transport into the Tice River and its consequent transport into the Veľká Krčava River bed. This variant of the solution enables the watering of the Tice and when controlling the water on required level as well the watering of dead branches of the river. The system can operate during the whole year except of short period when the main – drainage- function of Leleský and Somotorský channels has to be fulfilled.

2. scenario differs from the first one only by the fact that in the Latorica River a natural surface water level regime will be secured and no weir will be realised. Other elements will be the same as in the first variant. The required operation discharge would be in mean year just in 35 – 40 days secured and in dry years the possibility to improve the water level regime in the Tice will be possible only in 2-5 days per year.

Solving collective **recommended the realisation of 1. scenario** of the solution which enables the renaturation and revitalisation of the Tice River and its dead branches and the creation of conditions for more qualitative life of inhabitants in touched villages.

Conclusions

The presented INTERREG IIIA project is dealing with inter-disciplinary and inter-regional problems of water and land-use management in the Medzibodrožie region. It is not the first research project solving the water management in this region but certainly it is the first project which in wide spectrum and cross-border absorbs the water management problems of the Medzibodrožie region on both sides between the Slovakia and Hungary.

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Water in Agriculture – natural distribution, requirements, management and water protection

1. Introduction

Water is a unique and irreplaceable natural resource. It is the basic and final commodity, a vital ingredient of any production type and of raw materials. However, water is also active, overwhelming and sometimes destructive factor. It is involved in nearly all economic activities, either as a raw material or as a subsidiary substance indispensable for production and other processes. On the one hand, technological development and urbanisation require massive water amounts, and on the other hand endanger water resources and water environment. *However, the occurrence and quantities of water in nature as well as its quality differ spatially and in terms of time from the needs of people and economy.* An important condition of water use sustainability is a real estimation of current and future users' requirements with continuous maintenance of water quality. Present investments into protection from harmful water effects, along with use and protection of water resources are an integral part of future programmes and requirements of sustainable water management.

Water management activities have an economic, infrastructure and social significance for development of all countries. Social and economic relationships in water management are planned as a part of a continuous process of interactions and adjustment of all the factors essential for the overall development of all countries. Today's practice confirms technical and technological, and social and economic correlation between water management and a large number of economic and other related activities, in the first place with: ***agriculture****, power supply, traffic, tourism, a majority of industry activities, urban and public development, sports, recreation and ecology.* Increased water requirements, a growth of pollutants and human goods that should be protected from harmful water effects increasingly aggravate the current condition owing to the fact that water management systems are becoming more and more complex and significant for overall economic and social development. The fundamental goal in water management is to define on the one hand continual establishing and maintaining of balance in human aspirations, activities and needs, and on the other hand to define natural processes and resources including their continuance for the future demands. *Water and water management are not paid a deserved attention and have not got a due recognition in Croatia. It is confirmed by the fact that within the project "Croatia in 21st century " water management was not approved as especially significant thematic unit.* Neither is water adequately represented in other elaborated sector's documents. At the same time, in one of a series of planning documentation it has been confirmed that *"****water is one of key factors for the development in the Republic of Croatia with focus on agriculture and tourism ". A better economic and social development of Croatia is inconceivable without taking into account water management as a basic activity guided by a carefully planned national water policy.*** **This is also an integral part of the Water Management Strategy which became efficient on 15 July 2008 at the Croatian Parliament session.**

2. Water management

Water management comprises a set of activities, decisions and measures in order to maintain improve and implement a water regime of a particular area. To achieve those goals the required quantities of water of specific qualities for different purposes should be ensured, furthermore, water should be protected from pollution, and watercourses and other waters should be regulated. The flood protection is involved here as well. Water management is established on the following principles:

1) *Water is an irreplaceable pre-condition of life and work. The obligation of all people is to care about its quality, to use it with awareness and rationally, under the legally determined circumstances.*

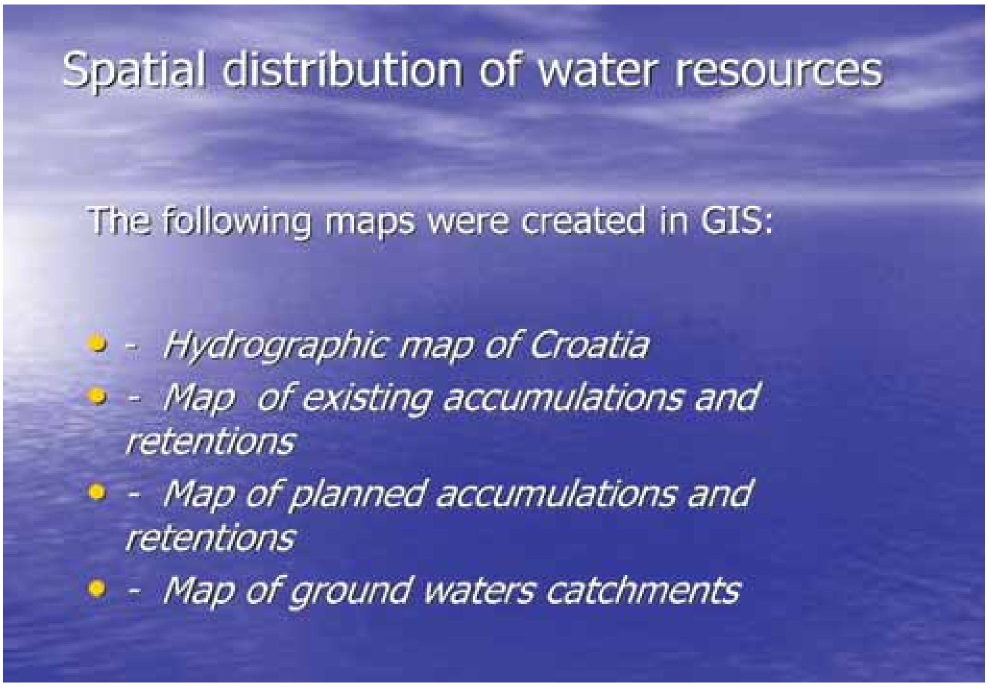
2) *Waters are managed according to the principle of water system totality and the principle of sustainable development to satisfy current generation's needs and not to endanger rights and chances of future generations to use water for them.*
3) *The water management territory units are water and catchment areas as hydrographical and economic unities. The borders of administrative and territory units cannot prevent integral water management in respective areas.*
4) *The starting point in preparation and plans development, which are the basis of water management, is the obligation of overall environment protection and implementation of general and economic development of the Republic of Croatia.*
5) *The fee equivalent to the benefit e.g. the impact scope on water condition is paid for the water use exceeding the limits of allowable general use, and is paid as well for water quality deterioration.*
6) *The regulations defining tasks and obligations for investment into water system improvement have to determine the financing sources as well.*

The water regime defined on the basis of long term monitoring of spatial distribution of quantity, quality and other water properties and water system constructability is particularly important for water management. The water regime modifications occur due to deeds and behaviour of people or due to natural forces' actions that change either water quantity or quality and water's spatial and temporal distribution.

Water and catchment areas define territorial outlines for water management. Water areas comprise one or more catchments of major river watercourses or their parts constituting a natural hydro graphic unit. The catchment area encompasses within the water region, one or several catchments of minor watercourses. An integral water management is ensured for them due to interrelatedness of water issues and due to constructed water system and economic conditions. A catchment area constitutes a territorial unit for local waters management. *The territory of the Republic of Croatia is distributed into the following water areas due to water management territorial basics*:

a) The Sava with 13 catchment areas
b) The Drava and Danube – with 7 catchment areas
c) Primorje and Istria, Lika and Gorski kotar – with 6 catchment areas
d) Dalmatia, and a part of Lika – with 8 catchment areas.

On 15 July 2008, basing on the Law on Waters (NN 107/95, 105/05) and Water Management Strategy (SUV NN 91/08) a long term planning document was issued on the Croatian Parliament 5th session identifying vision, mission, objectives and tasks of the state water management policy. The SUV contents was adjusted with relevant directives of the European Union, constituting thus the basic principle for arranging negotiations, and serving at the same time as the fundamentals for using the means from non-returnable funds of the European Union. The SUV is also the basics for the setting up of strategies and preparations of physical planning, environment protection and development of other water related sectors. The boundaries of water and catchment areas are determined by the Government of the Republic of Croatia (Figure 1).



Water management basic principles, Strategy of the State's Physical Planning, Environmental Protection Strategy, Planning principles of agricultural soil and forests management on state's level, and planning basics of inland waterways development system are being adjusted mutually, and along with the modifications occurring in the water system, economic and social development. VOH is determined by the Parliament of the Republic of Croatia.

3. Water resources of the Republic of Croatia

3.1. Basic data on watercourses and catchment areas

From the total surface of Croatia covering 56.538 km^2 the Danube's, e.g. the Black Sea's hydrographical catchment contains 35.131 km^2 (62,1%), and the Adriatic Sea catchment 21.407 km^2 (37,9%). The Croatian part of the Adriatic Sea's surface is 31.067 km^2, and the coast's length is 5.835 km.

The following rivers belong to major catchments (F > 10.000 km^2) on the Croatian territory:

- The Sava; F_{uk} = 95.419 km^2 and L_{uk} = 946 km, with Croatian part: 25.374 km^2 and 510 km
- The Danube; F_{uk} = 816.950 km^2 and L_{uk} = 2.120 km, with Croatian part: 2.857 km^2 and 138 km
- The Drava; F_{uk} = 41.238 km^2 and L_{uk} = 749 km, with Croatian part: 7.015 km^2 and 323 km
- The Mura; F_{uk} = 14.149 km^2 and L_{uk} = 493 km, with Croatian part: 473 km^2 and 83 km
- The Kupa; F_{uk} = 10.236 km^2 and L_{uk} = 294 km, with Croatian part: 8.412 km^2 and 294 km
- The Neretva; F_{uk} = 10.490 km^2 and L_{uk} = 215 km, with Croatian part: 280 km^2 and 22 km.

The following rivers have the catchment areas covering surfaces from 1.000 to 10.000 km^2: Bosut, Česma, Dobra, Glina, Korana, Krapina, Orljava at the Black Sea's catchment, and Cetina, Krka, Lika and Zrmanja on the Adriatic Sea catchment.

The largest natural lakes are the following: Vransko (near Biograd) 30,7 km^2; Prokljansko 11,0; Vrana (on the island of Cres) 5,6; Plitvičko 2,1; Mljetsko 2,0 and Bačinska lakes 1,90 km^2. The largest artificial lakes are the following: Peruča 13,0 km^2, Grudnjak 7,1; near Našice 11,0; D. Miholjac 6,9; Garešnica 6,2 and Crna Mlaka 4,5 km^2.

The total of 45,5% or 25.770 km^2 of the inland part of Croatia gravitates to the Sava catchment. The density of the Sava's hydrographical network ranges from 2,1 to 3,2 km/km^2. With regard to topographic, climatic, hydrological, pedologic and hydro geologic characteristics of the catchment areas the specific influents on the Sava's catchment range from 3,7 l/s/km^2 to 64,9 l/s/km^2, and the average specific influent on the Sava catchment is 12,7 l/s/km^2, while total surface waters quantities amount to 321,7 m^3/s e.g. 10.151 hm^3 (10.151.000.000 m^3/a year).

The Drava's and Danube's catchments in Croatia cover 9363 km^2 which is 16,6% of Croatia's inland surface. The average specific influents range from 11 to 22 l/s/km^2, and on the tributaries from 5,0 to 13,7 l/s/km^2. The total water quantities on the Croatian catchment area of Drava and Danube are 48,0 m^3/s or 1.515 hm^3.

The surface of Istrian and Primorje catchments (including the part of Gorski kotar, Lika and islands covers 8465 km^2 e.g. 15,0%. The average specific influents range from 0,97 (Pazinčica) to 25 l/s/km^2 (Lika). The area VGO Rijeka covers 11.729 km^2 – with the part of the upper catchment surface of Kupa and Una (2.770 + 494 km^2).

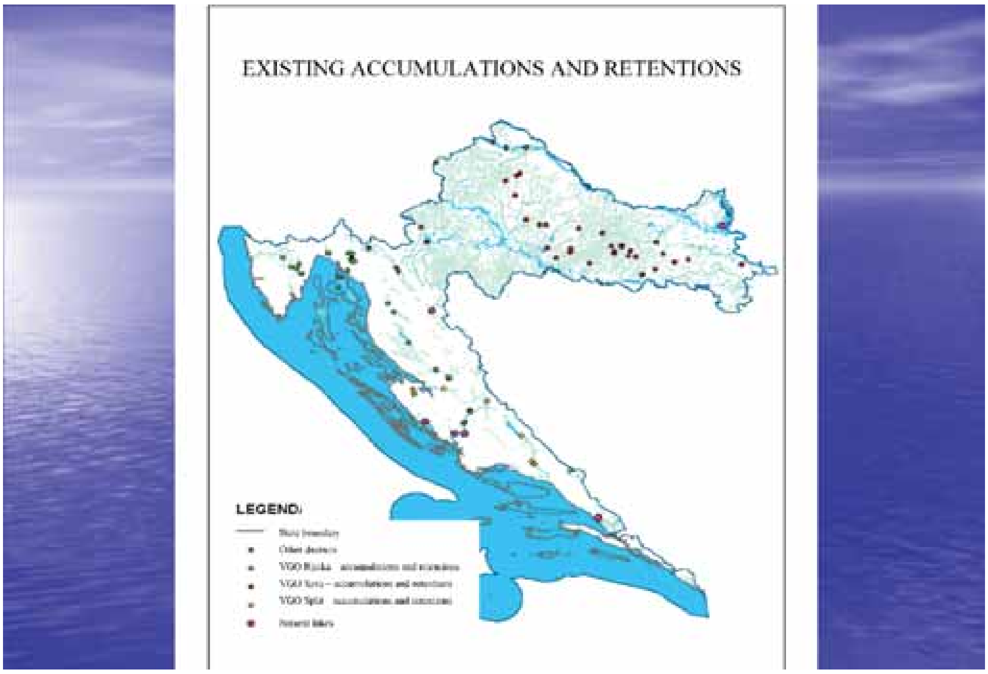
The surface of Dalmatian catchments with corresponding islands is 12.940 km^2 , which makes 22,9% of Croatia's inland surface. Average specific influents range from 12,6 (Ervenik) to 40,2 l/s/hm^2 (Ombla and Matica Vrgorska).

With regard to Croatia's spatial distribution related to the Black Sea catchment the inland and exterior waters are more abundant, and there is a larger specific discharge of proper waters on the Adriatic Sea catchment. The fact that the water regimes of the Black Sea and Adriatic Sea catchments are complementary as temporal units over the year period, but not identical over several years is very convenient for the water resources management in Croatia.

Ground water has a great significance as one of the components of total water balance. There are vital aquifers not only in the large part of karst regions in Croatia, but also in alluvial floodplains. The real condition of ground waters is not defined as it is the case with surface waters due to lacking data and the complexity of investigation.

With regard to climatic, topographic and other terrain characteristics of major catchment areas the average annual precipitations in Croatia range from 656 mm (Danube catchment) to 1.418 mm (Kupa catchment) on the Black Sea catchment, and from 1.073 mm (all islands' average) to 2.267 mm (Kvarnerski bay) on the Adriatic Sea catchment.

Basic indicators on average quantities of surface and ground water in Croatia are illustrated in tables and do not need any additional explanations.


EXISTING ACCUMULATIONS AND RETENTIONS
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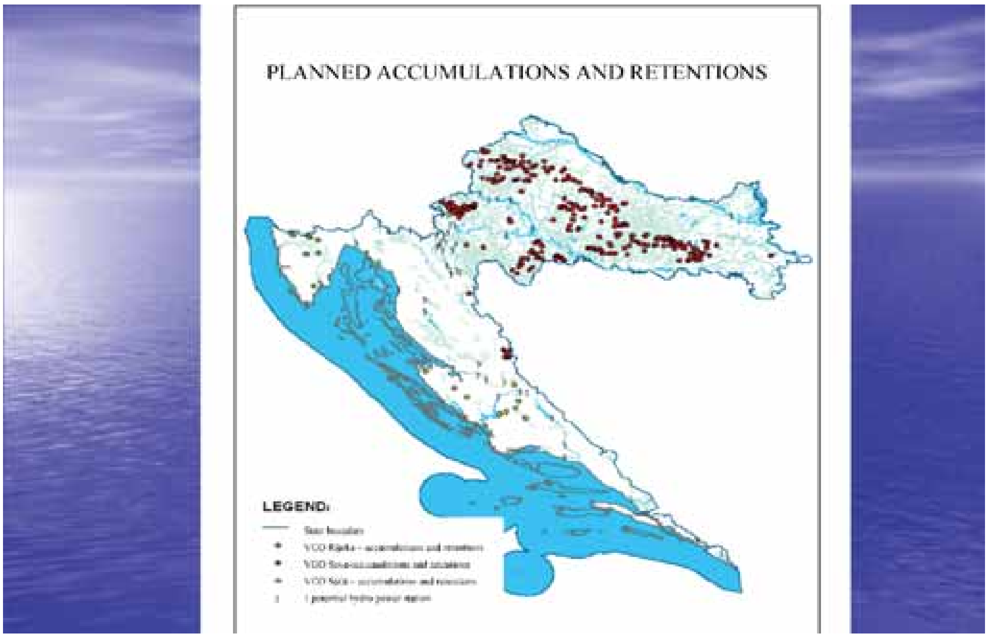
PLANNED ACCUMULATIONS AND RETENTIONS
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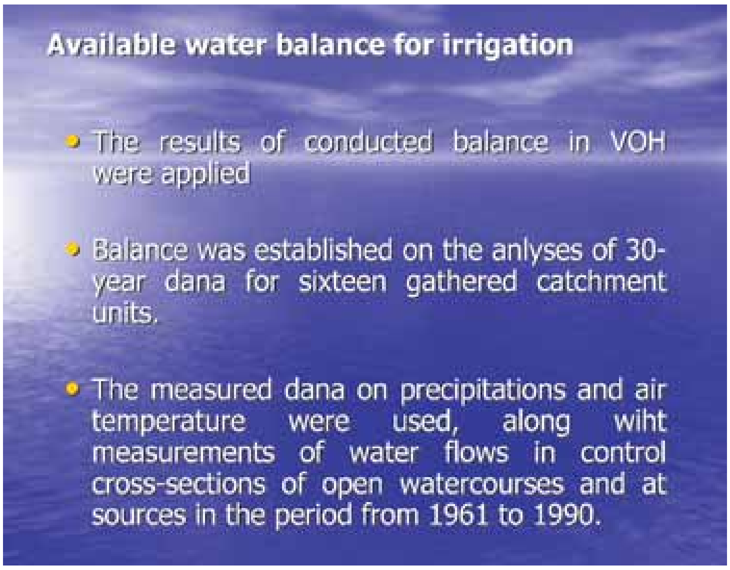
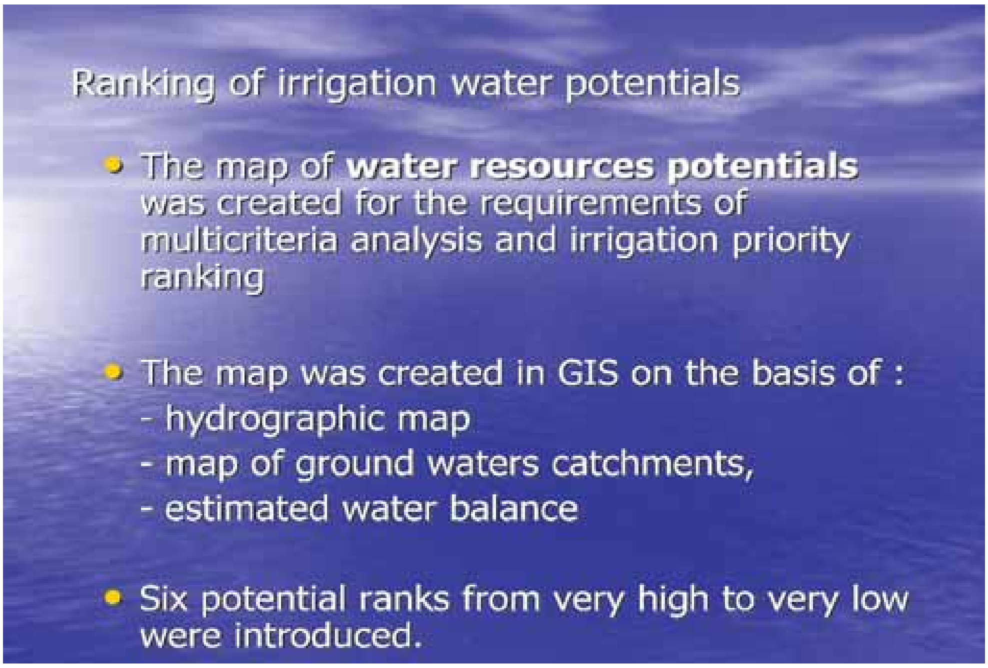
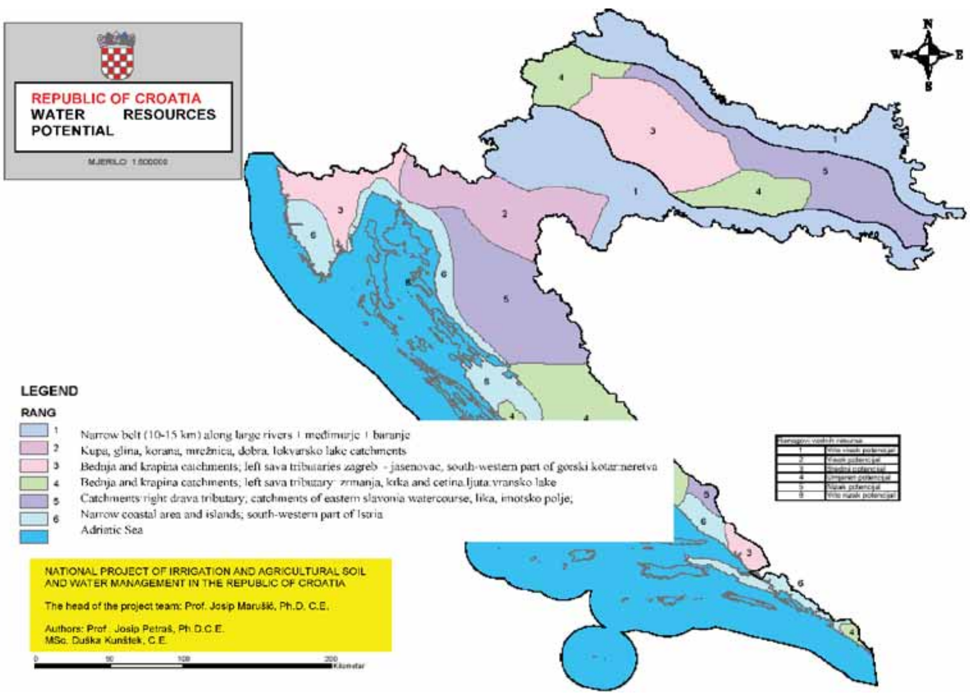


Table 1 – Average quantities of proper waters (Q), specific running off (q) and run off coefficient (C)

Ord. nb.	Catchment area	*Fsl* (km²)	*Q* (m³/s)	*q* (l/s/km²)	C – run off
1.	Krapina	1237	17	13,74	0,410
2.	Lonja, Trebež	4261	18	4,25	0,155
3.	Ilova, Pakra	1793	14	7,86	0,271
4.	Orljava	1618	12	7,66	0,264
5.	Sava's catchments in Croatia	7132	41	5,75	0,215
6.	Kupa	7643	178	23,24	0,517
7.	Una	2086	48	23,01	0,530
8.	Drava	7150	42	5,67	0,225
9.	Danube	2213	6	2,71	0,130
Total of Black Sea catchment (62,1%)		35.133	376	10,71	0,338
10.	Istra	2755	41	14,88	0,411
11.	Kvarnerski bay	1101	48	41,60	0,605
12.	Lika, Gacka and coastal region	3712	105	28,29	0,499
13.	Zrmanja and Ravni kotari	2670	54	18,82	0,421
14.	Krka and coastal region	2487	57	22,92	0,598
15.	Cetina and coastal region	3215	69	21,46	0,481
16.	Neretva and Dubrovačko primorje	1995	47	23,56	0,469
17.	All islands	3270	30	9,17	0,270
Total of Adriatic Sea catchment (37,9%)		21.405	451	21,07	0,466
Total of Republic of Croatia (100%)		56.538	827	14,63	0,397


Ranking of irrigation water potentials
• The map of **water resources potentials** was created for the requirements of multicriteria analysis and irrigation priority ranking
• The map was created in GIS on the basis of :
- hydrographic map
- map of ground waters catchments,
- estimated water balance
• Six potential ranks from very high to very low were introduced.


REPUBLIC OF CROATIA
WATER RESOURCES POTENTIAL
LEGEND
RANG
1 Narrow belt (10-15 km) along large rivers + međimurje + baranje
2 Kupa, glina, korana, mrežnica, dobra, lokvarsko lake catchments
3 Bednja and krapina catchments; left sava tributaries zagreb - jasenovac, south-western part of gorski kotar neretva
4 Bednja and krapina catchments; left sava tributary zrmanja, krka and cetina ljuta vransko lake
5 Catchments right drava tributary; catchments of eastern slavonia watercourse, lika, imotsko polje;
6 Narrow coastal area and islands; south-western part of Istria
Adriatic Sea
NATIONAL PROJECT OF IRRIGATION AND AGRICULTURAL SOIL AND WATER MANAGEMENT IN THE REPUBLIC OF CROATIA
The head of the project team: Prof. Josip Marušić, Ph.D. C.E.
Authors: Prof. Josip Petraš, Ph.D.C.E.
MSc. Duška Kunštek, C.E.
0 50 100 200 Kilometar

3.2. Basic indicators on Croatia's own waters

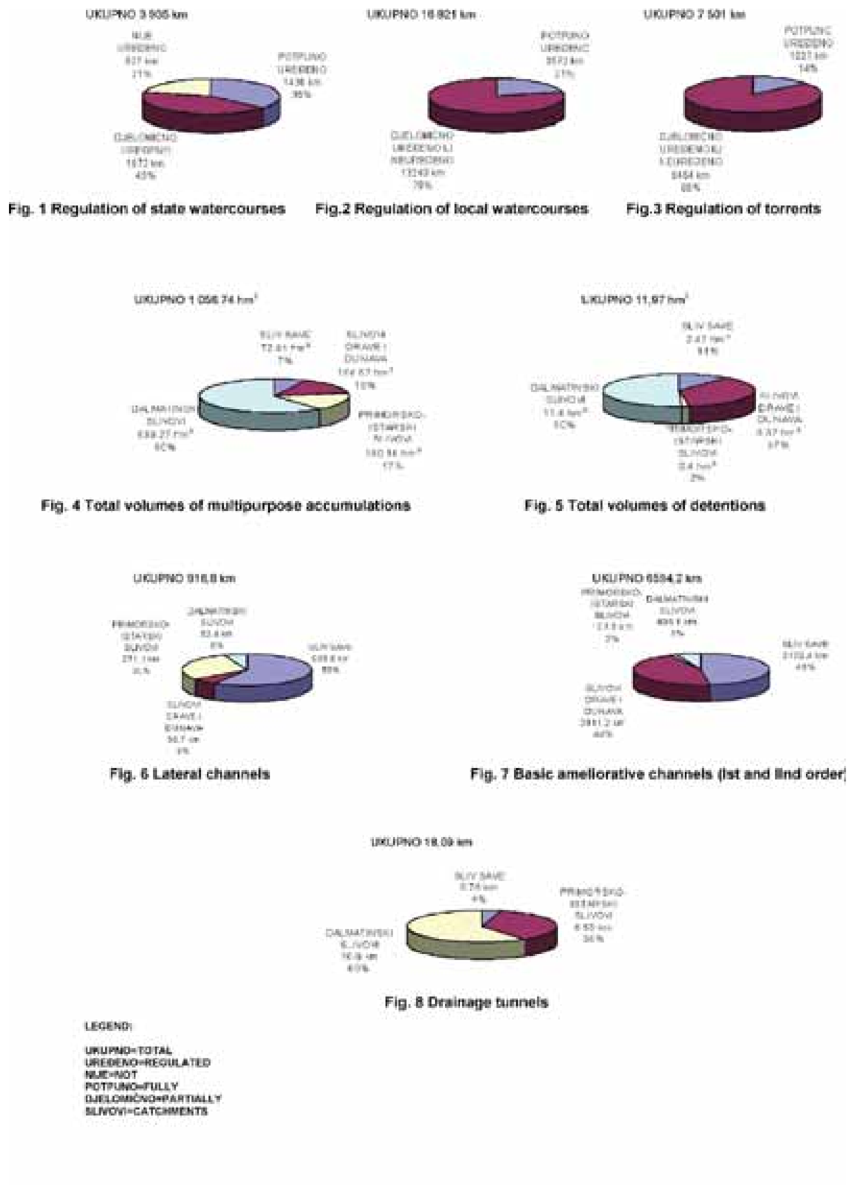
Table 2 – Croatia’s proper waters distributed according to catchments

Ord. nb.	Basic indicators of water quantities	Unit/month	Catchment area		Croatia
			Black Sea	Adriatic Sea	
1.	The area's surface (F)	km^2	35133	21405	56538
2.	Annual precipitation	mm	1001	1426	1192
3.	Annual precipitation	m^3/s	1115	968	8083
4.	Proper waters	Q m^3/s	376	451	827
5.	Specific run off	l/s km^2	10,71	21,07	14,63
6.	Annual quantity V	m^3/year	$1{,}186x10^{10}$	$1{,}422x10^{10}$	$2{,}608x10^{10}$
7.	Quantity V/F	m^3/km^2	237574	664230	461282
8.	Runoff coefficient	Q/P	0,338	0,466	0,397
9.	Inhabitants' number (2001)	N	3045829	1391631	4437460
10.	Quantity per capita	m^3/g/inhab.	3895	10220	5877
11.	Quantity per capita	l/s/inhab.	0,124	0,324	0,186
12.	Evapotranspiration	mm	663	761	700
13.	Quantity of exterior waters	m^3/s	3695	435	4130
14.	Quantity of outlet waters	m^3/s	4071	886	4957

Table 3 – Disponibility of proper waters according to inhabitants' number in Croatia

R. br.	Catchment area	Inhabitants	l/s/inhab.	3/year/inhab.
1.	Krapina	149577	0,114	3564
2.	Lonja, Trebež	257408	0,068	2135
3.	Iliva, Pakra	87834	0,161	5062
4.	Orljava	86532	0,143	4498
5.	Sava catchment in Croatia part	1317025	0,031	982
6.	Kupa	296059	0,621	19579
7.	Una	17066	2613	88698
8.	Drava	697500	0,060	1899
9.	Danube	136427	0,044	1367
The total of Black Sea Catchment (68,6% inhabitants)		345829	0,124	3895
10.	Istria	207826	0,187	0221
11.	Kvarnerski bay	239890	0,200	6311
12.	Lika, Gacka and coastal region	42081	2495	78688
13.	Zrmanja and Ravni kotari	140010	0,386	12163
14.	Krka and coastal region	102664	0,555	17509
15.	Cetina and coastal region	400795	0,172	5429
16.	Neretva and Dubrovačko primorje	137505	0,342	10779
17.	All islands	120887	0,248	7826
The total of Adriatic Sea catchment (31,4% inhabitants)		1391631	0,324	10220
Total of Republic of Croatia (100% inhabitants)		4437460	0,186	5879

Tables 1, 2 and 3 illustrate the basic indicators of available water resources in the Republic of Croatia, which are significant in quantity but irregularly distributed in spatial and temporal terms with regard to agricultural and other needs (water supply of settlements and industry, power supply, fishing, traffic, ecology).



Basic indicators about built hydrological structures in Croatia

4. Water and agriculture

4.1. Water requirements for plant cultures growth

Agricultural production has its humane goal to provide sufficient quantities of food for the increasing population of the Earth. Population increase requires intensification of agricultural production on the existing or creation of new agricultural areas. Intensification of agricultural production required also use of increasing amounts of water, for agricultural production is known as the largest water consumer. *Growing of field crops has often been extended to areas that are not suitable for cropping, and the conquest of new areas was actually a* ***struggle for water and against water***. Its side effects, however, often had a negative impact on the environment. Increased erosion, reduced biological diversity, polluted soil and water raised the concern about maintaining the biological balance. Application of various chemicals on areas under agricultural production causes part of unused or not degraded chemicals to be carried by water into watercourses, rivers, lakes, groundwater, and ultimately into seas and oceans. Scattered sources of pollution are difficult to control. Further, the global climatic changes have and will have many implications for the environment, and thereby also for agriculture. Droughts and floods are getting more and more frequent. *Prognostic models indicate that sources of good-quality water will become the key problem to mankind.* Naturally, global changes influence the availability and quality of these resources. Droughts are getting increasingly frequent also in Croatia, with damages to agriculture estimated at billions of kunas. Furthermore, frequent floods on both state and local watercourses cause considerable damages to agriculture as well. The negative influence of man's activities on water pollution was recognized long ago also in Croatia, and agriculture is singled out as one of the major sources of the emission of nitrates and pesticides into surface and ground waters. Hence, the agronomic practice has the important task to find management techniques and technologies that will not endanger the natural functions of soil, and which will protect surface and ground waters from pollution from this source. *The relations between water and agriculture are highly dynamic and complex. Hence the aim of this work was to analyze the major factors of these relations: water requirements in agriculture, effects of extreme hydrological conditions upon agriculture and the influence of agriculture on the quality of water resources.*

The relationship between water and human activities is so important that water can be considered the basic element of social and economic develop-

ment. This interdependence includes a number of existential, biological, social and economic functions, but also negative effects such as floods, droughts, pollution, etc. All these mutual effects always take place in the natural environment. Agriculture is the activity that mainly proceeds in the natural environment and therefore depends on water and affects water.

People have currently about 40 000 km^3 of recoverable water at their disposal, which amounts to about 7800 m^3 per capita a year. However, precipitation, watercourses, and groundwater reserves are not uniformly distributed over the Earth's surface. Only 8-13% of total water brought to land with precipitation can be controlled.

It is a known fact that agriculture globally utilizes about 70% of all the captured water quantities, with irrigation being the greatest water consumer. Of the overall 1.5 billion ha of sown areas, 250 million or about 17% are currently irrigated in the world, and about 40% of world food is produced on them (van Hofwegen and Svendsen, 2000*). Annual water consumption for irrigation is estimated at 2000 and 2500 km^3 of water.*

About 550 million m^3 of water is captured in Croatia per year, of which 375 million m^3 reaches the end users. The captured quantity is slightly less than 1% of total precipitation that falls on the continental part in a year. Namely, the inland part (56,538 km^2) gets on average 1162 mm of precipitation, or a total amount of 6.6x10^{10} m^3 of water. Captured quantities of water are used for different purposes: water supply, industry, agriculture, power supply, fishing, etc.

No data are available on the water quantities used in Croatian agriculture. Use of mathematical models enables estimation of water consumption in plant production. Using one of such models, “Cropwat” (Smith, 1992), water consumption was calculated for evapotranspiration of major field crops grown in the average climatic conditions in different agricultural regions of the Republic of Croatia (Table 4). For groups of crops (designated in Table as *other crops*) water consumption was estimated. Multiplying water consumption by average areas under the given crops data were obtained on water consumption in plant production in the territory of the Republic of Croatia. Plant production can make use of 10 to 14% of total precipitation that averagely falls on the continental part of Croatia.

Table 4 – Water consumption in plant production in the Republic of Croatia

Crop	Water requirements $m^3/ha/\ yr$	Total ha	Annual quantities consumed million m^3/yr
Maize	3200 - 4000	392,800	1,178.4 – 1,571.2
Wheat	4000 - 5500	224,200	1,008.9 – 1,233.1
Barley	3800 - 5000	47,200	198.2 – 245.4
Oats	4000 - 5000	21,200	84.8 – 106.0
Other cereals	3000 - 4000	38,600	115.8 – 154.4
Oilseed rape	3600 - 4700	12,300	49.2 – 61.5
Soybeans	3500 - 4500	43,500	174.0 – 217.5
Sugar beet	3800 - 4800	25,400	101.6 – 121,9
Sunflower	3500 - 4200	29,700	103.9 – 124.7
Other industrial plants	3000 - 4000	10,500	31.5 – 42.0
Potato	3000 - 3500	65,400	196.2 – 228.9
Herbaceae	3500 - 4200	10,000	35.0 – 42.0
Tomato and pepper	4000 - 6000	11,500	46.0 – 69.0
Other vegetables	3000 - 4000	49,100	147.3 – 196.4
Orchards and vineyards	4000 - 5500	123,000	553.5 – 676.5
Meadows	2500 - 4200	371,000	1,113.0 – 1,669.5
Pastures	1300 - 2000	1,147,000	1,720.5 – 2,867.5
TOTAL		2,622,400	6,858.0 – 9,628.0

Cattle production is another major water consumer. It is estimated that through food and water a head of cattle consumes about 4000 m^3, and a sheep 500 m^3 of water per year (FAO, 2003). Using the data on the average numbers of livestock and poultry in the Republic of Croatia, and the data on their daily requirements, it was estimated that the overall animal requirements amount to 20 to 25 million m^3 of water per year.

As the areas under irrigation are relatively small, 15.000 ha the quantities of captured water used for this purpose are also the smallest in Europe, estimated to 30 to 35 million m^3 a year.

4.2. Extreme Hydrological Events and Agriculture

Among the extreme hydrological events, floods and droughts are frequent both in Croatia and elsewhere in the world. We are witnesses of such events taking place throughout the world. While this text is being written floods are taking lives in different parts of the world, material goods are destroyed, and droughts are causing starvation and suffering of millions of people. Through such occurrences, water is demonstrating its unique force. Many researchers connect the increasing hydrological trends with the global climatic changes.

1) Floods

Floods are associated with high rainfall intensities and occur when recipients are unable to receive all water, which then floods the surrounding areas. Proximity to water has always meant security to man, fertile soils of river valleys rich in water provided abundance of food. Wishing to live near water, people build their dwellings, houses, raise cities on river banks. But, since water has an unpredictable character, it has often forcefully driven people out of such regions. People have been persistently returning, defying water with their intellect and with technical achievements. They have built dams, artificial banks, retentions and other hydrological structures only after suffering damage. Safety of such structures depends on the economic power of the country. Sometimes even these structures are not sufficient to stop the destructive force of water. The best examples are the floods of 2002 in Germany, France and Austria.

Floods are natural phenomena the occurrences of which are hard or impossible to forecast and avoid, but the consequences can be alleviated by undertaking different preventive measures. Floods rank high among major natural disasters also in Croatia, causing loss of life, high material damage, devastation of cultural treasures and ecological degradation due to the pollution spreading with flood waters. Almost no year passes in Croatia without floods on either state or local waters. Let us recall the most destructive ones: in 1965 water devastated some fifty thousand hectares of fertile land in the easternmost part of Croatia, imperiling 82 settlements and irretrievably carrying away thousands of houses. The city of Zagreb was flooded in 1964 with disastrous consequences. If this year seems to be in the remote past, let us recall some more recent floods: in Zagreb and in Hrvatsko Zagorje in 1989, in Požega, Nova Gradiška and Istria in 1993, Virovitica and Našice in 1996, floods of September 1998 in a large part of Croatia (Krapina, Vrgorsko Polje, Gorski Kotar), and the great floods of 2002, which took many lives and destroyed material goods throughout Europe and further afield.

Large mountain regions with high rainfall intensities, broad valleys of lowland watercourses, and inadequately built and maintained protection systems make Croatia very liable to floods. It is estimated that floods endanger more than 18% of the state continental territory. Some valuable agricultural areas are also situated in the regions at potential risk of floods.

2,415 km of dams have been constructed along the state watercourses, and 1,642 km of different levels of protection. Croatia has 58 multi-purpose reservoirs and 43 mountain retentions, and in the Sava catchment area 5 large low-lying retentions and three relief canals have been partially built, as well as 916.8 km of lateral canals for accumulation of mountain waters at the margins of protected regions. Some karst fields are drained by means of 9 drainage tunnels of a total length of 17.3 km. The page 2 displays basic indicators on the constructability level of facilities for protection from floods and drainage in Croatia. A number of smaller water regulation and protection structures have been also built, notably on local waters. Regardless of the given numbers and the occurring floods, it should be emphasized that the existing systems are largely unfinished, so that many parts are not at the necessary flood safety level. It commonly happens that serious actions are undertaken after floods with disastrous material and human consequences, and then the invested funds are far below the damages done by floods. A good example is the City of Zagreb, which started to be defended only after the disastrous floods in the 1970s.

Local floods of torrential mountain waters, which were very frequent in the last fifteen years, caused great damages at local levels, but were generally quickly forgotten by the general public. Adequate protection of agricultural areas from floods by external waters within the integral water management in catchment areas is a precondition of sustainable development of agriculture. Since efficient and economically competitive agricultural production is one of the strategic goals of the Republic of Croatia, the problem of flood protection should be paid adequate attention.

2) Amelioration systems of surface and ground drainage

Wishing to develop for agricultural production also areas that were not naturally suitable for it, complex drainage systems have been built in the world and in Croatia. It is estimated that about 580.000.000 million ha in the world have inadequate internal drainage. Detailed drainage has been applied on about 160.000.000 million ha in the world.

Croatia has a long tradition of designing, constructing and using hydro ameliorative systems. Most hydro ameliorative systems were built between 1970 and 1990, while construction of new ones was stopped in **1991**. Hydro ameliorative systems of surface drainage were installed on 43% of areas in Croatia, out of the total needs of 1,674,000 ha. Subdrainage systems were built on only 18% of the totally needed 822,000 ha. However, even the completed detailed drainage systems are not regularly maintained (Petošić, 2004). Bringing the greater part of hydro ameliorative systems to their project-implementation level would require considerable funds. Some of the systems have not been properly maintained since they were built and some were not executed in compliance with the design documentations.

The downward trend of sown areas has been noticeable for some time in Croatia, which is partly attributed to the poor condition of ameliorative systems. In the last twenty years or so the decrease amounted to about 20% (from 1,323,000 ha in the period 1981/1983 to 1,064,000 ha in the period 1999/2001).

Erosion

Water erosion is one of the oldest and most significant forms of soil impairment, which occurs with high rainfall intensities. According to available data erosion has destroyed 30% of the total arable areas in the world, and the production of erosion drift caused by anthropogenic influence is 2.5 times larger than the natural one. *Global estimation of soil degradation made by the United Nations revealed that one sixth of the overall world area under vegetation suffered a certain degree of damage in the last 50 years. Most of the damage is associated with agriculture, in which water erosion holds the first place. Soil erosion by water is certainly the most important and most dangerous process of soil damage in Croatia.* It is estimated that 1.8 million ha, or 31.8% of continental Croatia, is at high risk of water erosion. Bašić et al. (1992) estimate that 90% of arable areas in Croatia are exposed to water erosion of various intensities. It is estimated that the total mass of eroded material from agricultural areas in Croatia amounts to 3.8 million tons a year, or 1.21 t/ha/yr. Changes in the growing practices in agriculture could certainly help reduce the mass of eroded material on both agricultural and forest areas.

Drought

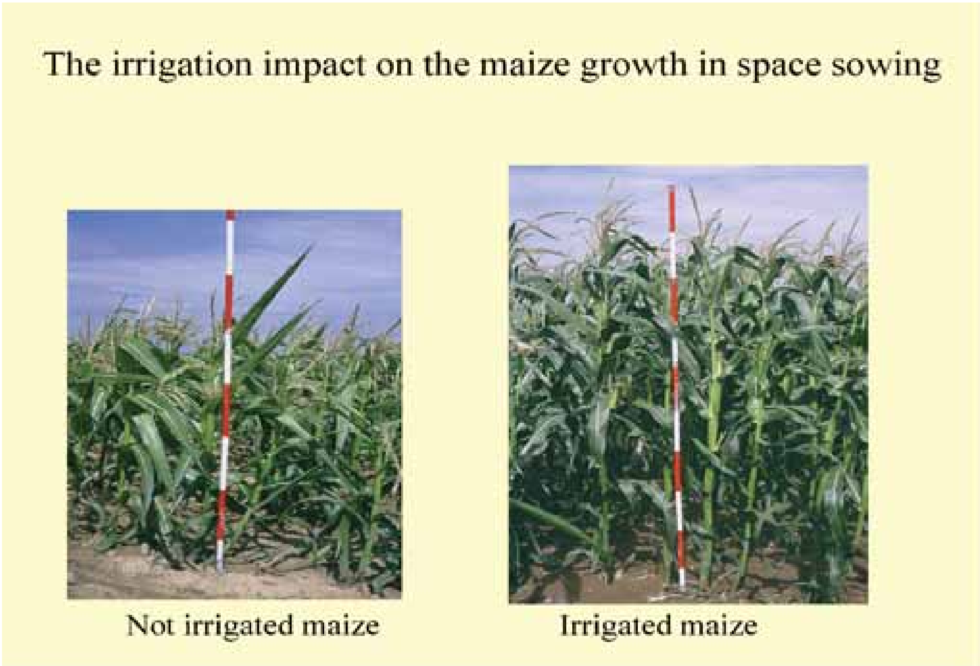
Drought is a normal and frequent climatic phenomenon, though it is often wrongly characterized as a rare and sporadic occurrence. It occurs in almost all climatic zones, but the way in which droughts appear may vary considerably from one region to another. Drought is a temporary occurrence and in that it differs from aridity, which is restricted to regions with low precipitation and is thus a permanent climatic phenomenon. *There are many definitions of drought, which in different ways describe the phenomenon characterized by deficiency of precipitation during a longer time period, usually one or more seasons. Its consequence is lack of water for different needs, among others for agriculture.*

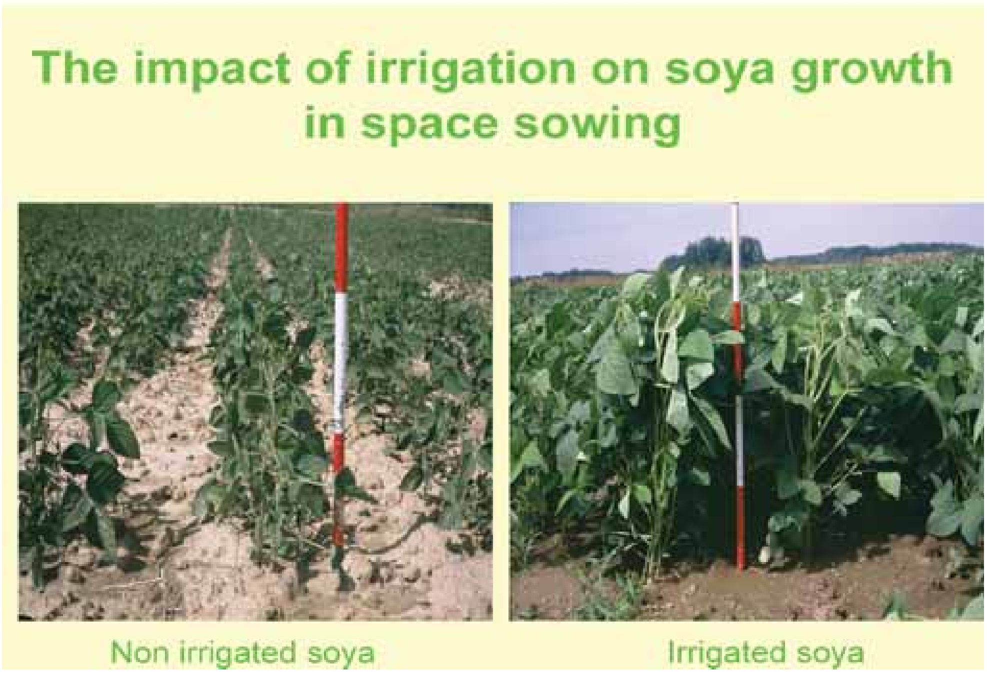
Drought in agriculture involves different characteristics of meteorological or hydrological drought and its effects on agriculture, focusing on lack of precipitation, differences between effective and potential evapotranspiration, soil water deficiency, lowering of the groundwater level, etc. *From the agronomic point of view, drought is the phenomenon when plants do not get enough water during the growing season, which is reflected in the growth and development of the crop grown and its reduced yield. In Croatia, droughts generally occur in each third to fifth year, and depending on the intensity and duration may cause a yield decrease of different crops by 20-*60%. Droughts of 1992, 1995, 1998, 2000 and 2003 were especially severe. The last two resulted in the official proclamation of the natural disaster state. All counties of Croatia reported damages due to the natural disaster, and the verified drought damage to agriculture amounted to 1,406,088,741.02 kuna in 2000. In 2003, the damage due to natural disaster – drought was reported in the amount of 2.4 billion kuna, the total verified damage amounting to 2,020,560,000.00 kuna. Confirmed damages, regardless of the method of assessment and their correctness, raise the important question of to what extent and with which measures the damages could have been avoided – through common collaboration of agriculture and water economy.

Irrigation is certainly one of the measures that can reduce, and in some regions fully prevent, damages caused by drought. Unfortunately, it is a fact that there is not a single modern irrigation system in the Republic of Croatia that could be singled out as a good example. Model systems have to be sought in the neighboring countries, where our experts participated in their design. As regards the size of irrigated areas, Croatia holds one of the last positions in Europe. In the Republic of Croatia, irrigation is not applied in accordance with the actual needs for a number of reasons. One of the primary reasons is reorganization of agricultural production. Family farms, as the main carriers of agricultural development, are neither economically nor organizationally capable of undertaking construction of demanding systems. Nonetheless, agricultural producers are aware that in the production of some crops, particularly fruits and vegetables, they cannot compete with the increasing competition from abroad and therefore they buy irrigation systems independently and in an unorganized way. Systems bought by individual producers are not at a high technological level. Intakes of water are done individually and it is not possible to control its quantity or quality. This measure is approached in a totally unorganized way.

At the same time, the Republic of Croatia has large unexploited water potentials and potentially fertile soils suitable for irrigation and, on the other side, there is a great demand for agricultural products (now imported) and vast financial losses are suffered by the whole community as a result of insufficient irrigation during drought periods. All this points to the conclusion that the Republic of Croatia has all the basic preconditions for several times as much irrigation as today (Romić et al., 2003c).

Science and the profession are conducting numerous investigations and are stressing the need of sustainable irrigation, as the basis of this measure. The measure has to be approached in an organized way, which will enable a higher technological level of the systems. The way to organized systems, which could ensure rational utilization of all natural resources to the benefit of the whole community, should be accompanied by adequate legislation that would define the rights and the obligations of all participants. It could be achieved by implementation of the National Project for Irrigation and Agricultural Soil and Water Management (NAPNAV)


The irrigation impact on the maize growth in space sowing
Not irrigated maize
Irrigated maize


The impact of irrigation on soya growth in space sowing
Non irrigated soya
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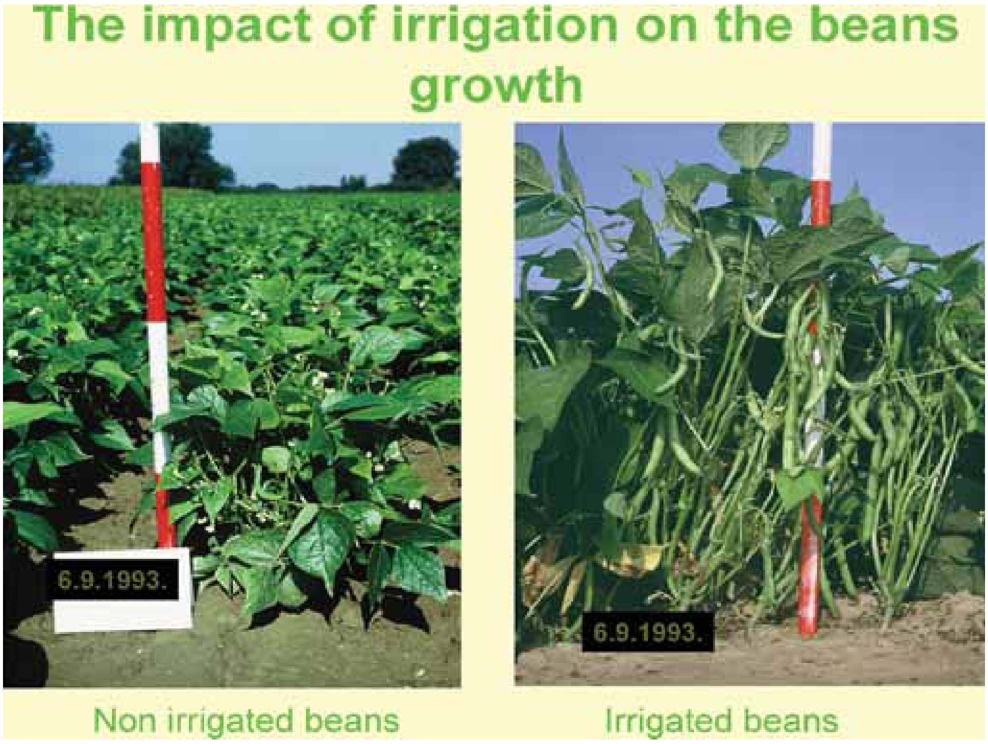

5. Sustainable Agriculture and Water Protection

Rational utilization of all available natural resources is the basic principle of the so called sustainable development of mankind. From the agronomic point of view, this does not only mean ensuring a sustainable food production but also taking care of the environment and human health, along with a satisfactory economic efficiency.

Agricultural production itself functions in a "symbiosis" between soil and water. In such circumstances, agriculture is both a ***cause*** and a ***victim*** of water pollution**.** Water passing over agricultural areas may get polluted by agents applied in agricultural production and thereby contribute to the pollution of surface and/or ground waters. At the same time, agriculture may be a victim of using waste or polluted surface and ground waters. The symbiosis in which agriculture functions imposes the need to find out the measures and procedures that should be applied to reduce the adverse impact of agriculture on water quality and thus protect the subsequent water users.

The negative influence of human activities on water pollution was recognized long ago. During the 1960s, a number of projects were started in the USA, Canada and Europe with the aim to diagnose the causes and find solutions for reducing water pollution from different sources, naturally including agriculture. They resulted in new scientific findings that clarified the problem and offered water conservation solutions. After that, many countries have issued special recommendations for the use of agricultural land, with special respect to water protection (*codices of good agricultural management*). Due to numerous instances of nitrate pollution, the European Union has issued ***Guidelines for Water Protection against Nitrates from Agriculture***. In some countries, the Guidelines were later extended so as to include phosphorus and pesticides. Groundwater underlying 22% of arable land in the EU contains nitrate concentrations above the statutory maximum allowable levels. Unfortunately, this also happens in some parts of Croatia with intensive agriculture, though much lower fertilizer and pesticide doses are generally used per unit area. Such regions are Međimurje, Podravina, part of Posavina, Neretva valley, generally in places with a shallow soil solum over the aquifer. Our science and profession are monitoring the state, searching for and suggesting solutions for conservation of water reserves. Thus, investigations into the effect of agriculture on the Lake Vrana water have been going on since 1995 in the Vrana basin. Results of these investigations indicate that the application of mulching and fertirrigation can influence a reduction of nitrate leaching. In the continental part of Croatia, researchers are investigating the effect of increasing mineral nitrogen rates on the growth and development of field crops, status of soil nitrogen and its leaching. Also, the research has been undertaken on drained soils, and the installed drainpipes are used to monitor nitrogen leaching. J The effect of irrigation and fertilization of field crops upon soil moisture dynamics and the possibility of nitrogen leaching has been investigated as well.

Croatian science is relatively extensively engaged on the problem of water protection; however, the ongoing investigations are not a result of some organized policy but rather of scientific curiosity of individual researchers. Besides professional and research work, the transition process from intensive to sustainable agricultural production should include a number of other prerequisites: legal regulations, control systems and, last but not least, producer education.

Conclusions

Water and water management activities have a great impact on agricultural development, which is the major strategic economic activity in Croatia. In countries with highly developed agriculture it has been confirmed that per an employed person in non-productive production of plant cultures there are 10 to 20 other employed people engaged on land organization and carrying on of accompanying laws and regulations, machine, equipment, vehicles production, construction of warehouses and facilities, manure and field crops protective means production, design and maintenance of hydro engineering facilities and systems, of traffic network, training of professionals and a series of other related activities. The timely construction and regular maintenance of hydro engineering facilities and flood protection systems, and timely drainage of excess surface and ground waters are the prerequisite of successful development of agriculture. High and stable yields on agricultural lands can be achieved only on areas with constructed irrigation systems. The average quantity of proper waters in Croatia is 827 m^3/s, and an average surface drainage hydro module is 14,63 l/s/km. An available quantity of proper waters in Croatia is 5.879 m^3/year/inhabitant. Unfortunately, the quantity and their temporal distribution of precipitations and available natural resources is often different from the agricultural needs and other water requirements (water supply of settlements and industry, power supply etc.).Therefore, the continuous collaboration of water management and agricultural professionals and researchers is highly recommendable to prepare and carry out plans, projects and programs of water and soil management in Croatia.

Under average conditions, plant production in Croatia utilizes from 10% to 14% of total water that precipitation brings to its continental part. Still, according to the overall quantity of captured water, which for animal production and irrigation amounts to a total of 55 to 70 million m^3, Croatia holds one of the last places in Europe. Croatian agriculture suffers great losses from extreme hydrological events – floods and droughts. Damages to agriculture incurred by droughts only are counted in billions of kuna. Great efforts should be made to reduce the damages done by extreme natural phenomena. Construction of hydro ameliorative systems should be continued while the existing ones should be adequately maintained. Pursuant to the recommendations of the profession, protection measures against water erosion in agriculture should be carried out in order to reduce degradation of agricultural soils and pollution of water.

Infrastructure for introduction of irrigation should be also provided in accordance with the ***National Irrigation Plan*** and soil and water management.

Croatia is also faced with the task of implementing and producing its own documents, with which it will regulate the complex relation between agriculture and water, as well as protection of water from agriculture. The way to the European Union imposes the need for many more activities in the subject sphere.

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State and Possibilities of Development Land Drainage Systems in Croatia

Abstract

This paper discusses the level of development of surface and subsurface drainage systems and their importance for achieving optimal water regime in agricultural fields. Also, there are evidences of insufficient maintenance of these systems which caused their malfunctioning. This paper also provides description of regular annual maintenance activities and their associated costs.

Public pressure on land drainage activities is getting significant in recent years due to its potential impact on the environment, especially on soil, water and biological diversity. In most of the European countries there are many ongoing researches aiming to find out a new approach to the development of drainage systems and their adjustment to increasing constrains and very restrictive legislation. The most important directives are Nitrates Directive (1991), FFH Directive (1992), Water Framework Directive (2000) and Flood Risk Management Directive (2007). Engineers are facing a challenging problem how to balance technical, economical and ecological tasks. The conventional channel design, conveyance and channel stability are now expanded with extra features such as non-uniform cross sectional profiles, meanders and inclusion of natural vegeta-

tion which increase the heterogeneity of depths and velocities and thus create diverse habitats. Subsurface drainage systems are considered to be the major paths of nitrates and phosphates to the watercourse and the possibilities of their development are within controlled drainage and subirrigation activities.

In the future land drainage systems are going to change and develop in a more ecological way while intensive enlargement of drained agricultural area cannot be expected.

Key words: surface drainage, subsurface drainage, environment, maintenance

1. Introduction

Depending on the terrain features of watershed areas and requirements towards optimal development, while also considering demand for high and consistent crop yields it is necessary to manage the water regime of agricultural areas. This goal is achievable by construction and regular maintenance of hydro-melioration systems for drainage and irrigation. Integral feature of such systems would be implementation of appropriate agro-technical measures and works in phase of land preparation and cultivation of certain plant species during vegetative phase.

According to the Law on water (Official Gazette 151/05), melioration drainage systems are group of water management structures and facilities for drainage of excessive water from agricultural and other land areas, which directly and indirectly facilitate faster drainage of surface or ground waters and ensure favourable conditions for land use and utilisation for economic and other activities. In this regard water management structures can be grouped into:

- Primary – melioration structures of I and II order which are included within melioration watercourses and main drainage channels, and pumping stations
- Detailed – melioration structures of III and IV order which include collecting (group) channels and detailed (parcels) channels as well as other structures on hydro-melioration system (circular and box culverts, sluice gates, siphons, water cascades, weirs and reinforcements of channel beds and banks)

Effective hydro-technical drainage systems ensure outflow of excessive surface and shallow ground water in due time, while systems for regular and additional irrigation ensure sufficient water quantities for optimal plant growth and development with the aim of high and stable plant yields. The main precondition for functioning of hydro-melioration systems is construction and frequent maintenance of hydro-technical structures for protection from flood water of both agricultural and other land areas. It is also important to carry out activities on continuous system maintenance – with the purpose of maintaining required water regime and rational management of agricultural land.

2. Basic indications on degree of completeness of hydro-melioration drainage systems

Considering needs and demands for optimal development of plant cultures in Croatia the current degree of hydro-melioration structures and system completeness is not satisfactory. This is the consequence of lack of continuity in implementation of development programmes in water management and agricultural sectors – both in former Republic of Yugoslavia and in present Republic of Croatia.

Unfortunately between year 1991 and 2005 no reparcelling of land was performed nor the construction of hydro-melioration structures and systems in fields of surface and ground water drainage and irrigation. Within completion of document entitled Foundations of water management strategy in Croatia (2004.) data was systematised for 34 water management branches within 5 water management departments of Croatia Water Authority – this was carried out in accordance with relevant data for watersheds, or actual melioration areas in Croatia in year 2001.

The results of obtained data systematization are shown on Fig. 1 and Fig. 2.

Irrigation system was developed only on about 2% or 9.000 ha

From year 2001 to the present day, significant improvements in development of hydro-melioration systems was achieved only in area of irrigation due to intensive activities on implementation of "National irrigation and management plan for agricultural land and waters in Republic of Croatia" (2005).

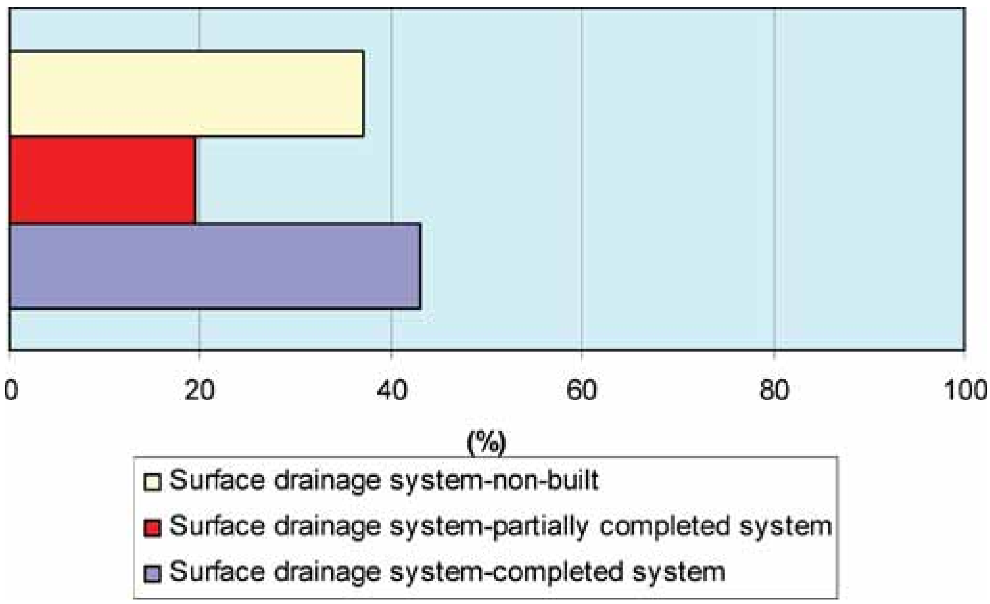

Fig. 1 – State of development of surface drainage (2001)

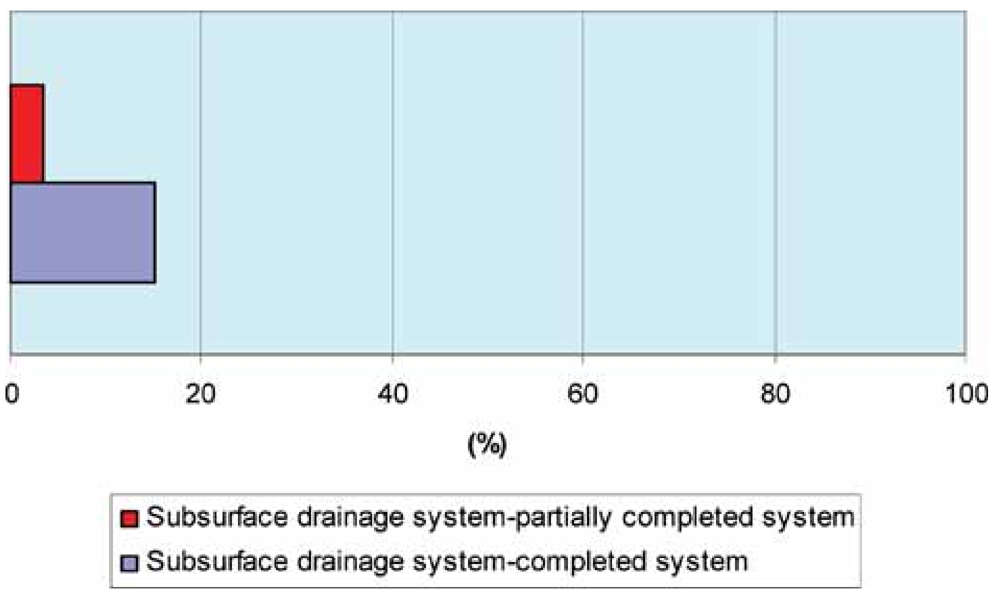

Fig. 2 – State of development of subsurface drainage (2001)

Besides the degree of completeness of surface and ground water drainage system, the other important activity is the maintenance of existing systems. The consequences of insufficient maintenance of surface channels may have influence the following:

- Ineffectiveness of the entire system;
- Increased risk in case of flood waters;
- Non-functioning of ground water drainage systems; and
- Absence of principal preconditions for more intensive implementation of irrigation.

Intensive activities on establishment of operational state of detailed channel network have started in year 2005, and until the end of year 2007 total of 30% of entire network was cleared. After the entire detailed network was brought into functional state, the responsibility for their further maintenance should be taken by respective Counties (Strategy of water management, approved by Croatian Parliament on 15th of July 2008.) Figure 3 shows the degree of functionality of surface drainage systems which for individual counties ranges between 10% and 100%. The improvement in degree of maintained area is significant, but still coun-

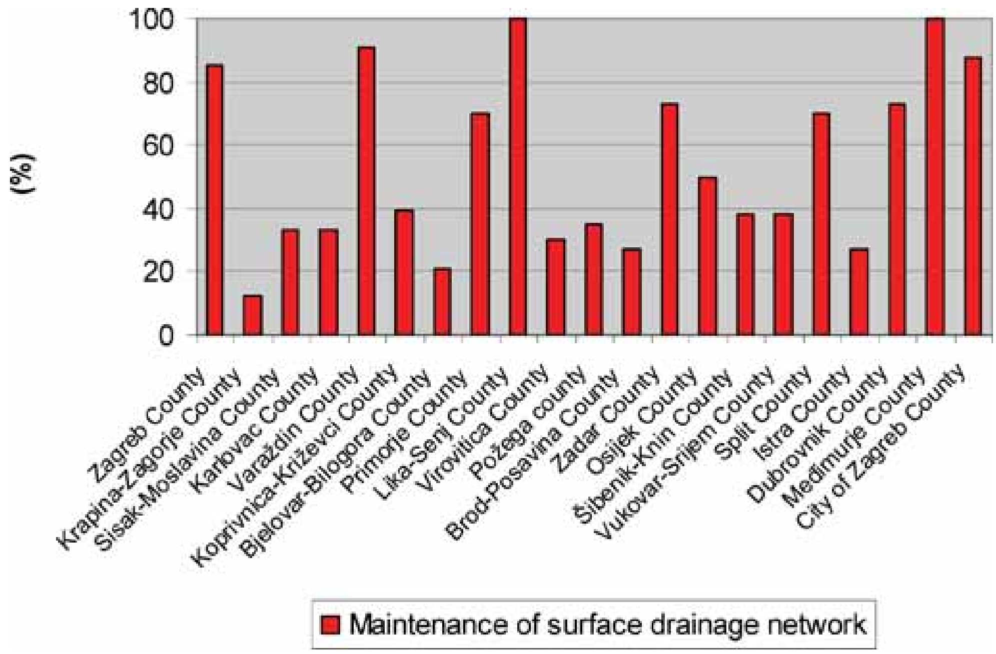

Fig. 3 – Degree of maintained surface drainage systems (2005)

ties with major agricultural areas (Vukovar-Srijem and Osijek-Baranya counties) have maintenance coverage degree of less than 50% which causes major problems during periods of high waters (Fig. 4).

Fig. 4 – Illustration of surface drainage maintenance

Apart from mentioned problems related to degree of completeness and maintenance of hydro-melioration systems of irrigation, it is important to mention their potential impact on environment, especially the process of surface water eutrophication by introduction of nitrates.

Intensity of dispersed pollution from agriculture is dependent on size of land parcel, category of landuse, amount of applied nourishment and soil type. The greatest burden from dispersed pollution is present on watersheds of Drava and Danube, and on proximate watershed of river Sava. In this areas the estimated pollution varies in range of 100 – 120 kgN/ha (Strategy of water management, 2008).

3. The development of hydro-melioration drainage systems in Croatia

Further development and improvement of hydro-melioration irrigation systems has to be performed with mutual and coordinated activities of both agricultural and water management sector.

By cooperation it will be possible to initiate gradual redevelopment of derelict systems for melioration drainage, and to encourage their development in accordance with planning documents, needs and financial abilities of agricultural producers and to meet the needs of flood protection of housing areas from inland waters. It is proposed to systematically stimulate merging of agricultural land which removes obstacles for efficient functioning and development of melioration drainage systems. Channel networks and other structures within system of melioration drainage are condition for development of irrigation therefore the future development of those two disciplines has to be viewed in conjunction. Bringing of detailed channel network into functional state will enable efficient implementation of “National project of irrigation and management of agricultural resources and waters”.

The condition for efficient functioning of melioration drainage system je appropriate protection of meliorated areas from outside flood waters as well as frequent economic and technical maintenance of water management structures for melioration drainage. Management of dispersed pollution sources form agriculture has to be implemented in accordance with Nitrates directive and Directive on dangerous substances, in other words it will be governed by “polluter pays” principle. Nitrate directive governs the following obligations: harmonization of legislative framework in water protection sector, setting up of pollution monitoring, planning of protection measures, establishment of good agricultural practices and reporting system. Planned measures will be accomplished through cooperation of agriculture and water management sectors. Areas sensitive to eutrophication and vulnerable areas will be established through special decree which will restrict discharge of wastewaters from sewer systems and introduction of nutrients from the agriculture. Areas sensitive to eutrophication and vulnerable areas will be established by water management in accordance with provisions of water directives (Strategy of water management, 2008).

4. State of drainage systems in European Union countries

The existing systems for surface drainage which were developed through past decades are currently in difficult situation. In fact, environmental protection and great pressure on agriculture in regard to its impact on environment – water, soil and wildlife bring the future of hydro-melioration systems into question. From the other point of view they became the part of cultural heritage of lowland area in many countries of Western Europe and integral part of landscape. In recent years many restrictive directives were introduced, such as Nitrate Directive (1991) according to which the final goal is reduction of nitrite quantities in all waters is to less than 50 mg/l, FFH Directive (1992) which aims at improvement of biodiversity and Water Framework Directive (2000) which aims to reach good qualitative and quantitative state of surface and ground waters. This enables creates a need for adjustment of technical, economical and environmental requirements:

- TECHNICAL REQUIREMENTS – hydraulic and geomechanical characteristics (stability) sustainable over time (maintenance)
- ECONOMICAL REQUIREMENTS – cost-benefit analysis including functionality of system
- REQUIREMENTS FOR ENVIRONMENTAL PROTECTION – water quality has to meet WFD criteria (deadline for enforcement is year 2015), while channels have to arranged and maintained in accordance with environment (Lübbe, 2008)

This is not an easy task. The first two conditions are applied in engineering practice for many years, while introduction of environmental protection requirements change the basic principles of melioration systems for surface and ground water drainage, which is the collection and drainage of surplus waters from meliorated area with the aim of achieving of optimal soil moisture content. One of the means of meeting environmental protection criteria is application of controlled drainage which means retention of water within system by using system of gates. This enables longer retention periods of water within meliorated area, reduces the need for irrigation, and in cases of lighter soil types enables use of sub-irrigation. Such systems require very developed means of management on a daily basis. Furthermore, water which is drained by channel to the recipient may be held in system using constructed wetland systems for purification. In this way water which still contains certain fraction of nitrates is brought back on agricultural land by being captured as irrigation water. Unique problem poses sediment removal from the channels as a part of their maintenance, which may be heavy contaminated by unwanted chemical compounds. It is common practice to dispose dredged sediment along banks of channel or its disposal on agricultural areas. Only recently it has been introduced to establish the chemical properties of dredged sediment prior to its disposal on agricultural land. In the case of high concentration of pollutants in sediment there is a requirement for its disposal on special landfill sites which incurs additional costs (Rekolainen, 2008).

Conditions for protection of environment requiring more natural positioning of channel and ensuring of growth of different types of vegetation which provide possibilities for development of habitats favourable for improvement of biodiversity have induced a number of hydraulic researches. Conventional channels were aimed at ensuring appropriate flow and stability of channel. Additional requirements aim at uneven cross section, meandering and variable depths of channels which will determine different vegetation cover along channel. Considering the fact that drainage channels and small waterways in cases of flooding have to discharge great amounts of water from endangered area, these requirements resulted in significant hydraulic investigations. Those researches are aimed at investigating impacts of vegetation on flow resistance, morphology of channel, transport of sediment and pollution. Until now, concluded researches showed very interesting results in respect to influence of vegetation within channel on flow velocities where hydraulic properties of channel (depth to width ratio, hydraulic radius and depth of channel) have much less influence on flow resistance than roughness of channel.

5. Conclusion

In Croatia as well as in European Union countries in the future it may not be expected to have significant development of hydro-melioration systems for surface and ground water drainage but only their maintenance. Croatia has a primary task to bring maintenance degree of surface drainage to the level which will ensure sufficient safety during emergence of flood waters and which will ensure functioning of irrigation systems.

Adaption to legislative frameworks which aim at overall environmental protection creates additional costs for maintenance and monitoring of water quality.

New trends in approach to surface drainage induced many hydraulic and eco-hydrologic investigations in European countries with the aim of meeting the required technical, economic and ecologic requirements.

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County Irrigation Plans

as basic documents for implementation of the National Project of Irrigation and Land and Water Management in the Republic of Croatia (NAPNAV)

Summary

The adopted National Project of Irrigation and Land and Water Management in the Republic of Croatia (NAPNAV) takes under consideration the potentials and limitations of irrigation development. The spatial analysis of available land, water resources and spatial limitations (protected areas, water protection and mined zones) has been carried out. The preparation of county irrigation plans together with the initiation of pilot projects form the first phase of the NAPNAV implementation. The contents and structure of county irrigation plans generally follow the NAPNAV, i.e. primarily consider land and water potentials and limitations on county level. After analyses have been carried out, county irrigation plans rank priority areas for irrigation development within county and nominate new development projects. The plan development starts with the definition of the Terms of Reference and their content, in which hydrotechnical / civil engineering, agricultural and physical planning experts take part. Reviewers and expert advisers from the ranks of renowned experts from the stated fields are actively involved in the preparation of this planning document. County irrigation plans form an integral part of physical planning documentation of each county and are, as a specialist segment, fully harmonized with adopted physical planning solutions. In this manner, a physical planning base is established for simple implementation of proposed development projects, i.e. obtaining of location permits in a short time frame. This paper offers an overview of county irrigation plans that have been developed to date, their structure and contents as well as the usual course and manner of preparation. Additionally, an overview is given of the developed plans' results as compared with the NAPNAV results, of public hearings and adoption of plans as well as of identified priorities in the course of development of individual projects. Finally, comments are made on the observed problems and shortcomings of the plans developed to date, i.e. proposal of methods and procedures for their novation and update in view of the implementation of the entire NAPNAV.

Key words: NAPNAV, county irrigation plan, land and water potentials, limitations and priorities of irrigation system development, irrigation system development projects

1. Introduction

Based on the size of its irrigated surfaces, the Republic of Croatia is among the last countries in Europe. The number of existing irrigation systems and total surface included in some form of irrigation in Croatia show that it is implemented to the extent that is barely necessary. The available quality of soil and abundant water resources in Croatia indicate the need for construction of new irrigation systems. In this manner, conditions will be created for the development of an efficient, economically feasible agricultural production; in other words, they will facilitate efficient, stable agricultural production under conditions of ever more frequent and longer draught periods. It is exactly the more frequent appearance of draughts and great damages they inflict on agricultural production that significantly influences the feasibility of construction of irrigation systems as capital state investments into infrastructure.

The above said and the lack of competitiveness of today's agricultural production due to a low technological level of production, small surfaces and low yields lead to the development of the project entitled: "*National*

Project of Irrigation and Land and Water Management in the Republic of Croatia (NAPNAV)". The development of this project was entrusted to Croatian experts lead by the Faculty of Agriculture and the Faculty of Civil Engineering of the University of Zagreb. About 30 leading Croatian agricultural and hydrotechnical experts participated in its preparation. Following the widespread public and expert discussions, the document was adopted by the Government of the Republic of Croatia in December 2005. For purposes of supervision of the Project implementation, a National Team headed by the Prime Minister was appointed, whereas for operational implementation the sectoral minister appointed an Expert Team comprised of experts from entire Croatia.

The main goal of the NAPNAV in terms of strategic basis for its implementation is as follows:

- to analyze and quantify potentials for systematic introduction of irrigation into the Republic of Croatia;
- to assess expected effects of economic and socio-economic aspects and to define rights and obligations of all participants in the system;
- the document should serve as a quality planning basis for introduction of irrigation systems, construction of infrastructure and implementation of production plans for agricultural crops in new conditions of organized and supervised implementation of irrigation.

Special goals of the NAPNAV can be divided into short-term and long-term and elaborated as follows:

- Short-term goals: development of county irrigation plans, modification of legislation, design and construction of pilot projects;
- Long-term goals: overview and ranking of additional irrigation projects to be implemented on the territory of Croatia, definition of organization and set-up as well as status of institutions for project planning, construction, use, maintenance and monitoring, proposal of introduction dynamics of systematic irrigation in Croatia by 2020.

By studying data on existing surfaces which are already irrigated within the Croatian counties, it is evident that irrigated surfaces are unevenly distributed and vary in their share in the total available agricultural land. The earlier quoted data indicate that it will not be possible to develop irrigation evenly on the entire territory of the Republic of Croatia. In other words, it is necessary, based on the adopted NAPNAV methodology and goals, to develop county irrigation plans. These documents are planning documents which should primarily assess natural resources, define priority areas for irrigation, assess scope of projects and determine socio-economic impacts of construction and implementation of irrigation systems.

2. County irrigation plan

Pursuant to Art. 45 of the Water Act, irrigation systems whose construction is financed or co-financed by funds from the state, county, town or municipality budgets are the property of the counties. The county is responsible for management, technical and economic maintenance of the ameliorative irrigation system, which it carries out according to the program enacted by the county assembly. From these quoted legal provisions from the current Water Act as well as from the NAPNAV guidelines, it is obvious that counties are at the centre of the process of planning, design, construction and maintenance of irrigation systems.

The county irrigation plan is the central planning document, i.e. its development and implementation form the Phase I of the NAPNAV implementation. To define the contents and form of this planning document, counties establish County Working Groups comprised of experts from the Ministry of Regional Development, Forestry and Water Management, Hrvatske vode and county departments which deal with the issues of agriculture, utilities and physical planning. The primary task of these working groups is to define the terms of reference necessary for developing county irrigation plans, conduct selection of plan developers and reviewers, ensure necessary existing baseline maps and data, coordinate and monitor development of plans, conduct public hearings and expert discussions about plans, inform potential end users about the contents and solutions proposed in plans and, finally, carry out the procedure of plan adoption by county administration and county assembly. Following plan adoption, this working group continues working on the implementation of adopted plan phases.

The main contents of a county irrigation plan are defined by the NAPNAV, whereas its elaboration and the level of selected maps and solutions should to be defined in the terms of reference necessary for the plan's development. Thus defined starting points resulted initially in different approaches to the development of the ToRs for individual plans. The experience gained during the development of the first county irrigation plans greatly added to the unification and standardization of the contents of all plans, with the consequential increased costs of development, but also enlargement and completeness of each plan, particularly in terms of the processing level for the existing and new data related to soil and water resources as well as the solution for adopted phase of further implementation of the plan.

A standard county irrigation plan is comprised of the following main chapters:

- Available water resources, soil resources and surface of areas suitable for irrigation
- Water demad for irrigation
- Limitations to development of irrigated areas
- Environmental protection and the concept of sustainable water use in irrigation
- Analysis of past plans and projects related to irrigation
- Proposal of irrigation plan

with the concept of sustainable use of water and land having the overall dominance over the general plan.

In terms of available water resources, soil resources and surface of areas suitable for irrigation, water balance is the basis for irrigation development in the region. Available water resources are the main factor which determines irrigation development in a region, while taking into account the existing hydrography of the terrain and the characteristics of land development in the area. Water demand for irrigation defines expected quantities with regards to water balance necessary for implementing of irrigation on a suitable surface in the entire area. Limitations to development of irrigation in an area are limitations to the implementation of irrigation in certain locations with regards to water availability, possibilities of its distribution, characteristics and conditions of soil, areas protected for other purposes such as protection zones for water abstraction for drinking water supply, infrastructure limitations, protected nature or monument areas, etc. Environmental protection and sustainable water use for irrigation are inevitable in terms of protection of water, soil and ecological products on the soil and are a prerequisite for implementation of irrigation. A disruption of environmental factors due to irrigation cannot be allowed and it is of primary importance to ensure the protection of groundwater and surface waters. The analysis of past plans and projects also contains an overview and a critical review of earlier irrigation plans in a region by taking into account the current priorities and global plans for a region which may have an influence on the implementation of irrigation. An irrigation plan proposal is a result of the above mentioned factors and should ensure a phased planning basis for irrigation's global development in a region and simultaneously serve as a basis for determining financial implementation of irrigation in a county.

The plans are developed on the conceptual level which includes spatial and technical definition of locations and applicable methods of water abstraction and distribution, while detailed project documentation will be developed for individual microlocations i.e. pilot projects proposed and adopted for implementation through plan adoption procedure. The irrigation plan is processed and presented on the same baseline maps which are normally used for county physical plans (1:100.000 and 1:50 000). Sketches and drawings are defined on the conceptual level, with the aim of defining necessary costs and clarifications of technical solutions. The development of a plan is based only on data and projects available to the county, Hrvatske vode and other entities, thus separate field investigations are normally not planned, only field visits.

The final form and contents of an irrigation plan are normally defined by the following:

1. INTRODUCTION

2. GENERAL ELEMENTS OF THE PLAN
   - 2.1. Reasons for irrigation of the area
   - 2.2. Characteristics of the area
   - 2.3. Economic basis for project implementation
   - 2.4. Past studies and investigation works in the field of land planning and irrigation – evaluation
   - 2.5. Scope of the plan
   - 2.6. Social basis for the plan
   - 2.7. Conclusion

3. GENERAL CHARACTERISTICS OF THE AREA
   - 3.1. Introduction
   - 3.2. Agroecological conditions for production – climate, hydrology, hydrography, pedology, water quality
   - 3.3. Agricultural and economic conditions for production
   - 3.4. Infrastructure and institutions of importance to the plan
   - 3.5. Past development programs and fitting into projects of greater scope and physical plans

4. TECHNOLOGICAL AND OPERATIONAL BASES FOR PLANNING OF IRRIGATION
   4.1. Introduction
   4.2. Assessment of present state of agricultural production
   4.3. Organization of irrigation area
   4.4. Expected water needs in the new sowing structure
   4.5. Applicable irrigation systems
   4.6. Assessment of available water for irrigation – water balance
   4.7. Risk analysis with irrigation implementation

5. PROJECT BASIS
   5.1. Project basis for implementation of irrigation
   5.2. Distribution of water to users – alternatives
   5.3. Concept of the plan
   5.4. Preparation of land for use in irrigation
   5.5. Other infrastructure
   5.6. Provisional costs of project implementation

6. MAINTENANCE AND MANAGMENT
   6.1. Organizational basis for operation & management of the water distribution system
   6.2. Technical basis and training
   6.3. Organization of monitoring and control of water and soil status for introduction of irrigation

7. PROPOSAL OF FURTHER ACTIVITES ON THE PLAN IMPLEMENTATION
   7.1. Proposal of irrigation pilot projects
   7.2. Proposal of necessary investigation works
   7.3. Overview of priorities for implementation of irrigation

8. BENEFITS AND SUSTAINABLE USE
   8.1. Entities in the plan implementation
   8.2. Expected benefits and economic indicators for the plan implementation
   8.3. Sustainable use of natural resources

In the course of development of the plan, the most frequently applied principle is the principle of active review, which means that there is a constant contact of developers, reviewers and the working group in the county, i.e. review of finished parts of the plan per phases. In this manner, the time necessary for adoption of the final version of the plan is shortened, potential problems and disputable issues are more easily noticed and solved during development and the integrity of the whole procedure is achieved. During development, it is frequent that the greater community (cities/towns, municipalities and potential users) is included already in the first phase. Also standardized is the procedure of conducting a survey among potential users and within the local self-government with the aim of collecting data on the actual interest and development potentials for irrigation on the previously defined agricultural surfaces.

In the last phase of the plan development, a series of presentations is held for the general public, experts and future users. Finally, after the final review and preparation of the plan summary, its presentation and adoption of the plan by the county administration and assembly, such adopted county irrigation plan is published in the official journal of the county.

3. Development and implementation dynamics of county irrigation plans

The Republic of Croatia is comprised of 20 counties and the City of Zagreb, which has the status of a county. The development of irrigation plans or novation of the existing ones (in the counties of Istria, Međimurje, Požega – Slavonia) started simultaneously with the preparation of the National Project of Irrigation and Land and Water Management. In this manner, the first irrigation county plans harmonized with the methodology of the NAPNAV were adopted already in 2005. To date, 17 county irrigation plans were developed and adopted, the development of two plans is under way, while two counties are refusing to develop the plan even after repeated invitation to cooperate. The plan development is co-financed by Hrvatske vode, funded by the Ministry of Regional Development, Forestry and Water Management in the amount of 50% of the value of works, while the remaining 50% is secured by the county. The value of works on the plan implementation is approximately 1,000,000 kuna, and the developer is selected through a public tender. To date, Croatian design firms, supported by the civil engineering and agricultural institutions of higher learning, have taken part in the development of county irrigation plans. The overview of counties which developed or are developing their irrigation plans are given in Fig. 1.

Fig. 1 – Overview of development dynamics for county irrigation plans

In the process of irrigation plans' development, the technology used was the GIS technology for presentation and linking of spatial data and information, which corresponds with the procedure used in the development of the NAPNAV. Spatial analyses of the potentials of agricultural soil and water resources were developed in smaller scale, thus the maps produced in this manner are more reliable and accurate than those obtained for the NAPNAV. On the example of data comparison obtained from digital maps, soil suitability from individual county plans and data obtained through processing in the framework of developing the NAPNAV, differences in some categories of agricultural land can be observed.

Available comparable data for 16 counties are shown in Table 2. The comparison shows minor deviations in the total analyzed surface, with larger deviations within individual suitability classes, which confirms the correctness of the conducted procedures and analyses, i.e. a greater reliability of data was obtained through processing and analyses conducted for county irrigation plans. When the development of all county plans is finalized, an integration procedure of all county data on the level of Croatia should be carried out. Thus, due to a greater reliability of data obtained through county irrigation plans, the accuracy of analyses on the level of Croatia would be improved and the novation of the NAPNAV for this segment per-

Table 2

No.	COUNTY	SUITABILITY CLASSES*					
		I		II**		III**	
		NAPNAV	COUNTY PLAN	NAPNAV	COUNTY PLAN	NAPNAV	COUNTY PLAN
I	Zagreb County	16.030,10	37.434,00	27.174,40	27.335,90	19.956,40	74.644,60
III	Sisak – Moslavina County	21.901,80	19.906,50	8.250,00	14.948,50	28.834,60	96.245,30
VI	Koprivnica – Križevci County	23.997,50	15.488,80	39.950,10	45.129,00	7.231,90	21.087,20
VIII	Primorje – Gorski Kotar County	414,90	190,20	8.917,80	8.643,60	12.956,10	9.138,20
IX	Lika – Senj County	688,60	2.811,60	4.440,30	6.449,70	43.968,00	40.371,70
X	Virovitica – Podravina County	17.022,90	23.211,10	25.598,00	23.204,80	5.911,10	19.466,00
XII	Brod – Posavina County	21.715,60	19.964,20	21.793,70	29.740,80	13.544,50	26.501,20
XIII	Zadar County	952,00	15.688,60	4.869,60	11.938,40	63.012,30	50.458,60
XIV	Osijek – Baranja County	49.885,10	118.058,50	121.734,80	42.004,20	5.466,30	112.717,40
XV	Šibenik – Knin County	919,90	7.588,90	487,50	9.840,10	44.590,70	41.727,70
XVI	Vukovar – Srijem County	44.856,70	68.389,70	70.371,60	27.283,60	3.609,50	41.630,20
XVII	Split – Dalmatia County	7.029,40	5.118,90	7.266,70	14.579,80	61.856,00	74.967,60
XVIII	Istrian County	2.181,70	2.181,70	64.545,80	64.545,80	21.313,90	21.313,90
XIX	Dubrovnik – Neretva County	4.679,40	4.679,40	4.909,70	4.909,70	13.192,60	13.192,60
XX	Međimurje County	8.103,70	29.098,40	33.891,90	1.995,30	1.505,20	18.392,90
XXI	City of Zagreb	8.148,90	5.877,00	3.032,50	2.423,00	4.841,50	10.782,00
TOTAL IN RoC:		228.528,20	375.687,50	447.234,40	334.972,20	351.790,60	672.637,10

SUITABILITY CLASSES*				TOTAL	
IV		V**		NAPNAV	COUNTY PLAN
NAPNAV	COUNTY PLAN	NAPNAV	COUNTY PLAN		
101.389,20	14.405,60	3.448,30	19.447,80	167.998,40	173.267,90
107.845,30	34.486,70	1.858,10	16.553,70	168.689,80	182.140,70
33.790,80	21.473,40	11,40	80,60	104.981,70	103.259,00
	358,00	63.580,20	107.720,70	85.869,00	126.050,70
6.472,00	6.767,00	141.351,30	109.628,00	196.920,20	166.028,00
78.989,60	54.403,40	22,10		127.543,70	120.285,30
68.446,50	32.746,20	258,30	5.632,80	125.758,60	114.585,20
5.379,40	8.852,50	207.335,90	129.234,60	281.549,20	216.172,70
128.913,70	4.155,20	5,30	913,20	306.005,20	277.848,50
3.785,10	1.889,60	190.317,80	135.444,70	240.101,00	196.491,00
49.585,90	25.426,70		1.042,10	168.423,70	163.772,30
1.973,80	3.337,30	133.644,50	119.663,30	211.770,40	217.666,90
3.147,90	3.147,90	55.991,00	55.991,00	147.180,30	147.180,30
4.852,70	4.852,70	64.001,30	64.001,30	91.635,70	91.635,70
13.088,00	4.341,60			56.588,80	53.828,20
14.444,90	2.745,00	2.499,20	4.765,00	32.967,00	26.592,00
622.104,80	223.388,80	864.324,70	770.118,80	2.513.982,70	2.376.804,40

formed, which is the reason why all county irrigation plans in Croatia should be developed, even if some counties do not wish to do it.

The most important part of each county irrigation plan is the selected pilot project or the list of priority irrigation projects whose implementation, if the end user is identified, is expected in the short-term period (up to 5 years). Through developed county irrigation plans approximately 50 pilot projects and priority irrigation systems are identified, whose design and construction should be implemented in the short-term period. These projects encompass about 40,000 ha of agricultural land, which, along with the surfaces included in the four national pilot projects, equals approximately 50,000 ha of the future irrigated surfaces.

Overview of included projects and their location within the counties is shown in Fig. 2.

The estimated value of the needed investments into design and construction of the stated irrigation system projects is about 1.5 billion kuna. In the period from 2005 to 2009, 12.94 million kuna were invested into the development of county irrigation plans.

Fig. 2 – Spatial distribution of county pilot projects and priority projects according to developed county irrigation plans

4. Conclusion

The development of county irrigation plans which, together with the national pilot irrigation projects, form the first phase of the NAPNAV implementation meant not only the creation of the planning basis necessary for the determination of potentials and priorities for irrigation development in a county, but also served the purpose of informing the general public and agricultural users about the possibilities and needs of irrigation system development in the framework of a new concept of agricultural development in Croatia. In terms of planning, physical plans facilitated the construction of capital hydrotechnical facilities (reservoirs, pumping station, pipelines, etc.) necessary for development of the irrigation system. Through expert discussions and public hearings carried out during the plan development and its adoption procedure, the circle of agricultural producers interested in the construction and use of new irrigation systems in counties is spreading. By adoption of a county irrigation plan and its publication in the county official journal, the planning and legal frameworks for phased design and construction of new irrigation systems are created. In ending the presentation of issues of development and adoption of county irrigation plans, the aspect of their dynamics should be also emphasized; in other words, the need for regular updates and novations of input data, results and adopted priorities of irrigation development in individual counties. This is particularly important when one considers the connection between a county irrigation plan and physical planning documents as well as other socio-political conditions which affect the implementation of all planned and adopted solutions.

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Determination of Optimal Water Storages in the Accumulation for the Irrigation Requirements

Summary

The disposal of suitable water quantities is the main pre-requisite of the irrigation system intended to make up for possible water shortages in agriculture. As such pre-condition is not often existing in the natural hydrological regime, the accumulation's construction can make up for the required water storage. There are several methods developed basing on climatologic parameters, and particularly on the data on precipitations in the vegetation periods determining irrigation water requirements. The lower the precipitation amounts, the higher are the irrigation water demands. The fact that precipitation's nature is of stochastic character points at the probabilistic approach for determination of needed irrigation water requirements. The construction of accumulation for water storage involves certain annual expenses, e.g. the annual investment, maintenance and usage expenses rising with the needed water which is going to be accumulated. On the other hand, the agricultural researches indicated that the specific crops increase of irrigated agricultural items per used water unit is the lower the more we satisfy 100% the irrigation water requirements. This fact and the stochastic character of the precipitations impose the issue of comparison of accumulation's annual expenses and the benefits from the irrigation at different supplying degrees, e.g. with different water storage amounts for irrigation requirements. The paper describes a probabilistic procedure of determining the optimal degree of water storage for the irrigation based on economic criteria. The paper also addresses the issues referring to determination of optimal construction size of multipurpose accumulations taking into account current water management trends of multipurpose accumulations construction.

Key words: irrigation, evapotranspiration, precipitations, irrigation norm, water storage, accumulation, safety degree, annual expenses, irrigation benefits.

Introduction

The available water quantities are surely the key factor responsible for possibilities of implementing irrigation for agricultural purposes and mitigation of increasingly recurrent drought consequences. As total water quantities in any observed area are not at the same time the all available water quantities to be utilized, it is necessary to determine both the annual precipitation regime and the runoff water regime. The part of those waters naturally runs off from the observed area within the hydrological cycle frame. The National Irrigation Project (NAP-NAV, issued in 2005) pointed at requirements for large water quantities in Croatia. On the other hand, the Strategy of Water Management in Croatia, issued in 2008, mentions great water riches of Croatia. From the aspect of required water quantities for development of agriculture in the vegetation period, and particularly during droughts such riches are not satisfactory at all. Some hydrological analyses of low waters periods indicate that in the natural conditions, and particularly during droughts there are no adequate water storages, with the exception of some constructed multi purpose accumulations planned for irrigation as well. The ecologically minimal required discharge necessary for survival of aquatic and aquatic-based eco systems is here of special significance. Basing on the definition of the drought itself *(climatological, hydrological, agricultural drought)* and on the ecological minimum, we come to the conclusion that the ecological minimum is not met in the drought period. Therefore is the development of water resources the pre-requisite for the implementation of the National Irrigation Project in Croatia. It implies also the works and facilities contributing to the "improvement" of existing natural water regime, so as to retaining water quantities during their abundance in order to dispose of them in the time of need. It can be mostly achieved through the construction of surface and (rarely) underground accumulations. In the course of preparing the Strategy of Water Management in Croatia even 318 potential locations for the construction of surface accumulations of quite different sizes were determined. Moreover, the power utility company listed in its plans even 61 locations for potential accumulations construction. Many of them should dispose of water storages for irrigation. Their construction size is going to depend directly on such water storages. This paper addresses a case of such estimation procedure concept for optimally required water quantities for irrigation.

Basis for determining required water quantities for irrigation

A determination of required water quantities for irrigation is based on temporal and spatial analyses of irrigated area's water balance. The main parameter to be identified is the evapotranspiration. A large number of evapotranspiration estimation methods have been developed by different authors throughout the world for design and irrigation system operation. Many of them are still in use today *(e.g. Thorntwait, Blaney-Criddle, Penman-Montieth).* The implementation of those methods requires, depending on the author's principles, different climatologic, meteorological, pedologic and other data.

Nowadays, a CROPWAT computer programme is being most often used in the world for determining of evapotranspiration and required water quantities for irrigation. The programme has been recommended by the FAO experts. It was developed in 1992 and published in FAO Irrigation and Drainage Paper No. 46, [15]. Today it is available on the Internet address *http://www.fao.org/waicent/faoinfo/agricult/aglw/cropwat.htm* In Croatia it was featured in the Handbook for Irrigation and Drainage in Hydro engineering, II volume, book 5 (*Romić and authors 1996*), [8]. In addition to the calculation of evapotranspiration and required water quantities for irrigation, such a programme enables the elaboration of the timetable of several vegetation cultures' irrigation, and defining of irrigation system needs dynamics. To implement the programme the climatologic, pedologic and agricultural data are required. The programme requires the data on temperature and relative air humidity, data on precipitations (daily, ten-day period, monthly), data on daily insulation duration, and data on wind velocity and crop rotation. Geographic data on meteorological station *(geographic coordinates and altitude)* are also necessary. The irrigation dynamics determination includes also data on soil, e.g. the rooting depth, field capacity and initial soil humidity.

On the basis of mentioned data types the programme calculates a series of indicators needed for design and utilization of irrigation system, with the most important indicators such as evapotranspiration of cultivated plants *(calculated according to Penman-Montieth) and* effective precipitations (P_{ef}), e.g. the part of precipitation left for evapotranspiration after the loss of precipitation water as a result of interception, surface runoff and percolation of the precipitation part into deeper layers down to ground water. A difference between the estimated evapotranspiration of cultivated plants and effective precipitation presents their water requirement. Depending on the great quantity of available precipitation data, the vegetation culture's water demands can be estimated as daily, ten-day, or the monthly requirement. The sum of those needs for the whole vegetation period is called the irrigation requirement. The above mentioned meteorological data can be provided from DHMZ, which conducts required measurements at 139 climatologic and 418 precipitation stations in Croatia [16], [17].

Basis for solving the issues of water storage supply

The pre-requisite of water storage supply for any purpose exists in Croatia's water abundance. However, the conditions for their utilization should be developed. It particularly refers to irrigation as the world's largest consummation aspect, which is not the case in Croatia. The Croatia's water riches might be listed as the major, and perhaps the most important strategic resource of its complete future development. The quantification of such riches was estimated by the computation of hydrologic balance in the framework of the Croatian Water Management Strategy's preparation. The balance computation was conducted for 16 gathered catchment units and Adriatic islands basing on data on average annual precipitations in Croatia, and hydrometric data on discharges at control entrance and exit profiles of border and cross-border watercourses. The calculation used the data from the period between 1961 and 1990. The balance shows Croatian water abundance at the level of mean hydrologic indicators. As it was mentioned in the Introduction, some rough estimations based on preliminary hydrologic analyses of low waters periods *(Trninić, D. 199 and 1998.)* [13], point at inadequate water supplies needed for irrigation in natural conditions during low waters periods and particularly during droughts. Therefore is the construction of accumulations necessary for water supply storages.

During the NAP-NAV elaboration and the preparation of the Water Management Strategy the data on existing and planned accumulations and detention basins were collected. Table 1 shows a total number and volumes of existing accumulations according to water districts in Croatia, and Figure 1 presents locations of planned accumulations.

The introduction has already pointed out that the water management identified even 318 potential locations for surface accumulation construction of very different sizes, and 61 locations listed in the power utility's plans. In addition to accumulations, a few detention basins were built *(9 +19 in the Zagreb area)*, and 75 detentions basins for flood protection are scheduled for construction. In many cases there are opportunities for

Table 1 – Existing reservoirs per river basin districts in Croatia
author: Petraš, J. (2005)

VODNO PODRUČJE RIVER BASIN DISTRICT	Hrvatske vode		Elektroprivreda		UKUPNO TOTAL
	izvedeno realized	x 10^3 m^3	izvedeno realized	x 10^3 m^3	x 10^3 m^3
Sliv Save	26	32747	3	5950	38697
Slivovi Drave i Dunava	15	19097	3	151900	170997
Primorsko-istarski slivovi	4	25960	9	202780	228740
Dalmatinski slivovi	3	36480	6	578039	614519
UKUPNO (TOTAL):	48	114284	21	938669	1052953

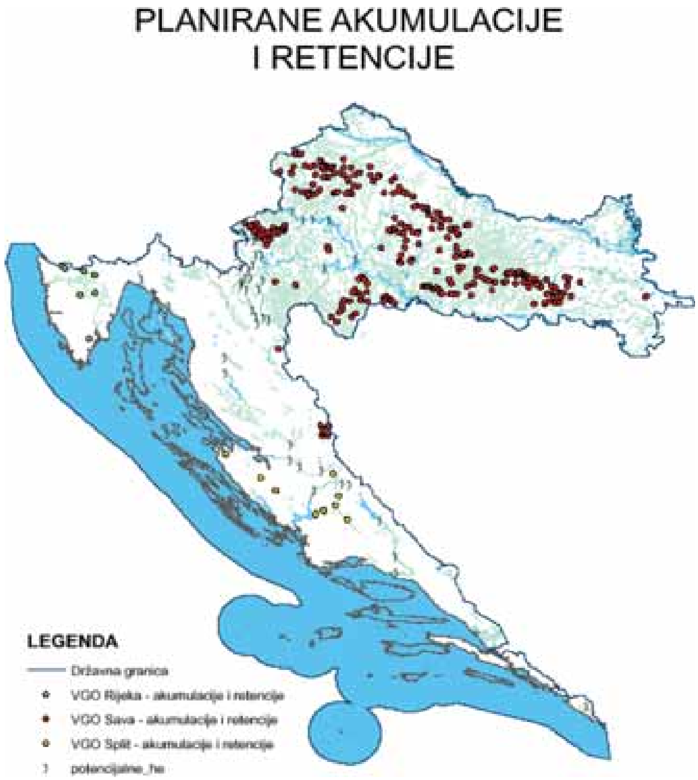

Fig. 1 – Planned water management reservoirs and retentions in Croatia
authors: Mladineo, N., Petraš, J., Kunštek, D.
source: Working papers of preparing NAP-NAV project in Croatia;
Faculty of Civil Engineering Zagreb

construction of multipurpose accumulations instead of detentions basins on planned locations. Next to usable volume they would also have a detention's volume for flood protection.

Data on those water management and power utility facts and plans make the basis for solving issues of water storage for irrigation in Croatia.

Planning and design of water resources development for irrigation implies availability of suitable meteorological and hydrologic data. Planning based on economic principles requires long term series of meteorological and hydrologic data that would enable carrying out of probabilistic and optimization analyses for water supply requirements. Meteorological data are available from DHMZ which contains a satisfying series of facts collected from 139 climatologic and 418 precipitation stations in Croatia.

However, despite the recommendations of the world meteorological organization that Croatia meets the minimal criteria of needed density of major hydrologic stations, there are not enough hydrologic data for analysis of available water quantities at some locations with scheduled accumulations. The lack of hydrologic data on the locations of planned accumulations can be replaced to a large extent with parametrical-hydrologic inflow analyses based on precipitation data. Therefore, the optimization analyses of water supplies should not be denied a priori.

Determining of optimal stage of water supply storages for irrigation

In designing the irrigation system in Croatia the required water quantities are usually defined on the basis of estimated irrigation norm for mean climatic conditions of the relevant area. The major input value for irrigation requirements are the data on mean monthly precipitation quantities in the vegetation period. Those values result in determining required water quantities which should be ensured through accumulation construction, but it is clear that in the drought periods there will not be enough water available. That means that larger water supplies should be accessible than the ones ensured by the construction of accumulation, the size of which would be established on the basis of mean monthly precipitations in the vegetation period. Hence the question – how big should be the accumulation? It could be assumed that the watercourse where the accumulation is going to be built possesses acquires the water quantity larger than estimated irrigation requirements in the annual hydrological balance.

The irrigation accumulation's size is today often neglected in designer's practice in Croatia, or is being solved in much too simple way. Frequently, the level of water supply requirements is being chosen without economic analysis (mostly 75% or 80%), and the water quantity is being determined for that level. The procedure is usually undertaken by conducting probabilistic precipitation analysis. The precipitation quantity is being determined for each month of the vegetation period with the occurrence probability equal to the chosen level of water supply storages. Thus, the corresponding irrigation norm is calculated with so determined monthly precipitation amounts e.g. less than mean monthly precipitations. To carry out such a procedure one has to possess measured data on monthly precipitations for the vegetation period, for a statistic series of satisfying length (at least 30 years). The calculation of corresponding irrigation norm can be conducted by means of CROPWAT programme. For other necessary meteorological data *(temperature and air humidity, wind speed, insulation)* in Croatian designer's practice the monthly mean values are being taken.

However, such a procedure ensures water supply storages with a chosen level for each month of the vegetation period. It is still questionable whether the total irrigation norm will have the same (chosen) ensurance level. It can be easily shown that it will not happen. Actually, the total irrigation norm depends largely on precipitations' distribution during vegetation period. The probability of irrigation norm can be more accurately solved if we calculate the irrigation norms according to calendar years. The CROPWAT programme calculates the needed water amounts for vegetative months and vegetative periods in a sum, for a series of calendar years. In this way a series of irrigation norms according to calendar years is going to be obtained, e.g. the norms suitable for concrete annual meteorological data. The calculation of irrigation norm probability can be conducted on the basis of such a series if it is of satisfying lengths (at least 30 years). In this way, it is possible to assign to any assumed irrigation norm its probability of occurrence, e.g. it is possible to state how high the ensurance level *(safety degree)* is if water supplies are ensured for assumed irrigation norm. Reversely, it is possible to determine for any chosen ensurance level the amount of corresponding required irrigation norm by means of mentioned probability calculation. But, there is the question which ensurance level *(safety degree)* to choose.

As mentioned above, the water supply ensurance level, order of magnitude 75% or 80%, is most often selected in designer's practice without conducted economic analysis which would justify such a choice. Is it the best choice from the economic aspect? There is a matter of relationship between irrigation benefits and water supplies costs, consequently to accumulation construction size. The increase in the water supplies leads to the greater irrigation benefits along with investment and other accumulation costs. Therefore, the analysis of expenses and revenues should be conducted. Such analyses often demonstrate that the costs increase become higher than benefits increase with higher levels of water supplies storages. It is obvious that the accumulation's construction size is an economic category, which should be determined by the optimization procedure based on the cost-benefit analysis. Figure ***2)*** illustrates the potential concept of such an analysis according to the criterion of maximal net benefits. A curve ***a)*** in Figure ***2A)*** represents the total probability of effective precipitations (P_{ef}) occurrence, e.g. of that part of gross precipitations which is available for evapotranspiration.

The curve [***a)***] expresses the probability *(on the abscissa)* of some observed effective precipitation quantity *(an observed ordinate)* taking place, or of the bigger quantity (*probability curve of exceeding effective precipitation P_{ef}*). Such a curve can be obtained by probability calculation applied to the series of data on effective precipitations of vegetation periods, according to same calendar years as it was with calculating irrigation norms. The series data of effective precipitations are acquired as one of the outputs while using the CROPWAT programme for calculating a series of irrigation norms regarding to calendar years. Effective precipitations are calculated for vegetative months and vegetative periods in a sum. Then, the curve ***b)*** in Fig***.2A)*** illustrates the summed probability *(on apscisa)* of any analyzed irrigation norm (*ordinate)* or smaller than it (*probability curve of not exceeding irrigation norm N)*. Accordingly, if water supplies should be ensured through accumulation construction for some analysed norm, then its occurrence probability will represent at the same time the water supply ensurance level or safety degree. One should bear in mind that water losses occur in the irrigation system's conduit and also in the distribution network and on the fields. Such losses should be determined and added to analysed irrigation norm. In this way it is possible to identify required water supplies, which will help define the accumulation's size. Determination of those losses depends on engineering solution of the irrigation system, and is mainly based on indicators taken from experience, which are not going to be considered here. If we sum the ordinate of the curve ***a)*** and ***b)*** we get a hypothetical probability curve of vegetation cultures' evapotranspiration in Fig ***2A)*** in the area of very strong and very low probabilities. Further on, if we calculate on the basis of disposable meteorological and other already mentioned data, a maximally possible evapotranspiration ${}_{\mathbf{max}}\mathbf{Evpt}$, and illustrate it in [mm] of the high water layer, so that in Fig***.2A)*** the parallel line with abscise is

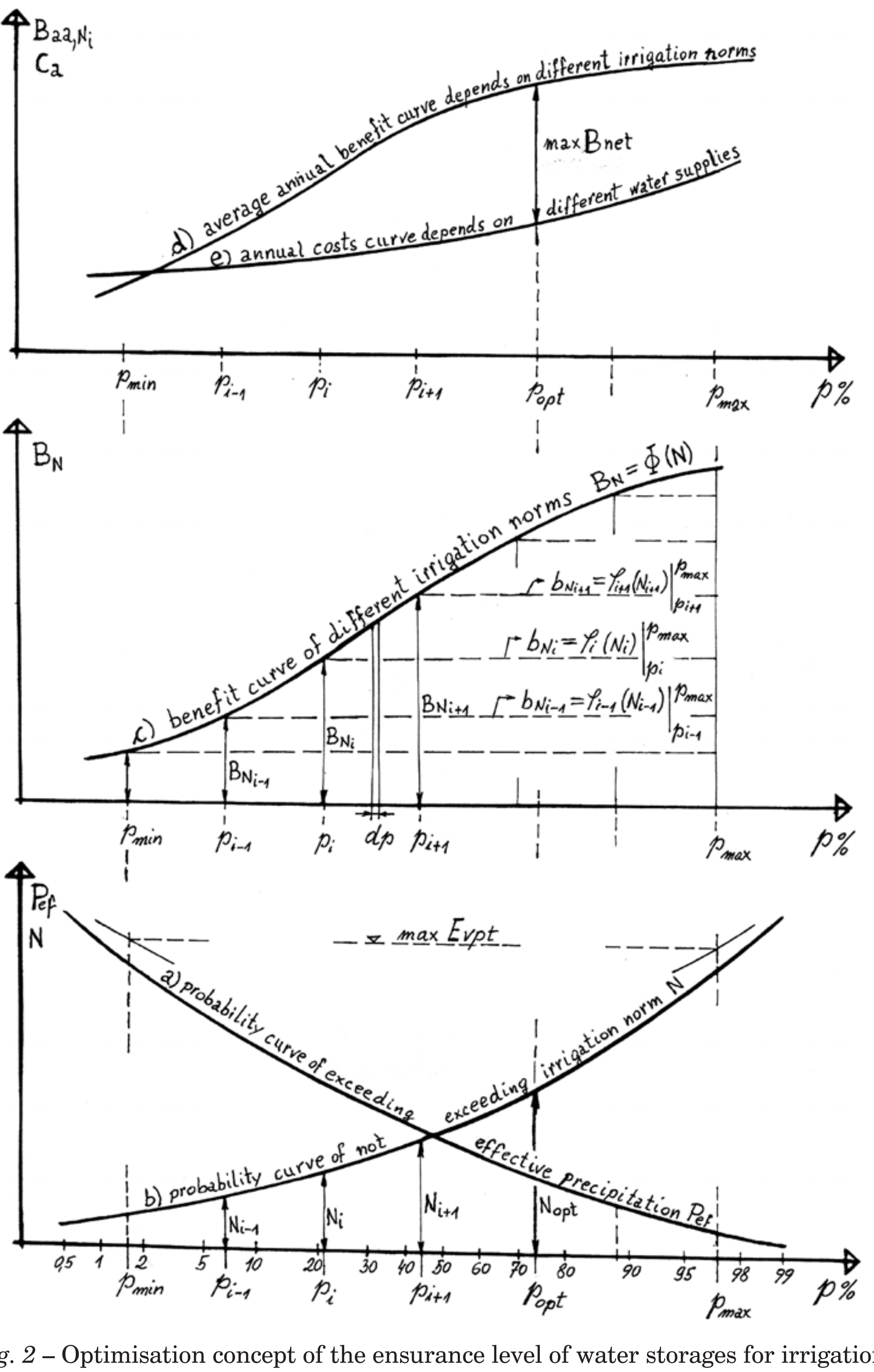

Fig. 2 – Optimisation concept of the ensurance level of water storages for irrigation

drawn at the position of this $_{\mathbf{max}}\mathbf{Evpt}$ ordinate. This line will cut the given sum of curves' ***a)*** and ***b),*** both in the area of low ($\mathbf{p_{min}}$) and strong ($\mathbf{p_{max}}$) probabilities. In this way the probability field is going to be defined, within which the analysis of irrigation norm can be reasonably conducted. Actually, in the probability fields $\mathbf{p<p_{min}}$ and $\mathbf{p>p_{max}}$ the sum of effective precipitations and corresponding irrigation norm exceeds practically possible evapotranspiration. It is therefore obvious that the realistic solution of given optimalization task should not be searched in these areas.

Furthemore, the curve ***c)*** [$\mathbf{B_N=\Phi(N)}$] in Fig. ***2B)*** could be calculated on the basis of the curve ***b)***. The curve's ordinate represents irrigation benefits under assumption of different water supplies, e.g. irrigation norms of different probability occurrences. The curve's calculation is quite complicated and at the same time the source of many ambiguities contained in this optimization procedure. The curve ***c)***'s calculation procedure is based on agricultural experience on the crops yields due to irrigation in relationship to the yields without it, implying different precipitation probabilities and corresponding irrigation norms. On the basis of the curve ***c)*** it is further possible to calculate the curve of **average annual irrigation benefits** [*curve **d)** in Fig. **2C)***] during the service life of the irrigation system.

The calculation of those benefits is carried out in the way that for any assumed irrigation norm the corresponding ordinate of the curve ***d)*** in Figure ***2C)*** is calculated according to expression ***1)***.

$$B_{aa,N_i} = \int_{p_{\min}}^{p_i} B_N \cdot dp + \int_{p_i}^{p_{\max}} b_{N_i} \cdot dp$$

B_{aa,N_i} – average annual benefit curve depends on different irrigation norms N_i

$B_N = \Phi(N)$ – benefit curve of different irrigation norms N, in the probability area pmin to pi

$b_{N_i} = \varphi(N_i)$ – benefit curve depends on different irrigation norms N_i, in the probability area pi to pmax

From expression ***1)*** it is clear that average annual benefits matched to some observed irrigation norm are calculated as the surface under the curve ***c)*** [$B_N=\Phi(N)$] in the area of less probability then the observed norm (from $\mathbf{p_{min}}$ to $\mathbf{p_i}$) plus surface under the curve $\boldsymbol{b_{Ni}}$ [$\boldsymbol{b_{Ni} = \varphi(N_i)}$] in the area of overrun probability of the observed irrigation norm, e.g. in the area from $\mathbf{p_i}$ to $\mathbf{p_{max}}$. The curves $\boldsymbol{b_{Ni} = \varphi(N_i)}$, regarding to different irrigation norms $\boldsymbol{N_i}$, are as well defined on the basis of agricultural experience on the difference between the yields of vegetation cultures when the applied irrigation norm is lower than the one needed with regard to effective precipitation. Subsequently, it is possible to construct the ***d)*** curve whose ordinates represents average annual benefits with regard to different irrigation norms ($\mathbf{B}_{aa,N_i}$), whereas the abscise features the occurrence probabilities of required irrigation norms, e.g. ensurance levels of needed water supplies.

If water supplies should be ensured through accumulation construction, its annual costs might be calculated on the level of preliminary design, e.g. all the investment and operational costs along with maintenance costs for the accumulation's service life, and all that in accordance with different water supplies, e.g. different ensurance levels. The required water supplies are determined so that water losses (on the conduit and distribution network, and on the fields) are added to the irrigation norm. The mentioned accumulation costs should be expressed as fundamental *(current)* annual value by means of economic analyses. In this way the ***e)*** **(*C_a*)** curve showed in Figure ***2C)*** is obtained. Eventually, it is possible on the basis of the ***d)*** and ***e)*** curves to decide on their maximal difference, e.g. to determine maximally possible net benefit ${}_{max}\mathbf{B}_{net}$ of the accumulation construction. The probability of the net benefit determined in this way *(on abscissa)* is the optimal level of water supplies ensurance. On the ***b)*** curve in Fig.***2A)*** one can read for this level a corresponding optimal irrigation norm, on the basis of which optimal water supplies for the accumulation construction are going to be determined by adding mentioned water losses. Next to the accumulation costs, there are also other cost types dependent on the irrigation norm, so that the optimization procedure should also imply those expenses and assign them to the accumulation costs.

The described optimization concept of ensuring water supplies involves many uncertainties, more of economic than of technical nature. In the computation of average annual costs and benefits it is difficult to assume economic trends, on the basis of which the investment and other accumulation costs are being translated to current or other basic annual value. There is also the question how one should reckon the benefit increase of agricultural products during the service life of irrigation system and accompanying cost of accumulation construction for water supplies ensurance, when estimating curve ***d)*** and ***e)***. However, it should not prevent us from carrying out the optimization and economic analysis of water supplies storage ensurance, e.g. accumulation construction's size.

A look at determining optimal irrigation water storage in multipurpose accumulations

The optimization concept refers to determination of optimal water supplies for irrigation which should be ensured through accumulation. Current water demands have led to the fact that single-purpose accumulations are not being built nowadays. Irrigation water requirements imply just one of the users. The most frequent uses of the accumulation water involve irrigation, use of hydro-power potentials and water supply for population and industry. Multipurpose accumulations also satisfy the needs for reservation of a specific accumulation volume belong to the category of general social benefits. It refers to detention of flood waters and use of particular water quantities from the accumulation for environmental needs, e.g. for sustaining of biologic minimum or ecologically required discharge in the watercourse, downstream from the accumulation, in order to sustain aquatic and aquatic related near shore ecosystem during drought periods. The issues of investments, e.g. allocation of construction and facility costs of multipurpose accumulations are very complex. There are several allocation models, particularly those considering general social benefits. In any case, the use of water by different users is always the starting point for determination of costs allocation. The simplest model is to define the water unit price on the basis of annual accumulation costs that would imply the costs belonging to general social benefits. In this case water users settle the costs of other social benefits originating from the accumulation. The other model type can be the case where the costs of general social benefits are settled by the state. As far as irrigation and optimization concept of water storage is concerned here, the concept can be applied in the case of ensuring water supplies in multipurpose accumulation. If annual accumulation costs are allocated on the basis of water consumption, then the ***e)*** curve on the Fig. ***2C)*** represents the curve of annual costs assigned to the occurrence probability of needed water supplies, obtained so that different presupposed water storages are multiplied with water unit cost. All other factors related to the optimization concept of water storage ensurance level stay the same.

Conclusion

a) The average annual water balance in Croatia shows that there are more than satisfactory water resources for irrigation, and that such a potential could be used during low water periods providing that there are enough accumulations to ensure water storages. During the preparation of the Water Management Strategy in Croatia not less than 318 potential water management locations for the construction of surface accumulations and 61 locations listed in the electricity utility's development plans were registered.

b) In the course of irrigation system designing in Croatia there are no optimization and economic analyses of water storage ensurance level needed for the accumulation construction, but the level of the order of magnitude 75% or 80% is common chosen from experience.

c) A defined concept of optimization level of water storage ensurance, and subsequently the accumulation size is recommended to be implemented in design of both single-purpose (irrigation), and multipurpose accumulations. The concept is described for a single-purpose accumulation, and the difference for the multipurpose one is only in determining the curve indicating annual water storage costs, assigned to different ensurance level.

d) The series of meteorological and hydrologic data should be obtained to carry out the mentioned concept. As there are 139 climatologic and 418 precipitation stations it is being supposed that suitable meteorological data for implementation of optimization concept could be obtained from the DHMZ of Croatia, whereas the hydrological data for the major part of the identified locations for the accumulation constructions are nonexistent. But, there is also presumption that such data can be successfully replaced by carrying out parametrical-hydrologic runoff analysis, based on the precipitation data.

e) There are many uncertain sources contained in the optimization concept of water storage ensurance level. It particularly refers to the computation of average annual irrigation benefits, as it is difficult to anticipate economic trends. Reliable economic factors would serve as a consistent basis for the computation of future irrigation benefits. Notwithstanding such reasons the optimization and economic analysis of the water storage ensurance level, that means the accumulation size analysis should be conducted.

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Small Hydro Power Plants and the Utilization of Hydro Potential in Croatia

Abstract

Technically exploitable hydro potential in the Republic of Croatia has been estimated at 12.45 TWh/year, 49 percent of which is currently being exploited by hydro power plants. In view of topographical and morphological characteristics of the county, it has been estimated that minor waterways account for approximately 10 percent of total potential, i.e. for about 1 TWh/year.

An overview of research results has revealed about 20 minor waterways with about 60 micro locations that can be exploited, and for which the economic analyses of construction are being carried out, as well as the analyses of conditions for their environmental integration.

Taking into account the fact that such facilities have relatively low installed capacity and small annual output, in the majority of cases they are not cost-effective. Therefore, an analysis of the newly introduced program for incitement of electricity generation from renewable energy sources is presented, along with the comparison with EU requirements.

The exploitation of the remaining potential in the Republic of Croatia requires harmonization with present and future land-use and waterway-use conditions, and conditions for the protection of natural values at site and the existing cultural and historical heritage.

After meeting the construction requirements, the dimensions of hydraulic equipment and the plant in general will be determined by the installed capacity, which is dependent on water head and flow. The possibility of plant design simplification and its standardization in order to minimize the costs is also considered.

The conclusion can be drawn that there are realistic conditions and technologies for efficient realization of the small hydro plant construction program in the Republic of Croatia, but there are also problems to be solved.

Key words: hydro potential, small hydro power plants, conditions for integration, legislative framework of the Republic of Croatia, specific site characteristics, specific characteristics of the power plant

Introduction

There is a growing trend to generate electricity from renewable energy sources. Hydro power plants hold the largest share among the renewable energy sources. However, the majority of adequate watercourses in Croatia and Europe have already been harnessed, meaning that hydro power plants with high installed capacities have been built on such watercourses. Still, there are a number of smaller watercourses on which small-capacity hydro power plants could be built. Compared to the large hydro power plants, fossil fueled power plants or nuclear power plants, such small hydro power plants could not compete with electricity prices generated by other power plants. However, since the hydro power is a renewable energy source in its form, such small hydro power plants bring the same benefits as do the other "new" renewable sources (wind power plants, biomass fueled power plants, geothermal plants, solar, etc.). Therefore, small hydro power plants are generally considered "new" renewable sources and have been included in the incentives systems to make electricity generation by small hydro competitive.

This paper considers the opportunities of the watercourse utilization in the Republic of Croatia and the construction of small hydro power plants in terms of their engineering design and environmental impact. Also, different types of incentive programmes for electricity generation from renewable energy sources, offered by both the European Union and the Republic of Croatia, are discussed in this paper.

1 Term and Definition of Small Hydro Power Plants

1.1 Definition of a small hydro power plant and its key components

The term and definition of a small hydro power plant, its constituent components and types and its environmental impact, together with the know-how of these issues have been well presented explained in a paper, published in 1998 by a group of authors, titled "MAHE: Program To Construct Small Hydro Power Plants: Preliminary Results And Future Activities". (12) Therfore, some of the following information are quoted, with minor alternations, from the aforementioned reference.

The Decision of the Government of the Republic of Croatia reached in March, 1997, launched The National Energy Programmes of Energy Efficiency and the Use of Renewable Energy. The National Energy Program of Small Hydro Power Plant's Construction (the MAHE Program) is included in the national programme scope. The principal objective of this program was to create all conditions for an increased construction of small hydro power plants in the Republic of Croatia.

Current international accounts on the development and construction of small hydro power plants vary in perspective of the term 'small hydro power plant' depending on the country in question, i.e. its living standard, morphological, topographical, hydrological and meteorological characteristics of the location and the level of technological development.

However, the key parameter for determining a small hydro power plant in all countries is exclusively its installed capacity. Depending on the aforementioned reports, world hydro power plants with installed capacities ranging from the lowest 5 kW in PR of China to the highest 30 MW in the USA are considered small hydro power plants. Some countries have classified small hydro power plants even further, dividing them into micro, mini and small hydro power plants. Given that, such classification varies from country to country, and the used terms are identical. So, when we talk about micro, mini and small hydro power plants we often do not exactly know what the installed capacities are for the mentioned power plants respectively. For an example, a small hydro power plant of 150 kW is called micro hydro power plant in the USA, while in the majority of European countries the power plant of the same capacity is called mini hydro power plant.

During the elaboration of the Small Hydro Power Plants Development Program in Croatia (in 1980), the limits were set to determine the gross output of small hydro power plants. The gross available energy potential of small watercourses was to be classified within those limits. Lower limit was set at 50 kW because Hrvatska Elektroprivreda was possibly interested in investing into plants up to this very limit. The upper limit was set at 5000 kW, due to the restrictions set by the standardization of turbines made before. However, the Republic of Croatia has accepted the current EU classification, namely – micro power plants (up to 100 kW), mini power plants (100 kW – 1 MW), small power plants (1MW – 10 MW) and large power plants.

In our country the state of affairs has somewhat changed since that time, and now small hydro power plants range from 10 kW to 10000 kW of gross watercourse potential at the planned site**.** Here we are talking about gross potential since gross potential is used in the analysis of a watercourse or a certain location on such watercourse. This parameter points to the feasibility of further studies or cessation of all activities related thereto. The proposed lower limit of gross watercourse potential is lower than the previous one since in the meanwhile the Law on Electric Power Industry has been adopted which allows individuals and legal persons outside HEP to be engaged in generating electricity for their own needs and for sales to third physical or legal parties. Thus, the circle of potential investors in small hydro power plants has significantly broadened and the interest of private investors arose, especially for very small plants with capacities ranging around the proposed lower limit.

It should be noted that the above limits are approximate values and that the particular methodology outlined specifically for small hydro power plants in Croatia can be applied only to those small hydro power plants whose dimensions of objects and equipment can be subjected to standardization and mass production. It is not rare that even if small hydro power plants of 4000 to 5000 kW have low head, high installed flow and available standard turbines, the standardization cannot be applied to facilities of such dimensions and special approach is required to engineering design with potential additional geotechnical and other research. The following structures and equipment are considered the main components of a small hydro power plant:

- facilities (objects),
- hydro-mechanical equipment,
- electrical and mechanical equipment,
- connection to the transmission network.

2 Analysis of individual watercourses potential for the construction of Small Hydro Power Plants (SHPPs)

2.1 Potential

Technically exploitable hydro potential in the Republic of Croatia has been estimated at 12.45 TWh/year, of which hydro power plants currently utilize 6.13 TWh/year or 49.2 percent. Based on the experience of other countries with similar topographical and morphological characteristics, it can be calculated that the potential of small watercourses accounts for approximately 10 percent of total potential (about 1 TWh/year). [9]

The research of small watercourses connected with the construction of small hydro power plants in Croatia started in the year 1980, when the elaboration of the "Methodology and Guidelines for Design and Construction of Small Hydro Power Plants" was designed. Also, a "Cadastre of Small Watercourses in the Republic of Croatia" was developed, identifying 63 watercourses which have the potential for the construction of hydro power plants. Altogether, 134 watercourses were surveyed and 699 sites identified on selected watercourses that were appropriate for the construction of new plants [9]. The remaining watercourses were not analyzed further. Total gross potential of the studied watercourses was estimated at about 1,310 GWh per year, of which watercourses with identified utilization sites account for about 1,180 GWh, and watercourses without identified utilization sites for about 130 GWh. It is important to stress that the sites were examined for the construction of small hydro power plants with the capacity of up to 5 MW. Further analyses, conducted in several phases, revealed 20 minor watercourses with the total of 67 possible exploitation sites. Detailed analyses should be carried out for these sites regarding the economics of construction, condition for their integration into the environment and environmental compliance.

Therefore, the number of potentially adequate sites for utilization decreased since the number of actually exploitable/utilizable sites is much smaller.

According to the above mentioned Cadastre, the following small watercourses were included in the survey: the Boljunčica, the Bijela, the Bregana, the Brzaja, the Butišnica, the Čabranka, the Čučkov Jarak, the Jadova, the Jadro, the Krupa, the Kupčina, the Kupica, the Ljuta, the Orljava, the Ovrlja, the Ruda Velika, the Rumin Veliki, the Slapnica, the Vitunjčica, the Voćinka and the Žrnovnica.

After completing a number of analyses, site surveys, environmental protection researches, cultural heritage protection studies and economic feasibility analyses in the period from 1993 to 2003, a large number of locations were disqualified from 67 potential ones. Entire watercourses were disqualified for a number of reasons, such as:

- unfavorable hydrological and topographical conditions: the Boljunčica, the Bijela, the Voćinka and the Jadova;
- acquired status of trans-boundary water flow: the Čabranka and the Bregana,

Fig. 2-1 – Potential locations for small HPPs [9]

• specific natural, cultural and historical characteristics: the Brzaja, the Krupa, the Rumin and the Ovrlja.

Finally, only 6 watercourses remained, although some sites were abandoned on these 6 watercourses, too, since they either did not meet the above mentioned conditions or the conditions of land use do not permit the construction of a small hydro power plant.

Finally, 18 potential small hydro power pants have been selected on 6 watercourses: the Orljava, with 9 potential small hydro power plants; the Kupčina with 4 SHPPs; the Jadro with 2, and the Vitunjčica, the Butišnica and the Ruda, each with one potential small hydro power plant.

2.2 The potential of possible small hydro power plants in Croatia

According to the final list from the Catalogue, there are 18 potential locations with elaborated detailed plans, drawings, site descriptions and type of work and with some other features defined. Those features are: access to the site, the size of the land plot, and description of building structure, electrical and mechanical part and connection to the network. The table 2-1 shows potential energy and economic indicators, depending on the watercourse.

Hence, the small hydro power plants in Croatia could in total have the installed capacity of 1.6 MW and the annual output of 8,300 MWh

However, there are 622 locations that have to be studied in more detail, since they represent significant additional potential for the construction of small hydro power plants.

In order to assess the total potential of small hydro power plants, the potential should be estimated for small hydro power plants with installed capacities ranging from 5 to 10 MW. According to available sources [10], the construction of small hydro power plants with the total installed capacity of up to approximately 125 MW is planned. Based on the utilization factor of the existing small hydro power plants and other hydro power plants which is about 0.34, the total production of such small hydro power plants can be conventionally estimated at about 300 GWh per year [9]. Since further analyses are required and limiting factors are to be met, it can be expected that this figure shall be much lower.

Table 2-1 – Energy and economic indicators per watercourse [12]

Small HPP	Installed capacity (kW)	Annual output (kWh)	Investment (HRK/kW)
Orljava 1	95	400,000	22,000
Orljava 2	54	270,000	32.000
Orljava 3	72	300,000	26,000
Orljava 4	66	280,000	26,000
Orljava 4/1	59	380,000	22,700
Orljava 5	99	540,000	15,700
Orljava 6	159	850,000	16,000
Orljava 7	209	1,100,000	15,000
Orljava 8	153	890,000	16,000
Orljava Total	**966**	**5,010,000**	
Kupčina2	18	100,000	86,000
Kupčina 3	23	140,000	55,000
Kupčina4	65	400,000	18,000
Kupčina 7	34	200,000	40,000
Kupčina Total	**140**	**840,000**	
Jadro 1	154	830,000	17,000
Jadro2	125	530,000	16,000
Jadro Total	**279**	**1,360,000**	
Butišnica 2	48	220,000	34,000
Ruda 3/1	149	870,000	16,000
Subtotal	**1,582**	**8,300,000**	

Figure 2-2 gives the schematic presentation of estimated energy utilization potential of watercourses considered for the construction of small hydro power plants.

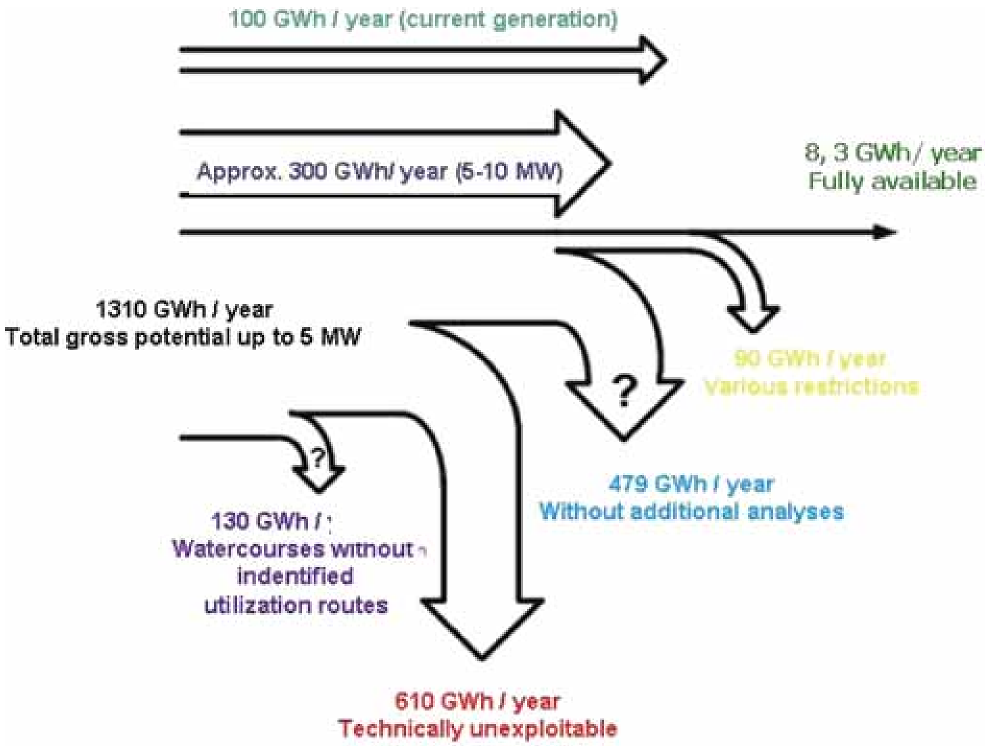

Fig. 2-2 – Balance of potential in small HPPs [9]

2.3 Objectives

Since energy development is the fundamental basis of general development, the Government of the Republic of Croatia recognized the need to define a clear energy development strategy. With this aim, The Draft Green Book – Adaptation and Upgrading of the Energy Development Strategy of the Republic of Croatia, has been published recently (October 2008), clearly defining the development strategy. Being aware of the need for increased electricity generation from renewable energy sources, including small hydro power plants, necessary activities were elaborated that have to be undertaken in order to meet the set goals.

It can be reasonably expected that in a very short period of time (by the year 2015) the generation of small hydro power plants will rise by about 10 GWh on the sites for which almost all research work has been completed. The expected total average generation of small hydro power plants will be about 110 GWh. Taking into account the 67 watercourses entered in the Cadastre with a technically exploitable hydropower potential of about 100 GWh which, after meeting a number of criteria, dropped to somewhat below 10 GWh, it can be estimated that 10 percent of technically exploitable potential will represent the expected lower limit of utilization of technically exploitable potential, after meeting all the criteria (economics, environmental conditions, cultural and natural heritage, trans-boundary flows).

The remaining hydropower potential technically exploitable by small hydro power plants below 5 MW is about 500 GWh and by plants above 5 MW about 300 MWh per year, making altogether 800 GWh per year.

Future electricity generation in small hydro power plants will depend on the utilization factor of technically exploitable hydropower potential. Three cases can be differentiated:

- Given that the utilization factor of technically exploitable hydropower potential will be equal to the anticipated lower level of 10 percent, additional generation of new small hydro power plants has been estimated at about 80 GWh. The total generation of small hydro power plants in the year 2020 has been estimated at about 190 GWh;
- Given that the utilization factor of technically exploitable hydropower potential will be around 20 percent, additional generation of new small hydro power plants has been estimated at about 160 GWh. The total generation of small hydro power plants in the year 2020 has been estimated at about 270 GWh. Such an increase is due to the realistic assumption that only several newly investigated locations would belong to trans-boundary flows. This scenario has been incorporated in the Strategy.
- Given that the utilization factor of technically exploitable hydropower potential will be around 40 percent, additional generation of new small hydro power plants has been estimated at about 320 GWh. The total generation of small hydro power plants in 2020 has been estimated at around 430 GWh. Such an increase rests on the assumption that among the newly investigated locations there will be a small number of those situated within protected areas and assumes an increased interest of investors, especially in small hydro power plants with installed capacities exceeding 5 MW.

Accordingly, along the lines of the EPS development scenarios anticipating the generation of 4,500 GWh of electricity, the projected share of generation from new small hydro power plants ranges between 2 percent and

7 percent. The Strategy has set an objective to generate 270 GWh of electricity by small hydro power plants until the year 2020, or 430 GWh by the year 2030.

As for the utilization of energy of small watercourses beyond the year 2020, on condition that the objective of total generation of 430 GWh is met till that period, in the period to follow this amount will be maintained since the available hydropower potentials have been exploited. Should such an increase not occur, efforts should be made to meet this objective by the year 2030.

Table 2-2 shows the anticipated growth of energy utilization of small watercourses by small hydro power plants up until the year 2030.

Table 2-2 – Growth in the utilization of energy of small watercourses by small HPPs in Croatia by the year 2030 [9]

	2010	**2020**	**2030**
Electricity generation [GWh]	110	270	430

3 Environmental impact of small hydro power plants

3.1 Introduction

The advantage of hydro power facilities is that their operation does not result in pollutant emissions into the air, as opposed to e.g. thermal power facilities. It has been estimated that annual operation of a small hydro power plant of 5 MW substitutes 1400 tons of oil equivalent of a fossil fuel and reduces the emission by 16 000 tons of CO_2 and 1100 tons of SO_2, compared to a fossil fuel fired plant of the same annual output. Furthermore, noise levels in power houses employing modern technological solutions in design and execution, are below permitted and recommended levels and are not considered pollution, especially if the plant is located outside a populated area (and this is true for the majority of locations adequate for siting small hydro power plants). The design of small hydro power plants is such that it can be fully integrated into the landscape, thus minimizing visual pollution. If a reservoir is envisaged in the scope of the plant, the reservoir can be used for water management and/or sports/recreational purposes. Reservoirs utilized by small hydro power plants cannot jeopardize geological and pedological characteristics of the site at which they are located, since they are small in size, contrary to large hydro power facilities which, due to the size of dams and reservoirs, often having adverse impact on geological and pedological characteristics of the site at which they were constructed.

Despite the fact that they use a renewable energy source, hydro power facilities can have adverse impacts on the environment. Therefore, especially if water resources are being mismanaged, the impacts of such facilities can be considerable.

3.2 Watercourses within the categories of the Nature Protection Act

The Nature Protection Act provides for the conservation of natural communities, rational use of nature and its goods, prevention of adverse impacts of human activities and disturbances in the nature and protects particular parts of nature in several aspects:

- environmental (a cornerstone of balance and potential of wider surrounding areas);
- aesthetic (landscape, tourist-recreational and similar);
- cultural and educational (here we can also include a symbolic one);
- scientific (geological, geo-morphological, hydrological, botanical, zoological, horticultural).

The above aspects could be found, individually or collectively, in the definitions envisaged in the aforementioned Act:

- national parks,
- nature parks,
- strict natural reserves,
- special natural reserves (botanical, zoological, geological, hydrological etc.),
- natural monuments (with the same sub-categories, but as small isolated localities),
- forest parks,
- protected landscapes,
- particular plant and animal species,
- monuments of park architecture (horticultural monuments).

Since watercourses can contain all the mentioned values and aspects (scientific, cultural and educational, aesthetic and environmental), it is logical that they occur in a number of legislative categories:

- as an exclusive or key subject of protection,
- as one of the values in the protected area,
- as a medium, i.e. biotope hosting protected animal or plant species.

The most beautiful examples of the first group could be found in the Plitvička jezera and Krka national parks, Mrežnica nature park, natural monuments of the Kupa, the Gacka, the Una and the Cetina springs, waterfalls on the Krupa, the Zrmanja etc. An illustrative example of the second group is the category of protected landscapes, dependent on watercourses. Such examples are the canyons of the Cetina, the Zrmanja, the Kupa, the Dobra, the Korana, the Kamačnik, the Krčić, the Ćikola, the Sutjeska, Vražji prolaz – Zeleni vir etc. The third group is a modest one for the time being, and includes the rivers Jadro and Vrljika, being habitats of endemic trout. The water is, as a biotope, represented in many other protected areas such as nature parks Kopački rit, Lonjsko polje, Donja Neretva etc.

3.3 Technical and technological solutions of small hydro power plants aimed at environmental protection

Small hydro power plants with specific engineering solutions are designed so as to minimize their impact on the environment. Therefore, in this program we primarily have in mind the facilities with the following characteristics:

- run-of-river operation, without water storage or with very small reservoirs, which means that such small hydro power plant has minimum impact on natural hydrological regime of the watercourse;
- parallel operation with the network is envisaged and the installation of asynchronous generators;
- small hydro power plants of small outputs (up to 100 kW) do not require the construction of a substation – instead, a pole-mounted substation is envisaged (by aerial connection to public network);
- plant's design is the following: small hydro power plant consists of a dam, i.e. low spillway threshold, an intake channel with a penstock, or penstock only, a powerhouse and a short tailrace channel;

- low spillway threshold serves only for the purpose of elevating the water level to the degree required for diverting it into intake structures of a small hydro power plant; its standard design being a massive concrete threshold with or without a stilling basin. However, regardless of its small height it can also be built as a rockfill dam which visually fits well into the environment, or as an earthfill dam made of gravel material obtained during excavation work performed for other structures of a small hydro power plant;
- instead of low spillway and lateral intake, the so called Tyrolean intake can be applied, which intakes the required quantity of water and does not elevate the water level in the watercourse, while allowing floating debris to pass uninterruptedly and which is practically invisible since it is always submerged;
- the intake channel is of closed type envisaged to convey water on steep slopes. In its major part it is buried underground and can be completely buried underground. In that way it becomes invisible if the siting conditions require it, since mainly small hydro power plants with smaller installed flow are located on such terrains and the dimensions of such channel are, consequently, smaller;
- the intake channel of open type is envisaged for larger water quantities and will be used, as a rule, on less steep terrains. It will be fully incorporated into the environment by its shape. The speed of water in the channel is generally at the minimum speed level required for uninterrupted maintenance. Therefore, it even contributes to the landscape with its grassy banks and clear water appropriate for bathing or providing water for cattle;
- the penstock of a small hydro power plant usually does not have large dimensions and is envisaged for conveying water to the power house via the shortest path possible. It can be of surface type or buried underground;
- the power house of a small hydro power plant has least possible dimensions since the operation of a small hydro power plant is fully automated and there is no need for rooms accommodating crew. External appearance of the power house can be fully incorporated into the environment, i.e. the building can be fully burried underground;
- the tailrace channel is a short, open channel which conveys water from the power house back in the watercourse; this water is highly enriched with oxygen due to turbulent currents occurring during its pass through turbines and fish gladly dwell there.

Conclusion can be drawn that the impact of small hydro power plants on the environment can be significantly mitigated by employing the proposed solutions. A number of examples from developed countries of the world where environmental movements are very strong report on small hydro power plants constructed in nature parks and national parks. By all means, in such cases it is vital to pay special attention to particular components of the plant, such as the spillway threshold with a fishway, the discharge of required biological minimum and similar.

4 Status and possibility of introduction of incentive measures in the Republic of Croatia

4.1 Status and history

As a candidate country and future EU Member State, Croatia ratified the Kyoto Protocol in April 2007 and obliged itself to reduce greenhouse gas emissions by 5 percent in the period from 2008 to 2012 with relation to the reference year's emission levels (1990). Negotiations are underway, within the UN Climate Change Convention, regarding the liabilities after the year 2012, in order to adopt a new international treaty, the successor of the Kyoto Protocol. The estimates made at the Intergovernmental Panel on Climate Change (IPCC) show that by the year 2020 developed countries should lower their emission levels by 25-40 percent, whereby the concentration of greenhouse gases in the atmosphere would stabilize at 450 ppm [9]. One way to limit the quantity of emissions is to increase the share of renewable energy sources in the electric power system and to enhance energy efficiency. The reason for introducing renewable sources is not only the Kyoto Protocol but also the security of supply. In other words, Croatia, like the rest of Europe, is not abundant with fossil fuel but has to import such fuel which makes its electric power system dependent on other countries and external factors.

The construction of new energy facilities and manufacturing of equipment for such facilities results in the growth of industry and, consequently, creates jobs and improves employment. Furthermore, the development of new technologies is ensured as well as prosperity of Croatian economy in general.

The researches into potential locations for the installation of renewable sources have shown that the largest potential lies in rural areas and on islands. This means that the installation of renewables in these areas could benefit the local inhabitants and spur the development of these parts of Croatia.

One of the key reasons is, surely, the protection of environment. Croatia, having intact and less polluted environment than the other European and world's countries, has to embrace the philosophy of sustainable development, which includes the introduction of renewable sources in the power sector.

Consistent with the EU policy, where all Member States have defined a mandatory share of renewables in total electricity consumption in the year 2010, Croatia set this share at the amount of 5.8 percent or 1100 GWh of electricity in 2010.

In the context of electricity market liberalization in Croatia and HEP Group's restructuring, the past incentivisation system is undergoing a change. In the past, Hrvatska Elektroprivreda, as the key player in the Croatian electric power sector, entered into electricity buy-back contracts with electricity producers from renewable sources paying the amount of 90 percent of market price of electricity per kWh. After the establishment of Croatian Electricity Market Operator (HROTE), HEP no longer has such obligation, since HROTE takes the liability to enter into electricity buy-back contracts. Therefore, HEP is no longer liable to purchase electricity at the contracted price. Instead, an incentivisation system in the form of feed-in tariffs has been introduced to stimulate electricity generation from renewable sources.

Taking into account economic indicators and current situation in the Republic of Croatia, 1100 GWh has been proposed as the target share of electricity from renewable sources by the year 2010, i.e. 5.8 percent of total electricity consumption in Croatia. Large hydro power plants have not been included in this amount. Such share is consistent with the EU Directive 2001/77/EC.

In comparison, electricity consumption in Croatia in the year 2006 amounted to around 17 TWh. Hydro power plants generated 35 percent and thermal power plants 32 percent of electricity. The remaining demand was met by Krško NPP, EP B&H Sarajevo and other imports. [1]

4.2 Feed-in tariffs

The tariff system for electricity generation from renewable energy sources and cogeneration anticipates the setting of incentive prices for electricity generation from renewable energy sources and cogeneration.

This tariff system contains guaranteed incentive prices for electricity generation in all power plants using renewable energy sources or cogeneration process that are entitled to incentives. Since eligible producers have the right to feed total electricity generated into the network, it is a requisite to define the purchasing price of such energy. In the case of renewable energy sources and cogeneration, the plants that supply electricity within the framework and up to the level of minimum share prescribed by the Ordinance on Minimum Share of Electricity Produced from Renewable Sources and Cogeneration, the generation of which is stimulated in the electricity supply, will be entitled to an incentive i.e. the incentive price.

The Ordinance on Fees for Incentivising Electricity Production from Renewable Energy Sources and Cogeneration defines the amount of incentive fees, which each energy supplier has to include in the energy price (both of tariff and eligible customers), with an aim to raise funds to meet incremental costs of incentivising renewable energy sources and cogeneration, in accordance with the following price list (VAT not included) [6]:

- 0.0089 HRK/kWh in 2007,
- 0.0198 HRK/kWh in 2008,
- 0.0271 HRK/kWh in 2009, and
- 0.0350 HRK/kWh in 2010.

In order to make the system functional, it is required to have the institution of market operator who will organize energy buy-back, regulate and implement financial contractual obligations and collect and organize the distribution of incentives for the utilization of renewable energy sources. In this way the system is created which is rather simple and easily controllable. In the Republic of Croatia HROTE plays this role (Hrvatski operator tržišta energije d.o.o. – Croatian energy market operator). Electricity customers (both tariff and eligible) are charged in their monthly bills with an amount increased by the costs of electricity generation from renewable sources. Market operator distributes the funds raised in this way among electricity producers from renewable energy sources, depending on the amount of energy produced. The producer of renewable energy has to obtain a special permission and status of an eligible producer. The law prescribes that all the plants using waste, renewable energy sources or generating electricity and heat in the same process (cogeneration) in an economically adequate manner and in line with environmental protection principles can obtain the status of eligible producers.

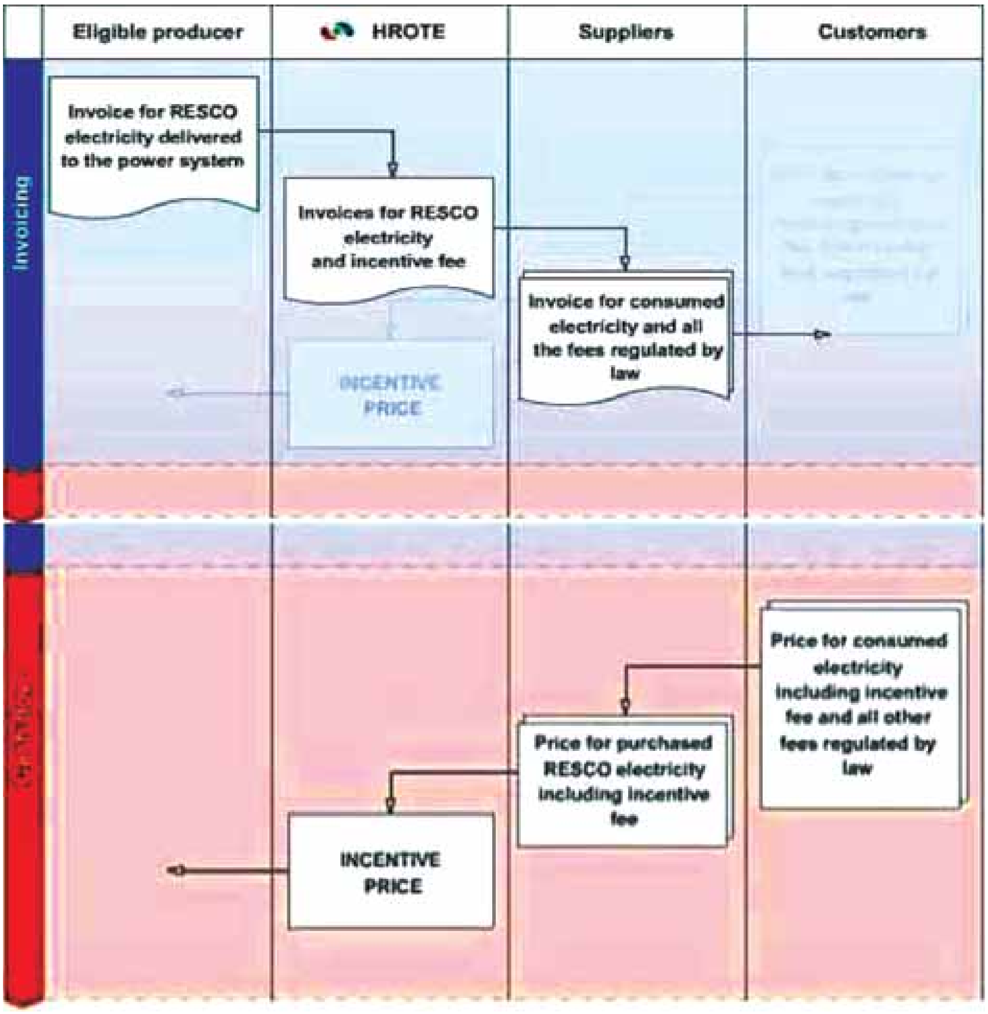

Fig. 4-1 – System of incentives for eligible producers (PP) [11]

According to recent sources [7], electricity producers from renewable energy sources having the status of eligible producers in the Republic of Croatia are entitled to an incentive price in HRK/kWh for the electricity supplied. Pursuant to the Tariff System for Electricity Production from Renewable Energy Sources and Cogeneration [8], a buy-back contract with an incentive price is signed with HROTE for the period of 12 years. Table 4-1 gives incentive prices for the purchase of electricity from various renewable sources, classified according to the output of the plant, 1 MW being the limit.

Table 4-1 – Overview of feed-in tariffs in RoC per type of renewable source and installed capacity [7]

Plant type	under 1 MW	above 1 MW
solar		
solar power plants with installed capacity up to and including 10 kW	3.4	-
solar power plants with installed capacity greater than 10 kW up to and including 30 kW	3	-
solar power plants with installed capacity greater than 30 kW	2.1	-
hydro*	0.69	
energy up to and including 5000 MWh generated in a calendar year		0.69
energy greater than 5000 MWh up to and including 15000 MWh generated in a calendar year		0.55
energy above 15000 MWh generated in a calendar year		0.42
wind	0.64	0.65
biomass		
solid biomass from forestry and agriculture (tree branches, straw, fruit stones...)	1.2	1.04
solid biomass from wood processing industry (bark, sawdust, chaff...)	0.95	0.83
geothermal	1.26	1.26
biogas from agricultural crops (corn silage...), and organic, agricultural and food industry waste (corn silage, manure, meat packaging waste, biofuel production waste...)	1.2	1.04
liquid biofuel	0.36	0.36
landfill gas and gas from water treatment plants	0.36	0.36
other renewable sources (tidal waves, etc.)	0.6	0.5
*installed capacity of up to and including 10 MW. Up to 1 MW the tariff is independent of production, above 1 MW it depend on annual electricity production.		

The amount of tariffs depends also on the share of domestic component in the project and annual price adjustment. More detailed data on this matter could be found in the Tariff System for Electricity Production from Renewable Energy Sources and Cogeneration. [8]

Conclusion

This paper considers small hydro power plants – a new renewable energy source with mionor impact on the environment. An overview of possible implementation of incentive measures is given as well as the description of current status in this field and in the field of available hydro potential. The questions arise by themselves: Is it possible and is it necessary to build small hydro power plants in the Republic of Croatia? Affirmative answers should be given to both questions. The survey of hydro potential has shown that there is enough room for the development in the construction of small hydro power plants and conclusion can be drawn based on realistic assumptions that in case of fully built-up watercourse (by the year 2030) 430 MWh/year of electricity could be generated by small hydro power plants.

The cost-effectiveness of construction on all adequate locations is questionable. However, thanks to a well planned incentivisation policy this issue can also be resolved by giving an opportunity to private investors to participate in future construction. At the moment, the purchasing price based on feed-in tariffs in the Republic of Croatia is more or less at the same level as in the EU, but compared to purchasing prices based on feed-in tariffs that are valid for other renewable energy sources it is relatively low. As a result, capital inflow could be greater for other types of renewable sources, but the time will show the actual impact of such prices on capital inflow.

Electricity generated by small hydro power plants will certainly not take the lead in the field of renewable energy sources in the future, but will by no means be irrelevant in total electricity generation.

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Geothermal Water as Energetic and Mineral Source

Key words: geothermal energy production, reserves, environmental protection, economy, Pannonian basin in Croatia.

Introduction

Geothermal waters are energetic and mineral resources of Republic of Croatia. It is a renewable and environmentally acceptable energy source and a possible trigger of local and country development. Most valuable and proved geothermal potential is encountered in the exploration and production blocks for oil & gas of INA Naftaplin in the Southwest part of the Pannonian basin.

Due to these activities, besides of an understanding of geological features, we have wells and surface equipments in place, useful to complete geothermal water production. Of course, additional development is necessary, as well as tests (4) and specific designs, all of which has to fulfill economic viability and strict environmental sustainability.

Another problem is to develop local markets for consumption, and to get effective support of the state and broader society, already formally declared.

According to our own and world experience, for a step forward in more efficient use of national hydro-geothermal potential, our geological and technological experience from oil as well as geothermal E&P, is crucial in any new project to reach it.

1. What is geothermal potential and how to explore it?

1.1. Basic understanding of geothermal fields in the area

In spite of numerous and sometimes important indications such as Istra's Spa in the Dinaridi area, the Pannonian part in Croatia has most of the geothermal potential of the country (Figure 1).

Fig. 1 – Sub-thermal indications and thermal Spas, beside surface heat follow and geothermal gradient values in Dinaridi and Pannonian areas.

In that area the geothermal characteristics are proven as favorable owing to a highly developed O&G E&P area. Numerous geothermal fields are already determined, and some are tested and in production. Unfortunately this is just a little part of the commercial potential which has to find its place on the market.

The geothermal potential of the area is primarily determined by the regional thinning of the crust, resulting in an enhanced surface heath flow density, due to the formation of heat conductivity. (Figure 2) The hydro-geothermal potential is further determined by the geology favorable to form geothermal field (1).

Geothermal fields are formed in the reservoir sequences of the insulating basin formations, in fractured basement or carbonate rocks or in primary sandstone porosity. If the fractured reservoirs are of massive size, sometime >1000m thick, or in overpressure sandstone formations, the overall surface heath flow picture could be enhanced by such a massive heat convection effect.

A better understanding of the geothermal picture lies in an interactive study of geothermal features and geology.

Surface heath flow density in the stated area varies significantly, due to the mentioned geological features. It varies from very low values of <10 mW/m^2 in the Dinarides to high values of >100 mW/m^2 in the Pannonian (2., Figure 3).

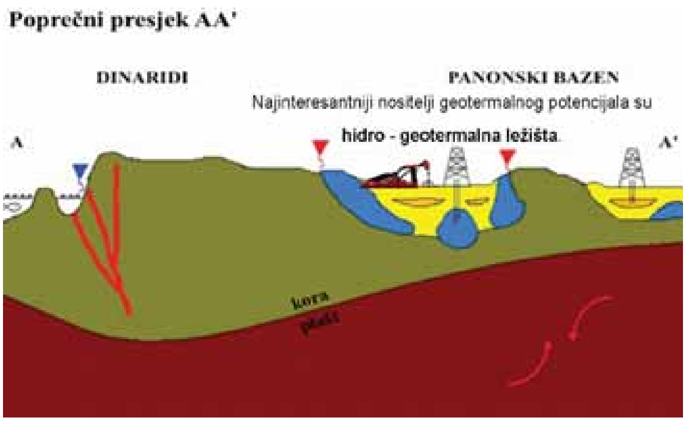

Fig. 2 – Thinning of earth crust from Dinaridi to Pannonian area results in affordable surface heath flow density, due to the thermal conduction from the mantle. These regional anomalies are enhanced by the thermal convection in the major geothermal water bodies.

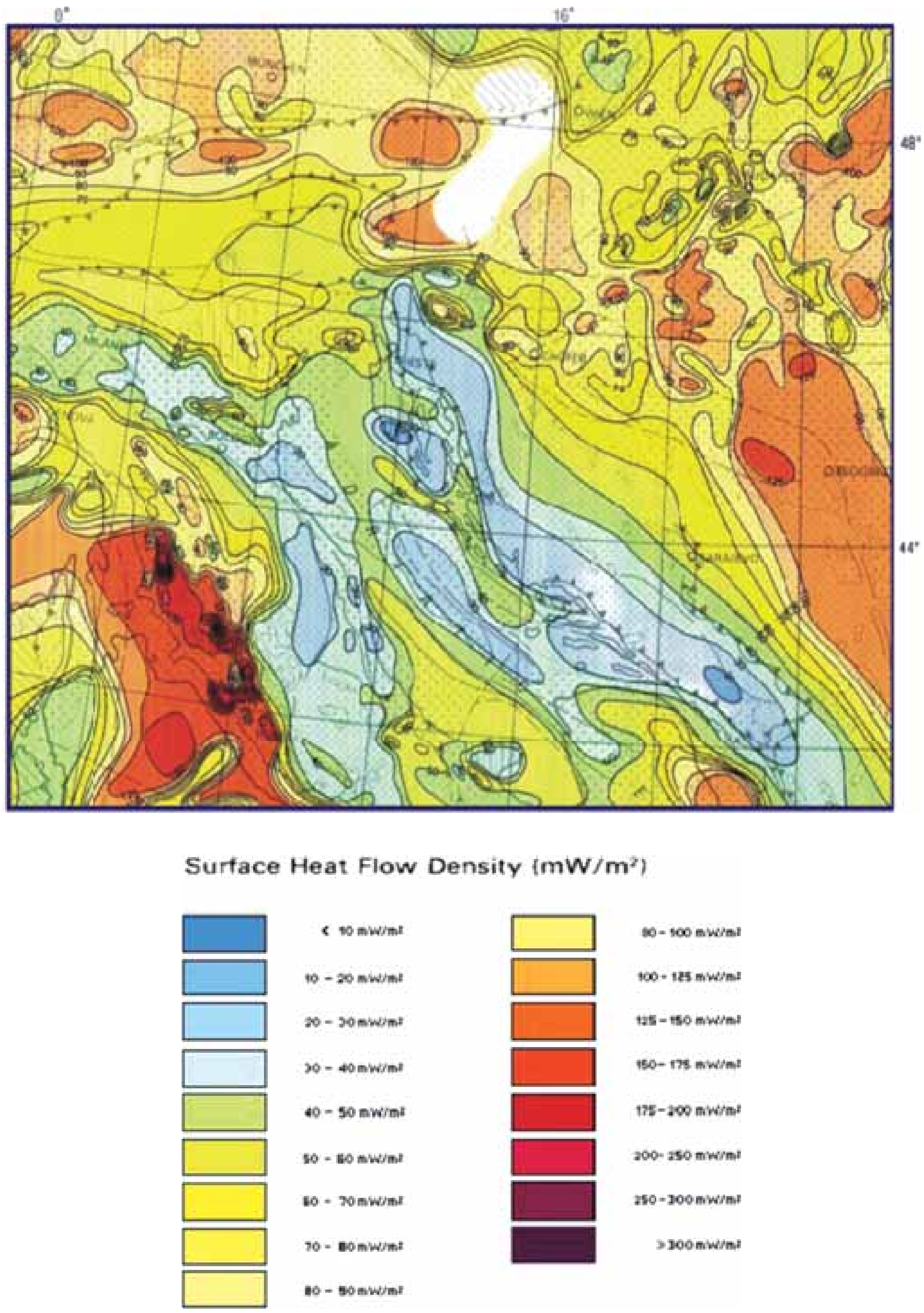

Figure 3. In Croatia surface heath flow density varies from <10 to >100 mW/m^2.

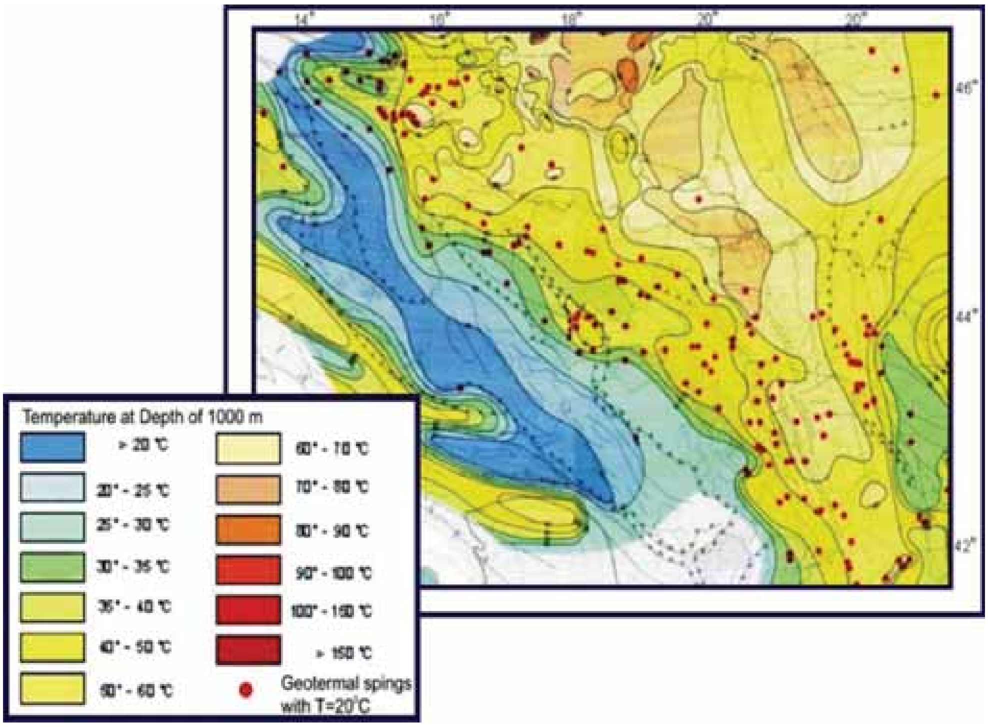

Fig. 4 – Regional anomalies in the Pannonian basin are >48°C/km, and local anomalies within it due to geothermal field as the one at Zagreb could be>70°C/km

Geothermal gradient (G_T) is very important in description of geothermal fields or promising areas. Average values for consolidated crust are 33 °C/km (3,3 °C/100 m). In the Pannonian area we have anomalous high values of 48 °C/km (4,8 °C/100m) and on some geothermal fields, as the ones in Zagreb we have values of >70 °C/km (7,0 °C/100 m) (Figure 4).

Although high geothermal anomalies are often connected with favorable geological features, sometimes this alone is not enough for geothermal field development, due to the missing technical infrastructure, consumption market or environmental issues.

1.2. Fields types

In the Pannonian, the prevailing geothermal field type is hydro-geothermal. In such a field, the main heat transfer is accomplished through the waters of deep aquifers. In defining the geothermal fields we find great similarity to these to oil fields. Reservoirs and traps are almost the same, because the migration path for hydrocarbons and heat transfer is almost the same process. Because of that we can say that the oil field classification according to I.O. Brod can be satisfactory. According to three main geological features we can distinguish geothermal fields in:

- Fractured bedrock and massive carbonate bodies below tertiary cover, with super conductive/productive zones developed along tectonically affected and chemically dissolved carbonate bodies
- Carbonates of Oligocene and mid Miocene age. According to sedimentary environment they form massive to layer type, of minor thickness. Because of carbonate nature, tectonic and chemical events have an important influence on their reservoir properties.
- Sandstones aquifers of the Pannonian and younger formations form layer type fields. In sedimentary environment features, very different bodies are formed from deep water slumps to deltaic and breading streams.

1.3. Field volume and water reserves

Reserve quantification is defined by the Mining law (6 & 7) and the manual on collecting data, and reporting and appraisal of the reserves of row mineral resources (8). Here will be pointed out some crucial elements of hydro-geothermal fields:

Reserves are calculated as $W = \dfrac{A \cdot h_{ef} \cdot \phi}{B_w}$ (m^3)

1.4. Geothermal power and energy

In appraisal of the energy, or amount of heat accumulated in that water, we look at in-place and balanced amounts.

In-place, at certain take of (G_w): $G_w = (c\rho)_{wout} \cdot (T_{wout} - T_s)$ (J/m^3)

Balanced amounts (G_{wp}) is: $G_{wp} = (c\rho)_{wout} \cdot (T_{wout} - T_{w\eta})$ (J/m^3)

Heat power (Pt)) is: $P_t = q_w \cdot (c\rho)_{wout} \cdot (T_{wout} - T_{w\eta})$ (W$_t$)

Geothermal heat exploitation per year is: $E_g = P_t \cdot t_g$ (Wh$_t$)

1.5. Well production

Darcy equation for well yield: $q_w = \dfrac{2\pi \cdot k \cdot h \cdot (p_R - p_{tf})}{\mu_w \cdot B_w \cdot \ln \dfrac{r_d}{r_w}}$ (m^3/s)

For some important parameters, such as h_{ef}(m), it is possible to measure them directly, or calculate them indirectly though the results of hydro-dynamic measurements.

It is sometimes possible to establish the reservoir volume V_p (m^3) by analyzing the pressure curve by the steady production.

For wells production, a characteristics productivity index IP (m^3/day bar) is often defined.

1.6. What influences quality, temperature and chemistry of geothermal water

Quotient of overall field potential and yearly productions show as how many years (t_{cT}) we can produce it with constant temperature (3).

$$t_{cT} = \frac{A \cdot h_{ef} \cdot (c\rho)_{\mathrm{P}}}{Q_w \cdot (c\rho)_w} \text{ (years)}$$

After the constant temperature production, prediction of declining temperature T_R (K, °C) is appraised.

$$T_R = T_{win} + (T_{wi} - T_{win}) \cdot erf \frac{A \cdot \sqrt{\lambda \cdot (c\rho)_m}}{q_w \cdot (c\rho)_w \cdot \sqrt{t_{cT} - \dfrac{A \cdot h \cdot (c\rho)_R}{q_w \cdot (c\rho)_w}}} \text{ (K, °C)}$$

So far, we can get an idea about basic parameter prediction. Things become more complex by introducing the next steps.

- techniques-technologies in field production
- economy of geothermal project

Along that process it is important to take care of the quality of crucial data and the level of risk and uncertainty they carry with them in the overall predictions.

1.7. Howe to use geothermal water

Geothermal potential of the Republic of Croatia is recognized as an important national resource since year 1995 (9) and a multidisciplinary approach to it is applied in the project GEO ENA (10). In the Lindal Diagram we can see a spectrum of the uses of geothermal energy

20-110°C (hot water)

20–30°C: swimming pools, biodegradation, fermentation, de-icing, snow melting, hatching of fish, fish farming

40°C: Soil warming

50°C: mushroom growing, balneology

60°C: animal husbandry, greenhouses by combined space and hotbed heating

70°C: refrigeration (lower temperature limit)

80°C: space heating (buildings and greenhouses)

90°C: drying food, intensive de-icing operations

100°C: drying of organic maters, grass, vegetables etc, washing and drying wool

110°C: drying and curing of light aggregate cement slabs

110-200°C (saturated steam)

120–130°C: evaporation in sugar refining, extraction of salts by evaporation and crystallization, fresh water by distillation, multy-effect evaporation, concentration of saline solutions

140-180°C: ELECTRICAL POWER PRODUCTION AND INDUSTRIAL STEAM

140°C: drying farm products at high rates, canning of food

150°C: alumina via Bayer's process

160°C: drying of fish meal, drying of timber

170°C: drying of diatomaceous earth

180°C: drying of highly concentrated solutions, refrigeration by ammonia absorption, digestion in paper pulp (Kraft), heavy water via hydrogen sulphide process, To improve the economy we need higher temperatures and higher temperature takeoff, shallower production depths, higher production rate, and energy consumption throughout the year. To reach these goals, consumption should be organized in a cascade manner, and electric power production is appreciated.

1.8. Rational and environmentally safe production

Geothermal energy is considered clean from emitting greenhouse gases, and other unacceptable products into the environment. In most cases to reach these standards it is necessary to establish a closed-cycle geothermal production. High saline brine, if not used for mineral production, has to be re-injected into the geothermal reservoir. It could be expensive, but in most cases, has no alternative.

1.9. Production cases study in the Zagreb area

For three main geothermal reservoirs, production possibilities are analyzed from testing results of several abandoned oil and geothermal wells in Zagreb area (11.; Figure 6).

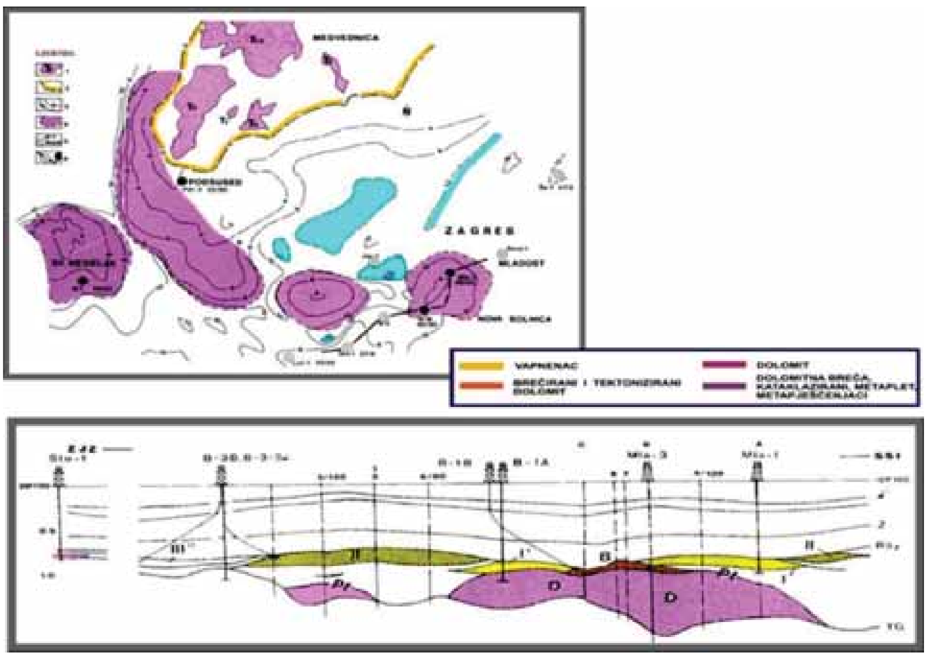

Fig. 6 – Locations and geological settings of the wells suitable for geothermal water production, from three main geothermal reservoirs, in the west Zagreb area.

Fractured bedrock and massive carbonate bodies below tertiary cover								
Well	Depth		Well Head	Well Head	Sup-posed	IP	Injec-tion	Injec-tion
	(m)		Flow	Tempe	Max Flow		Flow	Pres-sure
	Top	Botom	(l/s)	°C	(l/s)	(m^3/d bar)	(l/s)	(bar)
KBNZ-1B	816	1.065	88,0	82	50	1.300		
Mla-3	875	991	80,0	80	<50	1.220		
KBNZ-2A	1.118	1.227	16,7	70			35	50
Sa-1	222	800	16,7	26	30			
Sa-2	222	800	16,7	26	30			
PdTE-1	223	252	30,0	36				
PdTE-2	230	601	30,0	36				
Stupnik-1	862	1.136	8,1	57				
KBNZ-1A			6,9	68				
N-1	830	1.238	5,8-9,7	65				
Lak-1	1.261	1.317	>1,5	61				

Carbonates of Oligocene and mid Miocene age								
Well	Depth		Well Head	Well Head	Sup-posed	IP	Injec-tion	Injec-tion
	(m)		Flow	Tempe	Max Flow		Flow	Pres-sure
	Top	Botom	(l/s)	oC	(l/s)	(m3/d bar)	(l/s)	(bar)
Mla-2	807	837	74,0	64		1.060	50	10
Mla-1	840	1.057	3,4	72			25	36
KBNZ-3á	802	825	25,6	57		900		25
Luč-1			5,6	55				
Šal-1	945	1.014	4,0	58				
Veleševac-1	2.035	2.645	0,8	90				
Dka-1	1.018	1.060	0,6	48				
Sav-1	1.740	1.835	0,5	32				

Sandstones aquifers of Pannonian and younger formations								
Well	Depth		Well Head	Well Head	Sup-posed	IP	Injec-tion	Injec-tion
	(m)		Flow	Tempe	Max Flow		Flow	Pres-sure
	Top	Botom	(l/s)	°C	(l/s)	(m3/d bar)	(l/s)	(bar)
IvaT-1	1.271	1.308	2,8	61				
Ze-1	753	891	4,2	51				

From the tables it is possible to get an idea about the crucial parameters.

1. How the production started in the Zageb area

A first geothermal purpose testing was done on the abandoned oil exploration well Stupnik-1. Production is now at SRC Mladost, Lučko at the location of the new university hospital at Blato and at Naftalan in Ivanić Grad.

At SRC Mladost the trial production started with Well Mla-1 in the year 1981. Developed with Mla-3 producing and Mla-2 injection wells, production was raised on 165000 m^3/year

At Lučko the trial production started with the Well Luč-1 in year1986 and the production rate is set on 40000 m^3/year.

Production possibilities at well KBNZ-1 are similar to those in Mladost, but have never been developed to full scale, as was the case with two more well pairs in the same location at the new university hospital at Blato.

In the Hospital center Naftalan in Ivanić Grad the water from Well Iva-T1 is used for balneology.

2. Categorization and classification of geothermal source development

The Mining law (6; 7) and its sub ordered statements (8) classifies reserves of mineral and thermal water, to define how much they are explored and/or developed for production, according to natural and technological possibilities of production, on the balanced or not balanced part, and according to economic criteria on the viable and non-viable.

In Exploration we can distinguish **undiscovered potential** categories as: supposed-D2 on the basis of regional studies, prognosed-D1 on the basis of semi-regional studies, perspective-C2, explored in enough detail with indirect methods/prepared for direct testing by well drilling. **Discovery** leads us to declare **unproved reserves**, **possible** C1 and **probable-**B, where the level of testing opens a way to investments in the development of the field, while when the development is completed we declare a **proved**-A category (5).

Balanced reserves are those recovered part by the natural conditions and part by contemporary-techniques-technologies and economic viability. Parts of reserves we can't recover under these conditions we declare **un-balanced**.

3. Sensitivity test approach to building an economically viable project

Design of geothermal production on a certain geothermal field consists of not only geological and technical problem solving, but also of a search and development of the market, in order to get enough high enough revenue to cover the high investment, operating costs and some profit.

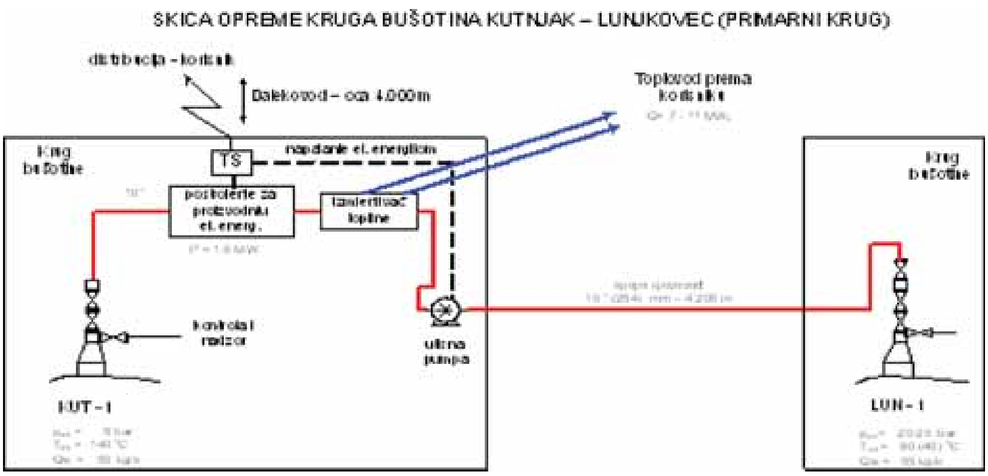

Fig. 7 – Technical solution (12.) Kutnjak-Lunjkovec primary circuit, producing-injection well couple Kut-1 Lun-1

An additional problem for a new-comer on the market is that energy prices are expected to be more convenient than the cheapest competing/natural gas. Besides that, it is hard to find all year round consumers, so producing electricity is a must, if possible. Case for such a complex field is Kutnjak-Lunjkovec.

There we tested the economical viability for three cases of production: A-electric energy, B-heat and C-electric energy and heat cascade use.

Basic predictions are presented earlier (12). There is one existing producing well with these characteristics: $q_w = 4.600\ m^3/d$, $T_w = 140^oC$, $P_w =$ 6 bar

Case A: production of electric energy

$\Delta T = 60^OC$, t = 8 400 h/year (12 month.), expected power P = 1,5 MW,

P_{NETO} = 1.0 MW, E = 8.400 MWh/year

Case B: production of heath

$\Delta T = 50^OC$ t = 3 600 h/ year (5 month.), power P = 11 MW_t,

heat energy E = 40 000 MW_{ht}/year

Case C: production of electric energy and heath in cascade use

$\Delta T = 60^OC$ i t = 8.400 h/ year (12 month.), expected power P = 1.5 MW,

P_{NETO} = 1.0 MW and electric energy: E = 8.400 MWh/year, cascade use of heat power P = 7 MW_t, heat energy E = 25 600 MW_{ht}/ year.

Economy analysis (13) according to price rates from the second half of year 2005, and exchange rate 6,05 Kn/1 USD, selling price of electrical energy 0,056 USD/kWh and heath energy 0,029 USD/ kWh_t.

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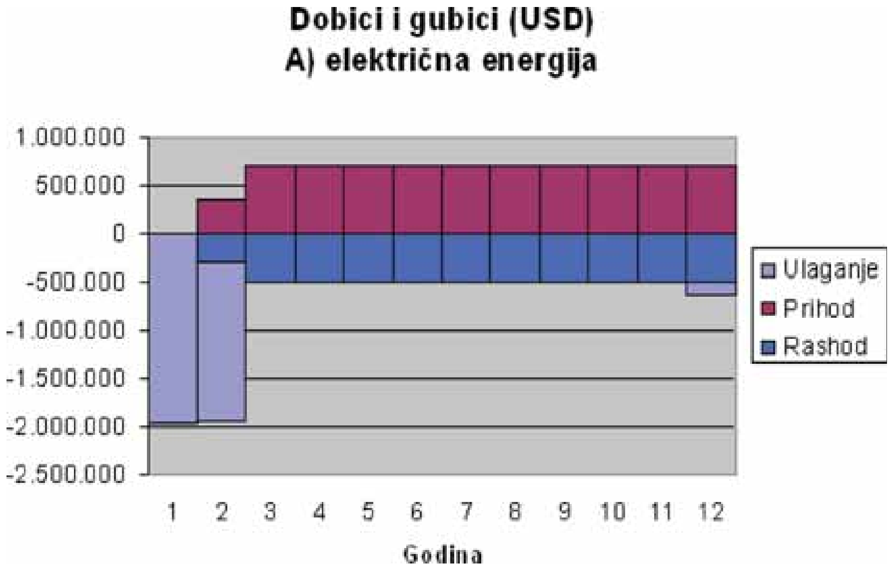

Fig. 8a – Cash flow in case A – production of electric energy: the development and production of geothermal field Kutnjak-Lunjkovec. Estimated investments 3,73 MM USD (violet), year income 0,69 MM USD (red) and year expenses 0,51 MM USD (blue)

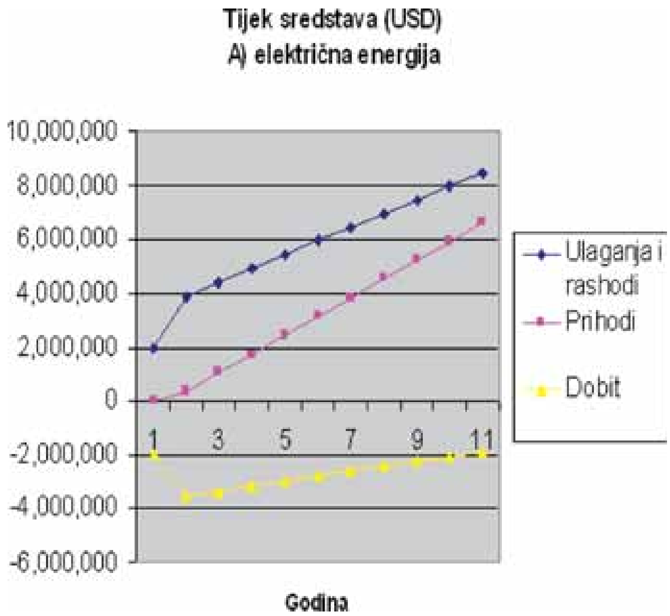

Fig. 8b – Case A – production of electric energy at the geothermal field Kutnjak-Lunjkovec observed life: costs (blue line), income (red line), where revenue doesn't shoe positive (yellow line)

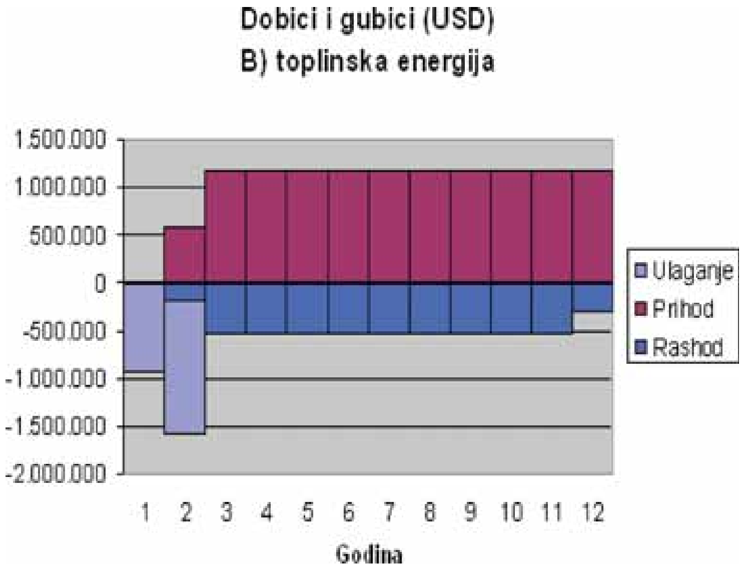

Fig. 9a – Cash flow in case B – production of heath: the development and production of geothermal field Kutnjak-Lunjkovec. Estimated investments 2,30 MM USD (violet), year income 1,16 MM USD (red) and year expenses 0,52 MM USD(blue)

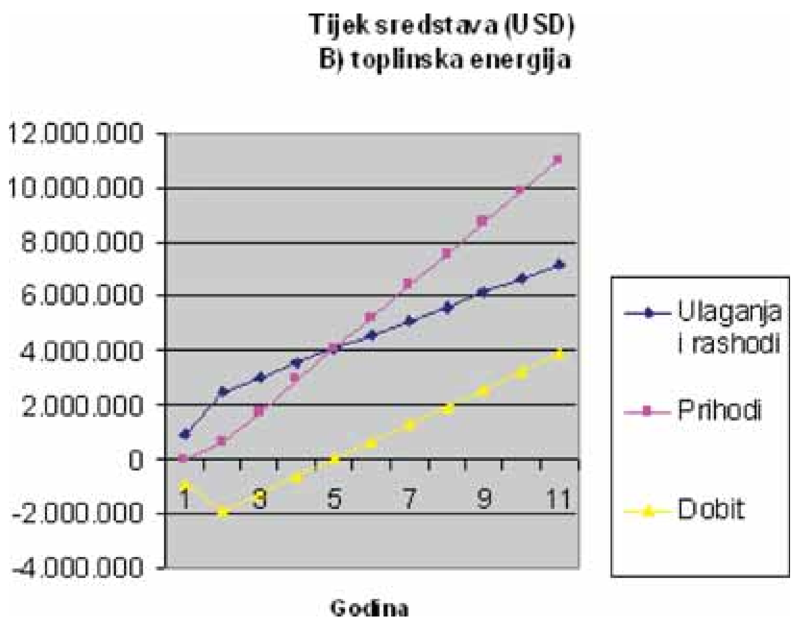

Fig. 9b – Case B – production of heath at the geothermal field Kutnjak-Lunjkovec observed life: costs (blue line), income (red line) and revenue is positive after 4 years (yellow line) earning 3 MM USD

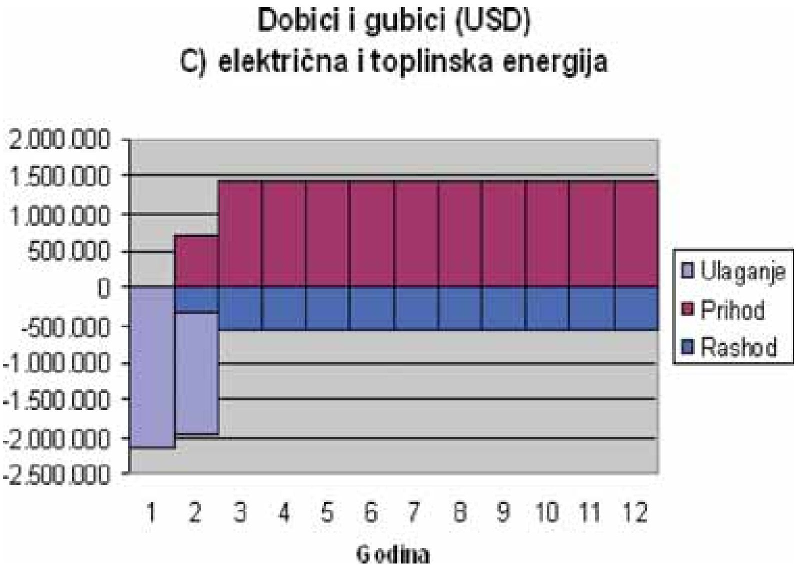

Fig. 10a – Cash flow in case C – production of electric energy and heath in cascade use: the development and production of geothermal field Kutnjak-Lunjkovec. Estimated investments 3,80 MM USD (violet), year income 1,44 MM USD (red), and year expenses 0,57 MM USD

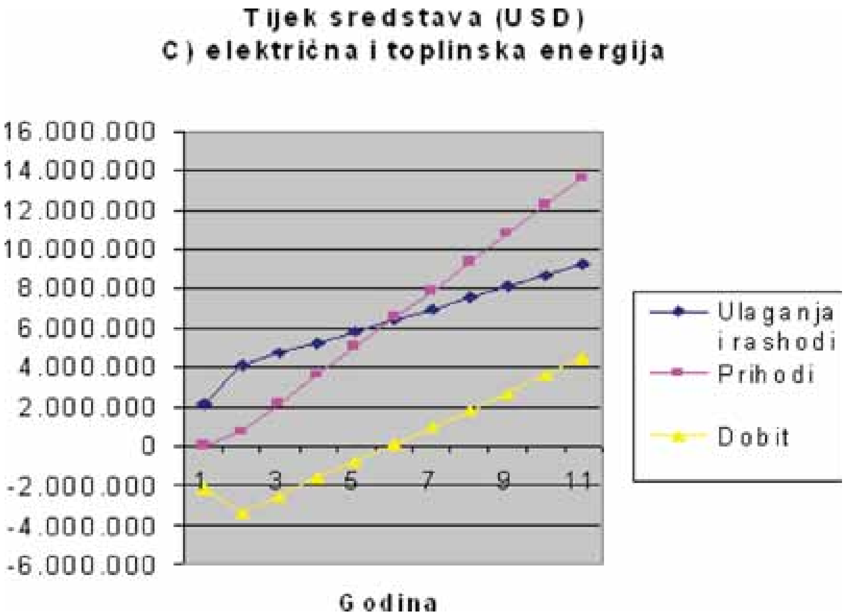

Fig. 10b – Case C – production of electric energy and heath in cascade use at the geothermal field Kutnjak-Lunjkovec observed life: costs (blue line), income (red line), and revenue is positive after 4 years (yellow line) earning 4 MM USD

This study has not included high investments by INA-Naftaplin in the exploration and testing of these Wells in the range over a MM USD, which strongly enhanced the very tiny revenues, reached by multiple and cascade use. Such projects need a strong support from the state; European and broader world society for the encouragement of the use of this dispensable, clean and renewable energy.

- The discussed geothermal resources in the Pannonian area have a disadvantage to be deeper in the subsurface than some near surface vents as those in Island, Toscana…but there is the convenience of existing oil exploration and production facilities and knowledge as the initial support in geothermal production development.
- Geothermal energy can improve the energetic independence of the country, diminish the emission of greenhouse gasses and even become economically important.
- A number of activities and industries in the country can switch to or develop on the geothermal energy and form an important market in: agronomy, secondary industry and tourism.
- Reasonable and stable geothermal energy price policy, beside geological and technological development can do much in establishing this new industry in our country and abroad.

4. Conclusion

According to positive experiences untill now, the future meaningfull development of geothermal production is possible (14) in a combination of gradual development according to the “Bizovacki Jarak” model and a maximal usage of existing technological objects and production in accordance with environmental safety. In order to initially speed up this proces, a grouping of all available means within the company and outside of it for the achievement of geothermal production in the following objects in strongly recomended:

Zagreb geothermal field so far with its production fulfils the needs for space heating and water in the recreation centre Mladost (Figure 6) with only a minor part of its capacity. Two to three such capacity twin wells systems are built on the bank of the Sava river, waiting for a consumer.

Kutnjak-Lunjkovec in Podravina, north from Koprivnica (Figure 11) which has recently been better explored within a wider analysis (16) and

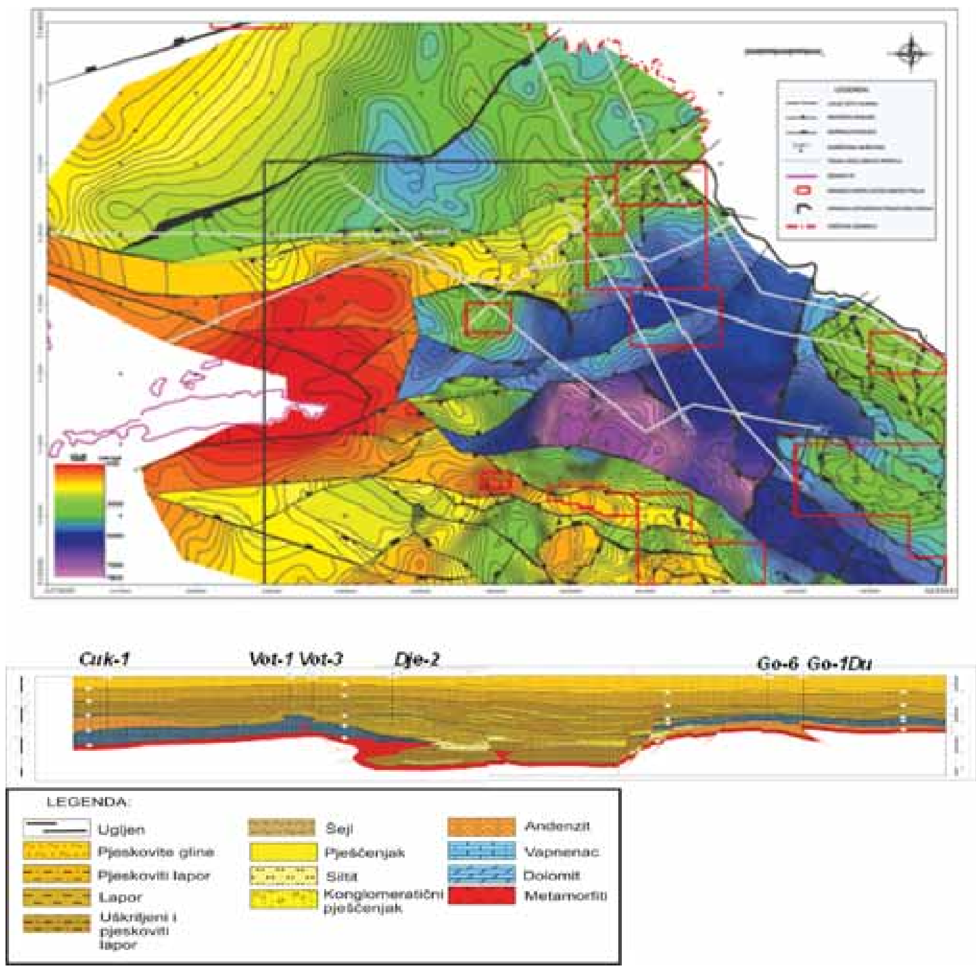

Fig. 11 – Structurulal map of the north Podravina area, on the base of the Tertiary/Top carbonate reservoir on the Kutnjak–Lunjkovec, and the geological cross section, running north from the mentioned field to the Gola Plato in the east on the Hungarian border. Between mostly insulating rocks colored white, brown and red except sandstone colored, yellow (some of which are good aquifers), we can find limestone and dolomite carbonates (colored blue) where the best geothermal reservoirs of the area are encountered.

has a nearly complete documentation. This agriculturally and economically very advanced and dynamic area can activate a number of similar objects.

Velika Ciglana, near Bjelovar has a great potential in resources and existing infrastructures (Figure 12), as well as some unsolved problems,

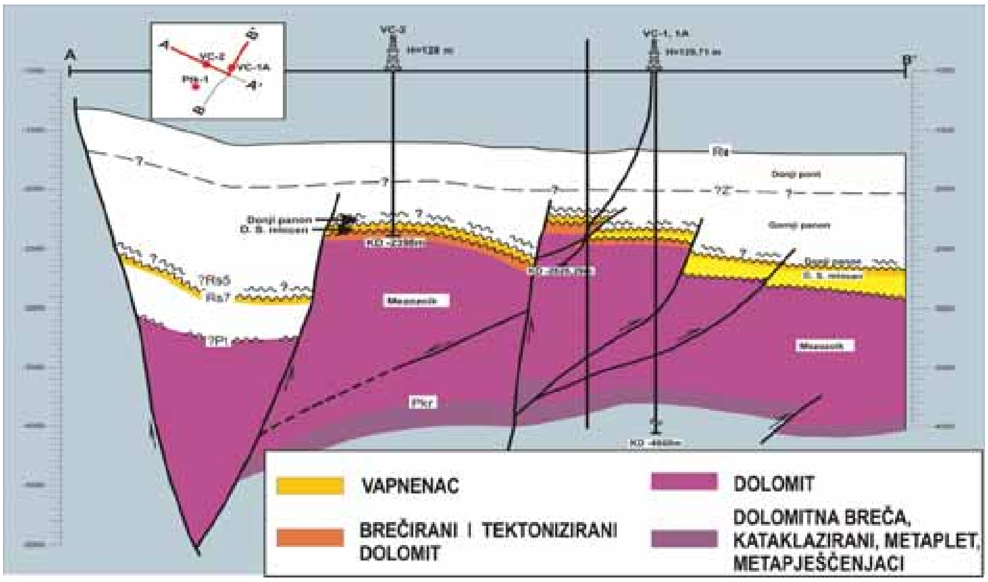

Fig. 12 – Geological ceros section through geothermal field Velika Ciglena, showing super productive zones on the top of several thousand meters dolomite sequence and along mayor fault zones, simultaneously with part of production and injection wells system.

which could be solved with a satisfactory approach (17; 18) which, in turn, could put their production on stream.

Beničanci oil field, situated half way between D. Miholjac and Valpovo, is, among other locations, one of the most important oil producers in Croatia but it is also very important for geothermal production. Some solutions will be tested soon (19), from which it is expected to find local consumers in agriculture and secondary industrial purposes. Besides that, there are attempts to test combined geothermal and enhanced oil production.

From these few examples we can see a huge space for rising production, acceleration of projects, finding appropriate and new solutions on already distinguished fields and opening a lot more in the Pannonian area.

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Possible Impact of EU Water Framework Directive on Energy Utilization of Water Resources in Croatia

Summary

During the nineties of the past century a debate was launched within the European Union on the re-definition of key water management principles. As a result, a new legal act – Water Framework Directive, 2000/60/EC, has been adopted. The document was published in the Official Journal of the European Communities on 22 December 2000, and entered into force the same day.

The adopted Directive rests on the consensus of European countries on basic principles of comprehensive water management, but also allows for a certain amount of freedom in the estimate of the level of implementation of those principles, given natural, socio-economic and institutional circumstances of individual countries.

The passing of the Water Framework Directive (WFD EC) represents a turning point in the development of European water policy. It establishes the framework for Community's actions in the field of water policy with the purpose of protecting inland surface and ground waters, transitional waters and coastal waters.

The goals set by WFD are mainly of environmental nature, which contradicts with historical use of water in almost every EU Member State. The problems related to the implementation of Directive differ from one district to another, whereby the use of hydro power is one of most affected fields since in the majority of cases it results in hydrological and morphological interventions in the water regime, while WFD defines "natural" as the targeted status of water and aquatic ecosystems. As for energy utilization of water, the most significant problems related to future utilization of water potential and the implementation of WFD are the ban on further deterioration of water status, possible increasing minimum flows, more stringent restrictions on maximum output, and the additional costs to preserve water ecosystem.

Being an EU candidate country, the Republic of Croatia is required to progressively adopt and implement all common rules of conduct and standards established at the level of the European Union. In line with the European legal system, Croatia is required to fully transpose the provisions of particular directives contained in the EU *acquis communautaire* into its national legislation.

The undertaken international obligations have influence on the water management policy in Croatia, which is increasingly being directly or indirectly controlled by international institutions and neighboring countries. Key instrument of such control will be common (coordinated) management plans for international aquatic districts with a program of measures to meet the set objectives.

Since Hrvatska Elektroprivreda is a significant user of water in the Republic of Croatia, it is interested in participating in the development of water management plans for river basin districts that constitute the basis of water management. Hrvatska Elektroprivreda is also a specific user of water and as such it is interested in determining economic significance and efficiency of use of water for electricity generation purposes. The objectives of energy policy, such as promoting energy from renewable energy sources and/or improving security of supply, can be met only by using hydro power in the best possible way (in the existing power plants and potential new capacities).

Key words: Water Framework directive EU, hydropower, cost of water service, river basin management plan

1. Introduction

In the middle of the 1990s a new European water policy on an integrated approach to water protection started to take shape by regulating the field of water management. The preparatory process for the adoption of an appropriate legal document was open and time-consuming, with a wide range of interested stakeholders (national, regional, and local governments; water agencies; providers of water services; water users; environmentalists) from EU Member States as participants. During the drafting of the document there were differences between the representatives of Member States and the European Parliament. The representatives of Member States advocated longer deadlines and greater freedom in the setting of objectives, while the European Parliament tried to integrate specific objectives and fixed deadlines related to water management into the document. Eventually, a compromise document was adopted, the EU Water Framework Directive (WFD), which rests on the consensus on the basic principles of comprehensive water management, but also allows for a certain amount of freedom in estimating the level of implementation of those principles, given natural, socio-economic and institutional circumstances in individual countries.

The EU Water Framework Directive, which entered into force on 22 December 2000 with its publication in the Official Journal of the European Communities, represents a turning point in the development of the European water policy (1). It establishes a common, binding framework for the actions of EU Member States in the field of water policy. It is important to stress that this is primarily an environmental document, and that it is as such aimed directly at the objectives of protecting water and the aquatic environment within sustainable water management policy.

The basic long-term goal of implementing the Directive is to achieve good water status, which refers to all water – surface water (inland, transitional, and coastal) and groundwater. The good water status implies at least “good” chemical and ecological status of surface water (with the exception of highly modified water bodies for which good ecological potential is required), or at least “good” chemical and quantitative status of groundwater. By introducing the “ecological status” the scope of quality indicators for the classification of water status has been expanded, because biological quality indicators are key for assessing the ecological status, along with the accompanying hydromorphological and physico-chemical indicators. Furthermore, it calls for the fulfilment of additional standards for the areas which require special protection (water intended for human consumption, water intended for the cultivation of economically significant aquatic species, water intended for bathing and recreation, water sensitive to nutrients, areas intended for the protection of aquatic and water-dependant habitats and species).

The achievement of good water status, as the principal obligation which applies to all water bodies, must take place within 15 years from the adoption of the WFD (i.e. by 2015), or in two subsequent six-year planning periods (at the latest by 2027). Any deviation from the established objective (in terms of the result or the deadline) has to be properly justified. The aim is permanent management, as a constant activity, which will be implemented in regular six-year planning cycles (the first one ends in 2015), and continued improvement of the knowledge about the field under management and the process under implementation. Integration and transparency as the main features of the management process integrate all functions of water, and they imply active participation (information, consultation) of all stakeholders, clear socio-economic parameters (costs, benefits) for all of the made decisions, and monitoring and regular reporting on the results of implementation.

The EU WFD introduces *river basin management plans* as the main planning tool for achieving the set water protection objectives. A river basin district, defined as the area of land and sea made up of one or more neighbouring river basins together with their associated groundwater and coastal waters, represents the main planning unit for water management. A management plan elaborates the implementation of the EU WFD in a river basin district, i.e. it defines specific water protection objectives and measures for their achievement, taking into account all the links between water in the environment and various water uses and users. According to the EU WFD, first river basin management plans for all river basin districts have to be developed by the end of 2009, and then continuously reviewed every six years. Their implementation is within the sole competence of Member States, which have to regularly report to the European Commission on the results of their implementing activities.

The WFD introduces a *water body* as the main analytical unit for water management. It represents a clearly defined and significant element of water which describes the status and defines the objectives of water protection, for which environmental objectives have to be achieved. A special group of surface water bodies are "artificial water bodies" and "heavily modified water bodies" for which less stringent environmental objectives in water protection are allowed than good ecological status, which is a general requirement for other water bodies. An artificial water body is a body of surface water created by human activity, while a heavily modified water body is a body of surface water which as a result of physical alterations by human activity is substantially changed in character.

Being an EU candidate country, the Republic of Croatia is required to progressively adopt and implement all common rules of conduct and standards established at the level of the European Union. In line with the European legal system, Croatia is required to fully transpose the provisions of particular directives contained in the EU *acquis communautaire* into its national legislation. With the adoption of the Water Management Strategy (2) and the Act on Amendments to the Water Act (3) first steps have been made in the implementation of the EU WFD. Full transposition of the EU *acquis communautaire* into national legislation is a precondition of the entry of the Republic of Croatia into the European Union.

2. Basic determinants of water use according to EU WFD

The development of mankind and civilisation was always very closely associated with the use of water. The character of water is defined by the requirements of the population living in inhabited areas, above all in the densely populated European area. These requirements may be protection against floods and natural disasters, the development of new transport and traffic routes, measures in the field of population water supply, general infrastructure measures and, of course, the use of water to generate energy, from purely mechanical use up to the modern hydropower plant.

The Water Framework Directive represents a comprehensive instrument with the goal of protecting all bodies of water as part of marked environmental protection, while water use is put into the background. It uses the undisturbed, natural body of water as the reference condition. Such approach implies substantial potential risks for all forms of the present and future water use, because it includes the following determinants for water management:

- to prevent further degradation and protect the status of water and water-dependent ecosystems;
- to promote sustainable water use and long-term protection of available water resources;
- to protect and improve the aquatic environment through specific measures for the progressive reduction or elimination of discharges, emissions, and losses of priority substances;

- to ensure the progressive reduction of pollution of groundwater and prevent its further pollution;
- to contribute to mitigating the effects of floods and droughts.

It is very important to notice that the EU WFD introduces a concept of integration into the water management process. In addition to legislation, this concept includes the following:

- integration of water resources – it encompasses all water bodies in the nature;
- integration of environmental objectives in the field of water – it encompasses all water quality elements on which the ecological function of water depends (biological, hydromorphological and physico-chemical quality elements);
- integration of the functions of water (multi-sectoral approach) – it refers to the coordination of the ecological functions of water in the nature and its socio-economic significance for a number of sectors and activities (health function, production function, traffic function, recreation function, aesthetic function, etc.);
- integration of various categories of pressures in the analysis of water status and impacts on water;
- integration of the widest possible spectrum of measures into the achievement of objectives in water protection, including economic measures/instruments promoting sustainable water use;
- integration of disciplines (interdisciplinary approach) in resolving problems in water management;
- integration of all interested subjects (stakeholders, the public) in the planning and decision-making in the field of water;
- integration of all management levels (national, regional, local) in the decision-making in the field of water;
- integrated management of integrated river basins, regardless of administrative borders (international coordination).

The EU Water Framework Directive introduces the concept of "water use" to designate those human activities that have a significant impact on the status of water in a river basin district. It is clear from the definition that the standard scope of water use is reduced only to the activities which are really relevant for the planning of water protection measures on the area concerned. This is the result of a pragmatic approach, which is focused on the situations significant for water management in which there is a conflict of interest between the water use function and the ecological function of water. The inclusion of a certain activity into the category of water use depends on specific water circumstances on the area concerned. An activity is or is not categorized as water use depending on the intensity of pressures, i.e. on the significance of impacts caused in the aquatic environment.

One of the obligations stemming from the implementation of the EU WFD is the introduction of economic measures in water management in line with the principle that water has an economic value for all of the interested users and that it shall be treated as an economic good. The starting assumption is that the appropriate price of water use, applied in accordance with the "user/polluter pays principle", can be an efficient economic measure for encouraging a more rational use, i.e. reducing pressures on water. Eventually, one should strive towards the "economic price", which implies that the users cover the entire economic cost which certain water use creates to the society as a whole (to the population, economy, environment; present and future generations), and not only direct investments required in order to make water from the nature serve a certain purpose.

In order for the pricing policy to be able to fulfil its purpose in the protection of water and aquatic environment, it has to encompass all the categories of costs related to water use. In addition to direct financial costs required for the "production" of the service at the level of the service provider, this also includes external costs borne by other present or future subjects, such as: environmental costs, in terms of the damage inflicted by water use to the environment and ecosystems and everyone using them, and costs of the water resource, in terms of the lost opportunities for other uses due to the exploitation of resources above the natural rate of recovery or repair.

Water use is a wider term, and according to the EU WFD it encompasses water services together with other activities which according to the analysis of pressures and impacts have a significant impact on the status of water. The EU WFD does not give a list of activities to be included in the group of water services, but only general definitions, leaving the selection up to the Member States depending on water management circumstances in a river basin district. In principle, water services are all services which provide, for households, public institutions, or any economic activity: abstraction, impoundment, storage, treatment, and distribution of surface water or groundwater, and collection and treatment of wastewater. In this process these services are neither water users nor water polluters, but rather intermediaries between water in its natural environment and real users (households, economic activities, institutions).

The term "water services" is emphasized because there is an important difference between water services and other uses in terms of the recovery of costs. Water services require a cost recovery analysis and reporting on the measures taken in that regard. The cost recovery provision does not apply to water use. According to our knowledge, there are great differences among European countries regarding the implementation of the cost recovery provision. It is generally agreed that public water supply and collection and treatment of urban wastewater are activities to which the cost recovery principle has to apply and all the countries deal with them, either as individual water services or groups of services. Some countries are considering a wider list of water services, which most frequently include the following:

- supply of irrigation water;
- drainage of rainwater from agricultural areas;
- flood protection (construction and maintenance of systems);
- management of water resources (quantity, quality);
- production of hydropower (the Netherlands, France, Portugal, Romania, etc.).

For such water uses, the subject of analysis must be costs which include direct costs of providing the service, as well as external – environmental and resource – costs. By integrating environmental costs and costs of water resources into the water price, the wish is to impact the behaviour of users and thus contribute to the sustainability of water resources and aquatic ecosystems and, eventually, to the reduction of total costs in water protection.

3. Characteristic environmental impacts of hydropower installations

It's a fact that in addition to its ecological function, water has a significant development role. The living conditions of the population and the level of economic activities on a certain area significantly depend on the level of development of water services and other aspects of water use which contribute to the total national product and prosperity. The original drivers of pressures and potential negative impacts on the status of water are the needs of the population to improve their living conditions, the needs of economic subjects for a more profitable production, and the needs of the society as a whole for economic growth, balanced development, and protection from floods.

It has to be pointed out that even though the EU WFD is primarily focused on environmental objectives, it coordinates the achievement of the desired level of protection of water and aquatic and water-dependent ecosystems with developmental needs and capacities of water users in a river basin district. In line with that, it allows postponement, mitigation and deviations from some of the established environmental objectives if supported by justified socio-economic reasons. An analysis has to be made for each water use in order to connect socio-economic indicators with the pressures generated by a particular activity.

Hence, one of the main tasks of the economic characterisation of a river basin district is to assess how much certain water use contributes to the economic development of the river basin district, and what is the relationship between economic contribution and pressures on water generated by such use. Water services are required to respect the cost recovery principle and to report on the measures taken in that regard, while other water uses are expected to make appropriate contribution to the recovery of costs of water services developed in order to prevent adverse environmental impacts generated by such use. The aim of the analysis of recovery of costs is to ensure financial sustainability of activities.

The indicators related to the consumption and pollution of water in electric power supply will definitely be favourable because it is neither a big consumer nor a big polluter of water. Electric power supply generates another type of water pressures, such as the abstraction of cooling water, discharge of thermally polluted water, water impoundment, regulation of flow, and morphological alterations. The identification of potential conflicts between the economic development and water protection paves the way to potential partial mitigation of objectives of the EU WFD. In accordance with the above, the production of electricity has to be the subject of economic analysis if it's present to a significant extent on the analysed river basin district. Due to different nature of pressures and impacts on the status of water, two branches of electric power supply, hydro power supply and thermal power supply, have to be analysed separately.

Thermal power facilities, in terms of the category of pressures (abstraction of cooling water, discharge of thermally polluted wastewater), may, but don't have to, be identified as a significant water use, depending on the intensity of pressures or the significance of impacts. Practice shows us that large thermal power plants often have no significant impact on water quality if they lie on the water bodies of high yields or high thermal capacities.

Hydropower facilities impact the status of water in an entirely different manner, and their possible impacts are illustrated in Figure 1. Constructing a hydropower plant is almost always associated with physical interventions and hydromorphological alterations of water bodies which frequently substantially and irreversibly modify their character. There is therefore no doubt in classifying hydropower supply into the category of significant water users. Since the production of hydropower includes a number of activities typical for the definition of water services (water impoundment, abstraction and transport of water), it is possible to analyse hydropower supply as a water service as well (which is a case in several EU countries).

By reducing the selected socio-economic indicators to a unit quantity of abstracted/consumed water, i.e. to a unit quantity of discharged waste-

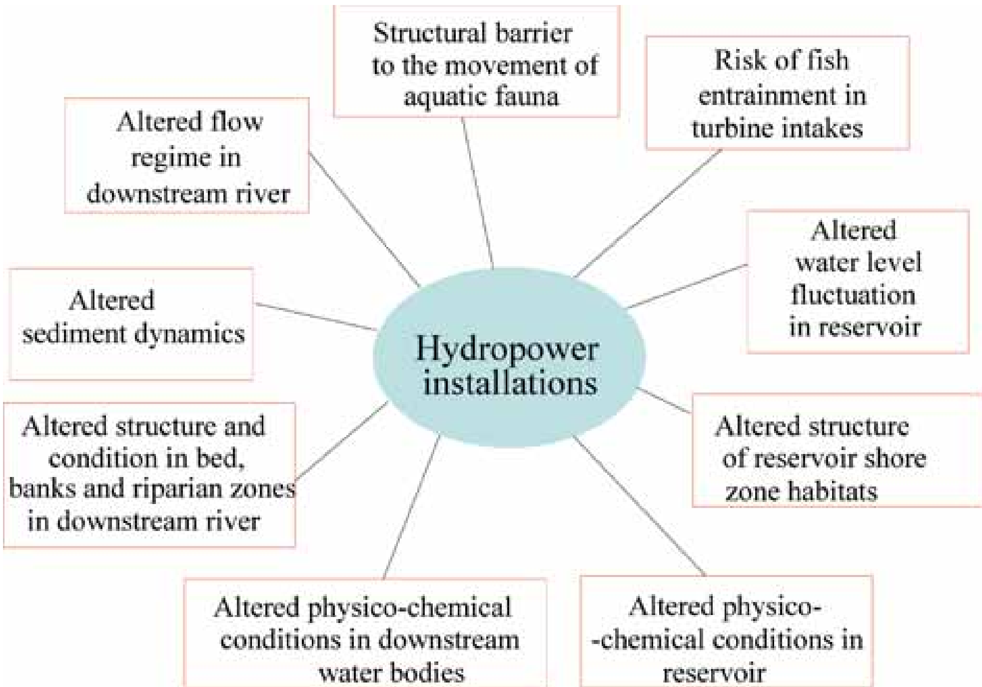

Fig. 1 – Illustration of possible alterations of water bodies and aquatic environment associated with hydropower dams

water, one can get an idea of the efficiency of particular aspects of water use. In the case of hydropower plants, these are the value of electricity produced and the share of sales revenues in the river basin district, number of employees, etc.

4. Impacts of the implementation of EU WFD on water use

If the production of electric energy is treated as “other” water uses, and not as a water service, then there is no cost recovery analysis, because internal costs in the production of hydropower are not relevant for water management, and it is only external costs created to other subjects in the surroundings (ecosystems, other users) that are assessed. In Croatia such external costs are today realized through water charges (water use charge, water protection charge).

Taking into account the provisions of the EU WFD, one should analyze the amounts of water charges and real costs caused to the environment and water resources by electric power supply facilities. It is only on the basis of such comparison that it will be possible to assess and, if needed, propose appropriate changes in the existing system of economic measures for the use of water in power supply. One should in the process not forget the fact that Article 9 of the EU WFD only calls for the introduction of the principle of the recovery of costs and an adequate contribution of different water users, leaving it up to the Member States to decide for themselves on the rate of recovery and instruments for the application of that principle.

The concept of environmental costs and costs of water resources is complex both theoretically and empirically, and it is difficult to apply in practice. These are usually treated jointly and they include all the negative external impacts of a particular water service, or water use.

On the other hand, if the use of water for the production of hydropower is singled out as a water service, it will be necessary to conduct a full analysis of costs and cost recovery mechanisms for that activity, and report in river basin management plans on the achieved cost recovery level and on the economic measures proposed in relation to the strengthening of the cost recovery principle, particularly in relation to external costs created by that activity to other subjects, in particular to the environment and ecosystems. More specifically, this includes an analysis of costs, revenues and subsidies for all the units which on a certain river basin district use the water power for the production of electricity. The analysis of the recovery of costs in the production of electricity in hydropower plants requires active participation of electric power industry. A problem in the cost recovery analysis is the identification of total economic costs which, in addition to financial costs, also include external environmental costs and costs of water resources.

The aim of the recovery of external costs is the sustainability of water resources and aquatic ecosystems. The costs of the water resource are usually the agreed costs of using water as a scarce resource in space and time. The costs of the resource can be based on the assessment of the difference between the economic value of water use and the economic value of the best alternative present or future water use. Environmental costs correspond to the damage in the aquatic environment caused by the degradation of water quality, i.e. by the exploitation of water resources. In that context a distinction is made between the damage suffered by the environment itself and the damage suffered by economic subjects who use that environment or might use it.

In order to achieve its objectives, the EU WFD stresses the significance of the recovery of external costs, in accordance with the user/polluter pays principle. This means that the price paid by the users should be associated with the pressures and impacts generated in the environment through their use. The selection of a method for the evaluation of the costs of the environment and water resource has to be coordinated with water users, who are expected to cover such costs. The selected method is expected to lead, in a reliable and desirable manner (interactive and participative), to the results acceptable and understandable to water users and decision-makers in the water sector.

Having in mind all of the above, and familiar with experience from other European countries in making the concept of environmental and resource costs operational, it can be concluded that in addressing this component of the economic cost of water use there is still a long process of learning ahead, both at the level of water management analysts and at the level of water users. To begin with, it would be useful to consider which data of interest for the assessment of environmental costs from the use of water for electricity are already collected, or what has to be done in order for them to be collected and monitored more properly. In that process, the monitoring and collection of data have to be related to those requirements or restrictions of the EU WFD which may have a significant impact on the use of water in electric power supply, such as:

- The requirement for the operation of hydropower plants to be coordinated with *ecological criteria*. Above all, this requirement is to be interpreted in such a way that the discharge, both in quantitative terms and with respect to its dynamics, must meet the needs of the water body ecology. For operation of hydropower plants this leads to the residual flow problem and the surge problem.
- The requirement for *undisturbed migration* is one of the central demands of the EU WFD. The ability of fish to pass migration hindrances, both for upstream and downstream migration, is a heavily debated topic. However, sediment transport can also play a role in connection with the undisturbed migration issue.
- Another challenge with which hydropower will be massively confronted in connection with the implementation of the EU WFD are the *morphological changes to rivers* caused by use of the water body. Morphology plays a decisive role with respect to the evaluation of water bodies.

With regard to morphology, undisturbed migration and environmental flow regime, the EU WFD specifies very stringent objectives because of the fact that the focus is on the "natural status of water". In order to permit rational implementation, the WFD has introduced another type of water body – the *heavily modified water body* (HMWB). A body of water with significant water use can be classified as a heavily modified water body and the objective is then no longer "good ecological status" but "good ecological potential", which is a slightly lower ecological criterion. According to the EU WFD, the category of a heavily modified water body is more and more strongly regarded as an exception and a "failure to attain the objectives".

There is also a potential financial burden on hydropower associated with the *recovery of costs of water services* per Article 9 of the EU WFD, which includes charging external costs to water users. In some countries a "water tax" is considered by which hydropower plants would finance the measures for (all) water bodies. Within the European Union this topic is dealt with in different ways, which results from different approaches to the significance and method of hydropower production. In Switzerland there is "water tax", while in Austria extensive investments in local infrastructure are made as part of the construction of power plants. This system has proven itself over the long term, since such investments were a sound basis for the future development of a region. We had similar cases with the construction of hydropower plants in Croatia. Further cost burdens would also have negative effects on the competitive situation between hydropower and other sources of energy, which must be regarded as contradicting the “renewable targets” of the EU.

The goals of energy policy, such as the promotion of energy from renewable sources in Europe or improving the security of supply, can be achieved only by using hydropower in the best possible way (existing power plants and new capacities). Any limitation of these resources could seriously jeopardise their achievement. A restriction would massively endanger peak load coverage in several countries. Because of the expansion of other renewable energy sources, such as wind power, which does not represent needs-driven generation, and the increasing demand for peak load coverage because of technological developments in Europe (e.g. air conditioning), the major storage and pump-storage plants would become even more important.

It can also be stated that potential consequences of the stringent environmental requirements of the EU WFD are in contradiction with other European targets, the most important of which is meeting the obligation of reducing CO2 emissions, assumed under the *Kyoto Protocol*.

5. Measures and costs of implementing EU WFD

Forgoing or limiting the use of water to generate electricity cannot represent a solution because of the developed structures and the significance of hydropower as the most important source of renewable energy in Europe. Here too, implementation must take place by classifying a water body as a heavily modified water body with moderate targets; otherwise there is the risk of missing other significant European targets.

Hence, for all water bodies where water is to a varying extent used for the generation of electricity, the first step is to consider the possibility of achieving good ecological potential. If such restoration is not viable because it would be technically infeasible, disproportionately expensive, or result in significant adverse effects on the specified water uses or on the wider environment, mitigation measures aimed at reducing the environmental impacts of the physical alteration should be assessed.

The selection of the appropriate restoration and mitigation measures within the planning cycles in any particular case will depend on a number of site-specific considerations. The selection of appropriate measure will depend on the adverse ecological effects of physical modifications; on the effectiveness of the measures regarding in particular the improvement in the ecological status; on the technical feasibility and the cost-effectiveness analysis of implementing the measures at the site, and in the case of a designated heavily modified water body or artificial water body, on the effects of the mitigation measures on those water uses responsible for the modifications and other uses dependent on the modification (e.g. bathing). In any case the efficiency of restoration and mitigation measures should be considered not only on a local water body scale, but also at a river basin scale.

Because of site-specific characteristics, the selection of an appropriate measure or combination of measures will rely on water managers in local and regional authorities being able to determine which alterations really present a significant ecological risk and then identify the most appropriate and cost-effective measures that could be taken to prevent, remedy or mitigate these ecological risks. To do this, they will also need to have a suitable knowledge and understanding of the potential effects of measures on the water use or uses related to the foreseen modifications. In that process water managers can be assisted by national guidance on how to assess environmental impact, and good communication between water users and water managers is particularly important.

For the purposes of river basin planning, water managers will need to identify as far as possible any restoration or mitigation measures still needed to achieve good ecological status or potential. Only those measures that are technically feasible and not disproportionately expensive to be made operational within the timescale of the first river basin planning cycle will have to be included in the first river basin management plan. In that context, measures to improve the ecological status cannot always be clearly related to one use or one alteration, but they are multi-purpose in many cases. For example, cross profile structures in rivers (dams and weirs) and deepening or channelization of a river may be necessary for navigation, flood protection and/or hydropower purposes. In practice, the relation between uses, alterations, state and measures can be complex.

Measures and instruments which can respond to hydromorphological pressures and impacts (water abstraction, flow regulation, morphological alterations) typical for the use of water for the production of electricity are of interest to the power industry. Examples of characteristic measures for the mitigation of impacts of hydromorphological pressures are changes in water levels, changes of flow, establishing passability, morphological alterations, etc.

In line with that, for existing hydropower plants the implementation of the EU WFD implies equipping them with fish ladders and connection to secondary water bodies in dam areas. But structural measures in dam areas and morphological improvements in discharge stretches are also an issue. Increased requirements for the biological minimum significantly reduce the production in hydropower plants diversion type. These impacts would be somewhat smaller for hydropower plants at larger water bodies, but reduced production of valuable renewable energy can be expected here as well. For storage hydropower plants, the potential of producing valuable peak energy would be reduced.

The topic of surge restrictions, which derives from the implementation of the EU WFD, is a special issue, having in mind the fact that storage and weir hydropower plants are designed in such a way that energy can be generated when it is needed to the maximum possible extent. Hence, such hydropower plants occupy a special place in the European power system.

The water status deterioration ban, stipulated by the EU WFD, will permit viable exploitation of the still available hydropower potential only in certain individual cases, in the first instance in locations where the water status will not be influenced (for example for pure pump storage power plants) or where the present aqua-ecological situation can be improved by applying the power industry because of existing burdens.

On the other hand, the expansion of other forms of renewable energy, such as wind and photovoltaic energy, means greater use of storage and pump storage power plants for the balancing of production because of the stochastic characters of such power sources. Hence, any limitation of such role of hydropower plants because of surge restrictions would not only be unfavourable for the hydropower system as a whole, but it would also result in the increased use and/or construction of thermal power plants which can be quickly included in the electric power system.

The European Union intends to increase the share of power generated from renewable sources in the total energy consumption to 12%, as specified by the *Directive on the promotion of electricity from renewable energy sources in the European Union's internal electricity market* (2001) (5). In this Directive, hydropower is generally, i.e. without limitation by means of an output limit, recognised as renewable energy. Among sources of renewable energy, hydropower occupies by far the most significant position, not only because it has the largest share in control output, but also because it has lowest generating costs in comparison with other renewable energy sources. In addition to that, the energy thus produced is characterized by high availability, potential to provide reserves and control power, and enormous reliability.

At the end of 2008, the European Parliament adopted very ambitious targets of 20% reduction in CO2 emissions and 20% share of renewable energies in overall energy consumption by 2020, defined in a new Renewable Energy and Climate Change Package (6), part of which is a new *Directive on the promotion of the use of energy from renewable sources*.

In addition to promoting the use of energy from renewable sources, targets have also been set to *reduce Europe's dependency on imports* in the energy sector and to *increase security of supply* within the EU. In order to achieve the above targets, the production of hydropower in Europe should increase further, which could be stopped or slowed down by the strict implementation of the EU WFD, which pursues purely environmental objectives. The analysis of results achieved in the use of renewable energy sources has shown that it will be difficult to achieve the current goals of the European policy by 2010, which means that the achievement of new, much more ambitious goals by 2020 will require optimization between the purely environmental objectives set by the EU WFD and objectives in the field of energy-economy-ecology set by the new EU Renewable Energy and Climate Change Package.

6. Conclusion

With its requirement to achieve good status of water, the EU WFD sets standards which could, if strictly applied, seriously hinder or practically diminish the continued use and expansion of hydropower. The implementation of the EU WFD at present differs widely in Europe, but nevertheless, a compromise is sought between hydropower and strict environmental requirements. Comprehensive and costly measures will be necessary, but it is still not fully clear who should cover the costs of these measures. It is to be expected that they will be covered by the government and water associations, as well as industrial users.

In the interest of a forward-looking and environmentally oriented European, and Croatian, energy policy, the EU WFD must be implemented in such a way that, in terms of volumes and quality, hydropower retains the position that it enjoys today.

Therefore, in the process of implementing the EU WFD on the national level one should strive towards the criteria which would facilitate future use of water for the production of electricity, which can be realized through the inclusion of hydropower supply in the forthcoming implementation processes of the EU WFD; avoidance of competitive disadvantages both on the national and international level; respecting hydropower as a long-term option of energy industry and climate policy; and maintaining the current financial burdens for hydropower.

On the other hand, the implementation of the EU WFD contradicts the clean energy policy targets of the European Union, because hydropower plants are an indispensable element in Europe's power supply, and, as such, of European energy policy.

The implementation of the EU WFD has to be considered as a process taking place over a longer period. One should somehow assess a potential risk which is to be expected from the management of existing hydropower plants, and create conditions for the realization of new hydropower plants in Croatia. The entire process of implementation should be continually monitored, because new issues and changes occur on the national and international levels.

7. References

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New Achievements in Understanding of Embankment Dam Failure

Summary

Dams provide many benefits for our society, but floods resulting from the failure of constructed dams have also produced some of the most devastating disasters in the last two centuries. When dams fail, property damage is certain, but loss of life can vary dramatically depending on the inundation area, size of the population at risk and the amount of warning time available. Appropriate simulation of embankment dam breach events and the resulting floods with detailed information about the water levels and velocities at downstream locations are crucial for characterizing and reducing threats due to potential dam failures. The goal of the presented paper is to review the state-of-the-art dam breach analysis tools, surge parameters and procedures for predicting the influence of flood waters on structures and human subjects. According to the literature survey that include results given in the previously documented dam failure case studies, prior laboratory testing and the existing physically-based models, the entire breach erosion process can be divided in five stages. Current breach prediction methods are based on relations between hydraulic energy dissipation rate and dike erodibility. The depth averaged shallow water equations are useful and reliable for flood modeling. The CFD simulation of this flow is a non-trivial technique and some new software packages are developed. Accuracy, stability and reliability of new codes are tested with various types of examples, real life case of flood wave propagation and experimental data obtained by the physical modeling. Flood waves have a potential to cause heavy damage. Flood can be dangerous for an individual due to the depth and velocity of water. It is defined how human subject can cope with different flow conditions. As a result we know when the velocity and/or depth of flood flow pose a life threatening hazard. Some projects are achieved to develop a procedure for predicting the interaction of flood waters and structures in the flood plain. As a result of the achieved researches it is possible to distinguish inundation, area with partial damage and area with total destruction of structures in flooded area.

Key words: dam failure, embankment dam, breach, flood wave

1. Introduction

Flood induced by dam and levee breach happens occasionally in the world. Floods can induce serious loss of life and enormous economic losses. To know the effects of dam break, we have to know how dams may break and how a flood will propagate. Warning time is the most important parameter affecting potential loss of life due to dam failure. Numerical and physical models can be used to predict flood wave propagation and provide the information about the area to be flooded, wave front arrival time and water depth. Therefore, models are useful tool for developing evacuation plans and warning system for areas having potential flood risk.

When population centers are located close to dams, accurate prediction of breach parameters is crucial to development of effective emergency action plans. The development of a dam break is a complicated problem that consists of a lot of uncertainties. Compared to the breach development process the propagation of a flood wave can be modeled more "accurately". However, the propagation of the dam break flood wave is an extreme phenomenon and there is very little valid observation data available. Therefore, physical models are not only used to study the behavior of the prototype but also to produce necessary verification data for numerical models.

The 1964 failure of Baldwin Hills Dam, near Los Angeles, California and the near failure of Lower Van Norman (San Fernando) Dam in 1971 prompted the state of California to enact statutes requiring dam owners to prepare dam failure inundation maps. The need for developing procedures for estimating the breach hydrograph was thus born (Wahl 1998). The need to mitigating damages produced by extreme hydrologic events has stimulated some important researches in last decades and the obtained results are described in the presented paper.

Fig. 1 – The breach (Badaluta, 2007)

A Working Group on dam break modeling, called CADAM and sponsored by European Union has been created within the Framework of IAHR. It aims at the promotion of cooperative research on this topic (Petitjean, 1998).

The EU-project RESCDAM – *Development of rescue actions based on dam-break flood analysis* – was launched in 1999 and coordinated by Finnish Environment Institute (RESCDAM,2000). The three goals of this project were to test 1) human stability and manoeuvrability in flowing water, 2) permanence of houses in flowing water and 3) roughness coefficient of forest and houses.

2. Development of a Breach

Earthen dams are subject to possible failure from either overtopping or piping water which erodes a breach through the dam. The breach formation is gradual with respect to time, and its width, as measured along the crest of the dam, usually encompasses only a portion of the dam's crest length. In many instances, the bottom of the breach progressively erodes downward until it reaches the bottom of the dam; however, in some cases, it may cease its downward progression at some intermediate elevation between the top and bottom of the dam.

Comprehension of the breach development process, and the mathematical translation of this process into the model, is of great importance to design method of dikes.

During the last decades, many methods have been developed to predict the outflow generated during a dam failure event. They are continuously improved and validated using the historical data and/or the data taken from laboratory and/or field experiments.

The analysis methods can be grouped into the four categories:

1. **Physically based methods** – Predict the development of a breach and the resulting breach outflows using an erosion model based on principles of hydraulics, sediment transport and soil mechanics

2. **Parametric models**- Use case study information to estimate time to failure and ultimate breach geometry, then simulate breach growth as time dependent linear process and compute breach outflows using principles of hydraulics

3. **Predictor equations** – Estimate peak discharge from an empirical equation based on case study data and assume a reasonable outflow hydrograph shape

4. **Comparative analysis** – if the dam under consideration is very similar in size and construction to a dam that failed, and the failure is well documented, appropriate breach parameters or peak outflows may be determined by comparison.

In this paper physically based methods will be described (Fig 2.). Simulation of erosion processes are based on relations between hydraulic energy dissipation rate and erodibility.

The size of the breach, as constituted by its depth and its width, and the rate of the breach formation determine the magnitude and shape of the resulting breach outflow hydrograph. This is of vital interest to engineers concerned with real-time forecasting or evacuation planning for floods produced by dam failures.

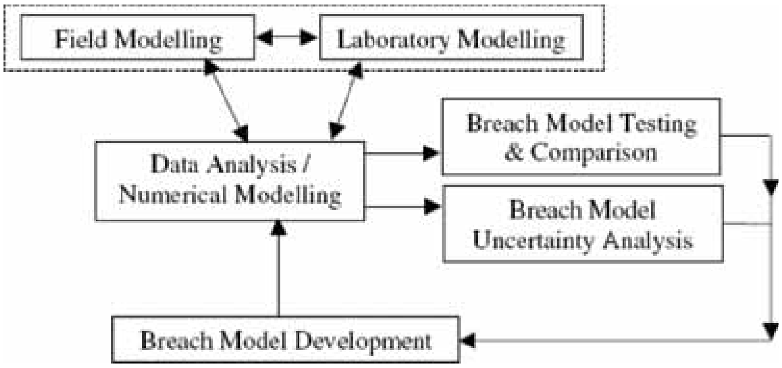

Fig. 2 – Programme of field, laboratory and numerical modeling (Moriss at al. 2007)

Available prototype as well as experimental data of dike failures, which are of high importance for model calibration are scarce. Due to the complexity of the dike breaching process, most studies are under presumption of homogeneous dikes.

For modeling of breach growth in dikes, the key problem is the description of the rate of erosion of the dike by the flow. The crucial soil erodibility coefficient M_e used in existing erosion formulae is often stated as an experimentally or empirically determined constant (Zhu, 2006).

A compensive literature review of embankment dam breach parameters prediction was made by Wahl (Wahl, 1998).

The first was Cristofano (1965) who derived an equation which related the force of the flowing water through the breach to the shear strength of the soil particles on the bottom of the breach and, in this manner, developed the rate of erosion of the breach channel as a function of the rate of change of water flowing through the breach. Harris and Wagner (1967) used the Schoklitsch sediment transport equation and considered the breach to commence its downward progression immediately upon overtopping and the erosion of the breach was assumed to progress to the bottom of the dam (Fread,1988).

There are numerous tools available today for analyzing dam failures and their resulting outflow hydrographs. Some of the best-known and most widely used are: Dam-Break Flood Forecasting Model (DAMBRK); the U.S. Army Corps of Engineers Hydrologic Engineering Center Flood Hydrograph package HEC-1 (Hydrologic Engineering Center, 1981) and the

Simplified Dam Break Flood Forecasting Model SMPDBK (Wetmore and Fread, 1983, after Wahl 1998).

One of the most frequently used breach erosion model BREACH (Fread 1988) is based on principles of hydraulics, sediment transport, and soil mechanics. The model uses equation of weir or orifice flow to simulate the outflow entering the channel that is gradually eroded through an earthen dam. Conservation of reservoir inflow, storage volume and outflow (crest overflow, spillway flow and breach flow) determines the time-dependent reservoir water elevation. A sediment transport relation, the Meyer-Peter and Muller equation modified for steep channels is used to predict the transport capacity of the breach flow. Breach enlargement is governed by the rate of erosion.

If an overtopping failure is simulated, the water level in the reservoir must exceed the top of the dam before any erosion occurs. The first stage of the erosion is only along the downstream face of the dam as denoted by the line A-A in Fig 2. An erosion channel of depth-dependent width is gradually cut into the downstream face of the dam. The flow into the channel is determined by the broad-crested weir relations.

When the bottom of the erosion channel has attained the position of line B-B in Fig. 2, the breach bottom (H_c on Fig 3.) starts to erode vertically downward. The breach bottom elevation is allowed to progress downward until it reaches the bottom elevation of the dam.

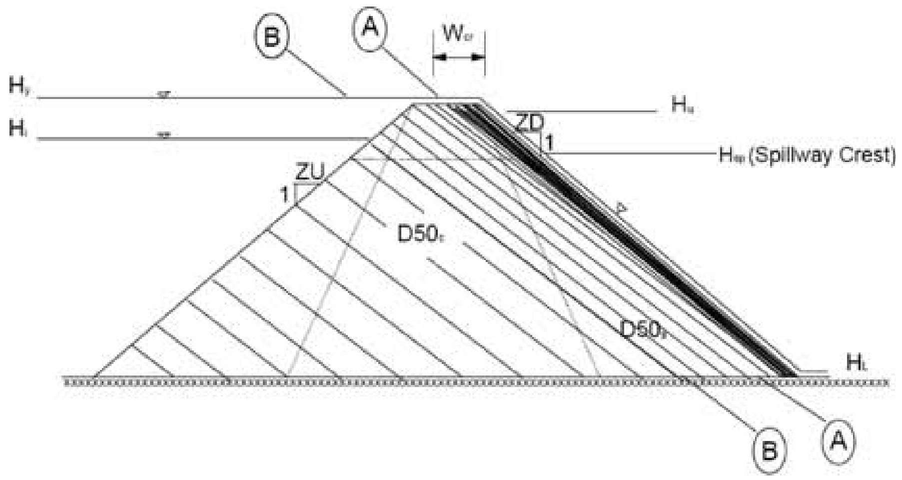

Fig. 3 – Side view of dam showing conceptualized overtopping failure sequence (After Fread, 1998)

The method of determining the width of the breach channel is a critical component of any breach model. In the described model (BREACH) the width of the breach is dynamically controlled by two mechanisms. The first assumes the breach has an initial rectangular shape as shown in Fig 4. The width of the breach (B_0) is governed by the relation

$$B_0 = B_r h_c \tag{1}$$

in which B_r is a factor based on the optimum channel hydraulic efficiency ($B_r = 2$ for overtopping and $B_r = 1$ for piping failures) and h_c is the critical depth at the entrance to the breach. The second mechanism controlling the breach width is derived from the stability of soil slopes.

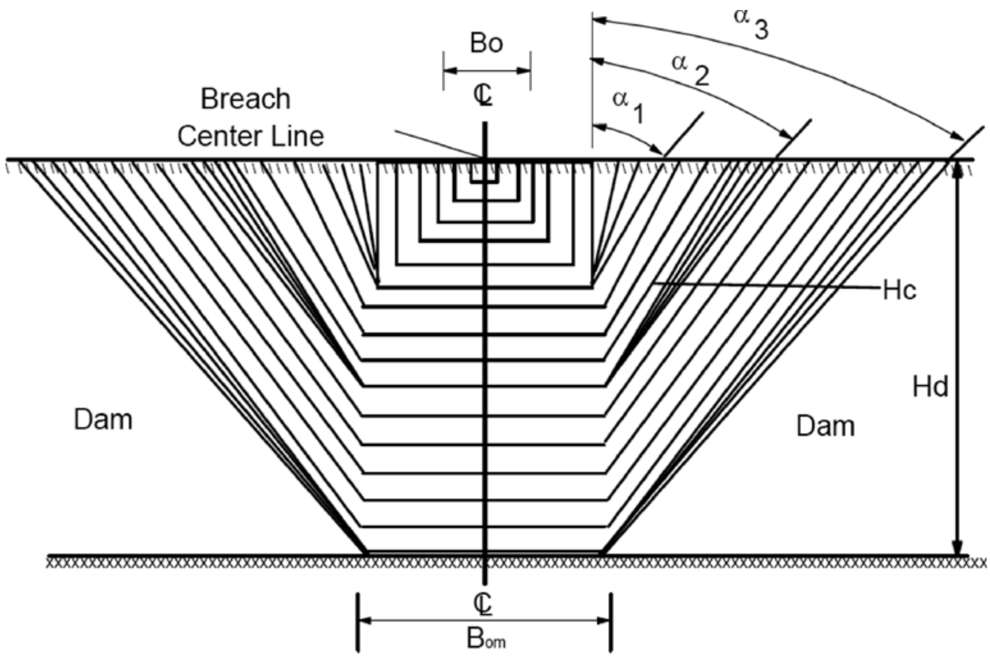

Fig. 4 – Front view of dam with breach formation sequence

Recently developed models distinguish five stages in the breach developing process in sand-dikes (Visser, 1998) and in clay-dikes (Zhu, 2006).

In Stage I, flood water flows through the initial breach in the crest and starts the breach growth process by eroding soil away from the inner slope of the dike and, depending on the flow velocity, possibly also along the dike crest. Stage II commences after the inner slope of the dike arriving at the critical value β_1 (see Fig. 6) and the erosion of the crest is now intensive. In Stage III erosion of the outer slope occurs. In Stages II and III, the dike body in the breach is eroded until at the end of stage III the dike body in the breach has been washed away completely. In Stages IV and V, the breach grows further mainly laterally due to principally flow shear erosion along the side-slopes of the breach and the resulting discrete side-slope instability (Zhu, 2006).

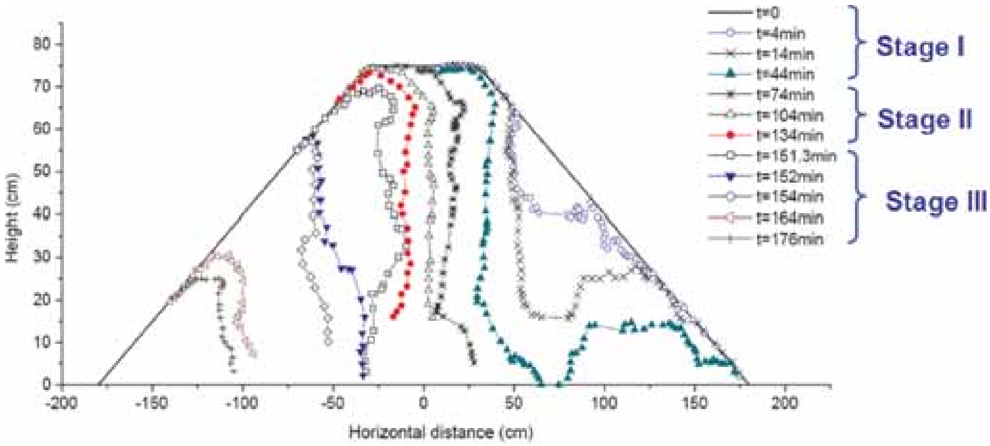

Fig. 5 – Dike profile development (Zhu,2006)

In Stage I, water flows down and accelerates along the inner slope of the dike, getting more and more erosive. At some point, it achieves the normal flow. In that stage the breach flow attains its largest erosion potential in the vicinity of the toe of the dike, unless the inner slope is very long. It can be expected that the dike breach erosion should often initiate close to the toe of the dike. Due to the larger erosion rate close to the toe of the dike than at the upper part of the inner slope, the slope becomes steeper and steeper as time goes on. When a certain critical slope angle β_1 is achieved by the inner slope, Stage I ends.

It can be assumed that the breach acts as a broad-crested weir during the erosion process and therefore the discharge Q_{BR} through the breach is defined by the equation:

$$Q_{BR} = mB\sqrt{2g}h_p^{3/2} \tag{2}$$

where m is the discharge coefficient, B is the width of the weir, and h_p is the depth of the stream over the crest.

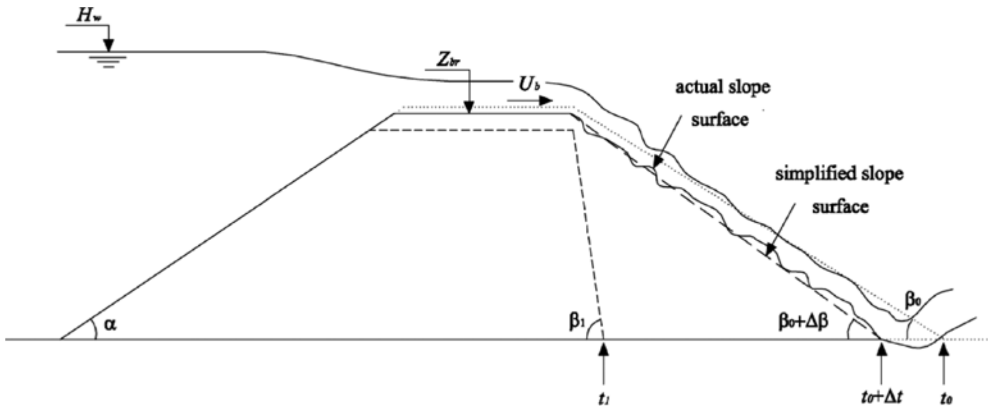

Fig. 6 – Breach erosion in Stage I (Zhu 2006)

Along the inner slope, the breach flow shear erosion occurs. Frequently used equation for the rate of soil erosion is

$$E = M_e(\tau_b - \tau_c) \tag{3}$$

in which τ_b is bed shear stress and is critical shear stress. The bed shear stress is calculated by

$$\tau_b = \frac{1}{C^2}\rho g v^2 \tag{4}$$

in which C is the Chezy coefficient, ρ is water density and v is the cross-sectional average flow velocity.

Due to the larger erosion rate at the toe of the dike than at the upper part of the inner slope, the slope becomes steeper and steeper in time and accordingly the slope angle increases from the initial value to a critical value β_1 (Figure 6). Within one time step dt the increase of the slope angle $d\beta$ is calculated as:

$$d\beta = \frac{E}{x_e}dt \tag{5}$$

in which x_e is the length at which normal flow occurs.

In cases in which the breach flow velocity at the dike crest is not large and the erosion rate at the dike crest is small compared to that near the toe of the inner slope, the discharge through the breach (over the weir) depends strongly on the water level in the reservoir. That means that in Stage I there is no significant increase of discharge.

In the case when the volume of retained water in retention basin is not very large compared to the volume of dam, it is not possible to reach critical slope angle β_1 and the following Stages II and III. It means that the progressive erosion of the dam will be held up.

3. Flood Wave Simulation Models

Mathematical modeling of flood wave has advanced significantly in the last decades. However, it remains a problem of calibration of dam-break models for which real data are rare. It is difficult to obtain parameters of flood wave because flooding usually takes place unexpectedly and, above all, because during flood events all resources are mobilized to help the affected people and to mitigate the disaster, and not to acquire reliable data.

The CFD simulation of flood wave is a non-trivial technique when dealing with non-linear transient problems. In the flood wave, multiphase flow processes occur (water and air); the fluid interfaces are not known in advance and move throughout the domain.

IAHR published the report “Guidelines for Documenting the Validity of Computational Modelling Software”. This report presents an important step toward the development of standard procedure for software validation. It contains a detailed set of guidelines for the documentation of the validation of a computational model.

To test the accuracy of the existing and newly developed codes a lot of simulations with various types of examples, including a partial dam-break problem, have been carried out (e.g. Gjetvaj at all. 1998, Ying X et al., 2005, Loukili and Soulaimani, 2007, Družeta, 2004, Gouda and Karner, 2002). The most important projects sponsored by Europian Union are CADAM, RESCDAM and IMPACT.

The Concerted Action on Dam-break Modelling workgroup (CADAM) performed a considerable work for the development of new codes and for the adequate verification of their performance. In the contex of the

CADAM project, a new 2D computer code is developed, tested and applied. Accuracy, stability and reliability of the code are tested on a selected set of case studies (Calefferi at al., 2003).

A numerical code FLOOD2D based on the integration of de Saint Venant equations for two-dimensional flow (RESCDAM, 2002) was developed with the main task to simulate the flood wave following the possible breaking process of the Kyrkosjärvi dam, upstream of the city of Seinäjoki, Western Finland.

Joint European project named Investigation of extreMe flood Processes And unCerTainty (IMPACT) with the aim to test numerical models of flood propagation (Alcrudo and Mulet, 2007). The case study is based upon the failure of Tous Dam in Spain and the flooding of Sumarancel, a small town located 5 km downstream.

During a dam-break flow, the whole valley is involved, which implies that roads, bridges and other structures become obstacles to the flow. The purpose of particular investigations was to provide data about the influence of such an obstacle on a dam-break wave. Flow observation shows that after the violent impact of the wave on the structure, the flow is forced to change its direction to pass the structure (Soares-Frazao and Zech 2007). It is a part of the broader study of flood propagation in urban areas undertaken during the IMPACT project.

To complete the risk analysis of 67 dams in France, computer codes MASCARET (1D) and TELEMAC (2D) are used to simulate transcritical flow. They enable simulation of transcritical flows over domains which may reach 300 km, including propagation over dry areas (Petitjean, A., 1998).

Experimental data obtained at a laboratory test facility combining a square–shaped upstream reservoir and L-shaped channel were used for comparison with computation results by 8 research teams (Fig. 7) (Petitjean, 1998).

It is found that newly developed numerical schemes are robust and stable, and are capable of predicting complex flow phenomena that involve subcritical and supercritical flows. The high efficiency of this method has made it possible to provide fine details of the water circulation, velocity and pressure around the buildings in city areas during the flooding process.

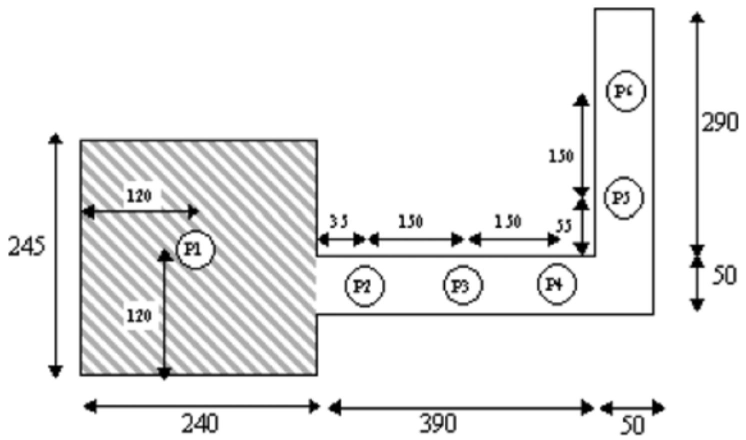

Fig. 7 – UCL test-case: L-shaped channel. Geometry of the channel and position of the gauging points (after Petitjean, 1998)

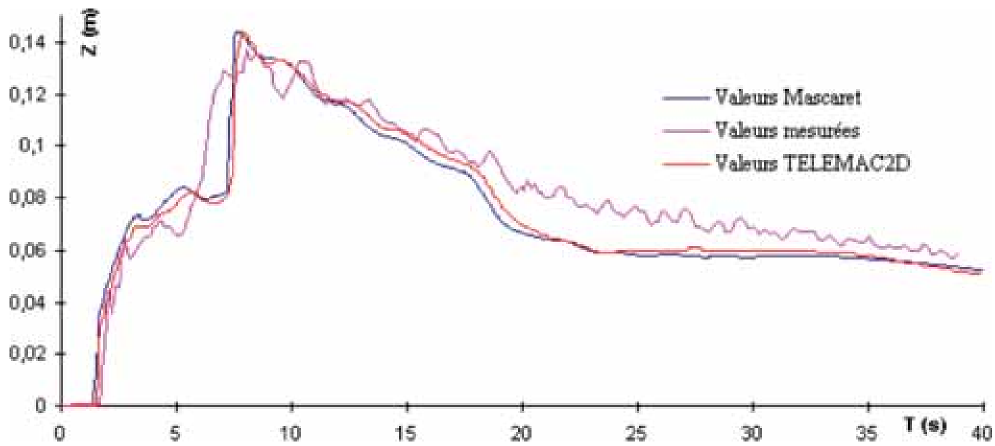

Fig. 8 – UCL test-case: L-shaped channel. Comparison of measured hydrograph (pink) with 1D computation (blue) and 2D computation (red) at gauging point n°4. (Petitjean, 1998)

4. Human Stability and Manoeuvrability in Flowing Water

Flood can be dangerous for an individual due to the depth and velocity of water. It is important to define how human subject can cope with different flow conditions. The knowledge of human limits in the flow helps to determine the time interval, in which the rescue action must be completed.

The first study on human stability in a high flood hazard zone was completed at the Colorado State University in the late 1980's. The purpose of the study was to find out when the velocity and/or depth of flood flow pose a life threatening hazard. In other words, to identify when an adult human could not stand or manoeuvre in flowing water.

The manoeuvrability of seven test persons (characterized by the coefficient: height times mass (mkg)) was tested in the laboratory by using velocities of v = 0.6-2.75 m/s and water depths of d = 0.3- 1.1 m (RESCDAM, 2000).

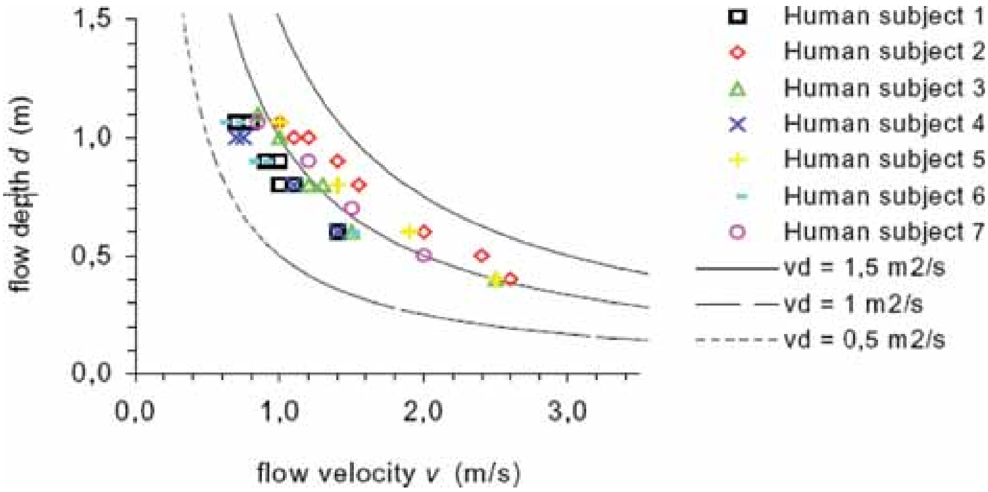

Fig. 9 – Loss of stability or manoeuvrability (after RESCDAM 2000)

Due to the individual properties, there exist a wide range of product numbers *vd* describing a person's manoeuvrability in the flow (Fig. 9). The product number *vd* causing loss of stability or manoeuvrability varied from 0.64 m^2/s to 1.26 m^2/s. Taller and heavier individuals managed better in flowing water.

The performance of buildings in flowing water was determined by studying literature and laboratory experiments. For masonry and brick houses partial damage occurs if flow velocity is $v \geq 2$ m/s and damage parameter $vd \geq 3$ m^2/s. Total damage occurs if flow velocity is $v \geq 2$ m/s and damage parameter $vd \geq 7$ m^2/s (RESCDAM, 2000).

5. Summary and Conclusions

This paper presents a survey of the existing literature to identify current breach prediction methods, state-of-the-art software packages to model flooding processes and cognition about human stability and structural damage in flowing water.

Recently developed models distinguish five stages in the breach developing process in sand- and clay-dikes. In the first stage water flows over the dike crest and accelerates along the inner slope of the dike, getting more and more erosive. In that stage the breach flow attains its largest erosion potential in the vicinity of the toe of the dike, unless the inner slope is very long. It can be expected that the dike breach erosion should often initiate close to the toe of the dike. Due to the larger erosion rate close to the toe of the dike than on the upper part of the inner slope, the slope becomes steeper and steeper.

In case that the breach flow velocity at the dike crest is not large and the erosion rate at the dike crest is small compared to that near the toe of the inner slope, the discharge thought the breach (over the weir) depends strongly on the water level in the reservoir. That means that in the Stage I there is no a significant increase of discharge.

In the case when the volume of retained water in retention basin is not very large (huge) compared to the volume of dam, it is not possible to reach the critical slope angle β_1 and the following Stages II and III. It means that the progressive erosion of the dam will be hold up.

It is found that newly developed numerical scheme for flood wave modeling are inherently robust and stable, and is able to predict complex flow phenomena that involve subcritical and supercritical flows. The high computational efficiency of this method has made it possible to provide fine details of velocity and pressure around the buildings in the city area during the flooding process

In the RESCDAM project, approximate limits of adult human manoeuvrability and stability in flowing water are defined. Due to the individual properties, there exists a wide range of product numbers flow velocity (v) times water depth (d) describing a person's manoeuvrability in the flow. The product number vd causing loss of stability or manoeuvrability varied from 0.64 m^2/s to 1.26 m^2/s.

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Water – Croatian Export Product

1. Introduction

With the **C**omplex **T**echnological **a**nd **D**evelopment **P**roject "Potable water – export product" – financed by the Ministry of science, education and sport of the Republic of Croatia, the authors of this work wanted to encourage the process of consideration change on water resources as exclusively social category into the natural resource of valuable economic importance in the development of Croatia. The University in Zagreb (Faculty of Geotechnical Engineering Varaždin and the Faculty of Civil Engineering Zagreb) and the Academy of Technical Sciences of the Republic of Croatia – Centre for Developmental Projects participated in the Project. The Project was co-financed by the companies Croatian Waters and Croatian Electric-power Industry. In the framework of the project the problems of available water resources in Croatia, the possible transport variants as well as the water market in the broader area of the Mediterranean and in Croatia were scientifically and professionally processed.

The growth of water consumption in the world, higher life standard of the inhabitants, decrease of water resource of the adequate quality and the uneven spatial arrangement of the water resources are the reasons for intensifying ecological, social and political problems, which were presumed to develop in future into the serious conflict of the international proportions. The time when the water will overtake the role of the present fossil fuels is not far, and numerous world experts predict that the water resources will become in 21st century the subject of a serious interest conflicts such as petroleum and gas today. The fact is that the world population multiplied for three times from the beginning of 19th century, the energy and water consumption increased for more than 30 times, the industrial production increased for about 50 times, and the available qualitative water resources are considerably decreased by pollution and technical interventions in space, by which the effects of the dry periods are increased. Water as the natural source is becoming progressively important segment in planning of economic growth of particular countries and the countries rich with water, to which Croatia belongs as well, can think on commercialization of a part of water resources and endeavour to include, in time, in selling water to those countries which do not have enough water quantities for a normal economic growth. It primarily refers to the countries of the Near-East and the parts of the North Africa, but a serious deficiency of water strikes South Italy, South Spain and some parts of Greece. Huge quantities of water are used in agricultural production which provides European Countries with fruit and vegetable during the winter period, while in summer in the Mediterranean area, million of tourist come, who essentially increase the consumption of high quality potable water in relation to the normal consumption of domicile inhabitants. Such trend of water consumption increase will surely be kept in some next ten years and the natural water resources will stay the same or they will be decreased because of continuous processes of space encumberment and pollution. The World Health Organization warns, that even today there are about 1,2 billion people in the world who have great problems caused by the lack of water. A special problem is the bad quality of potable water which has negative effects on the health of people in the developed and the undeveloped countries of the world. From the OUN point of view the water is promoted as a public good, which must be available to everybody, but it applies only within the boundaries of a particular country and it does not mean the uniform water distribution on the world level. In Croatia the water is treated as the public good too, with the policy of accessibility for all the inhabitants of our country, however when speaking about the commercialization of a part of the water resources, they are then the water surpluses in relation to the present and the future needs for water in Croatia.

Croatia today commercializes a part of its water resources by selling water in bottles in the commercial chains in Croatia, and even by exporting it abroad. These are relative small water quantities, of the best quality indeed, which use all together 200 to 300 l/s water on the whole area of the state, which is less than the water consumption of a smaller town. However Croatia is one of the richest countries in Europe with water, especially in the Mediterranean and with its water resources it has to take the appropriate place on the international water market, on which, the French and German companies realize profits greater than 50 billions US$ annually even today, only in the area of the Mediterranean. According to that, the market exists, the needs for water increase and the main problem is how to be included into that market with its disposable reserves. It is not an easy job, because the water quality in the natural systems must firstly be adequately protected and preserved; by which we have an advantage over the other potential water exporters for now, but the places for water intake must be determined and the water transport must be design prepared with continuous contacts with the potential market.

What is the state on the Mediterranean market? The North Africa is surely one region in the world with the greatest absence of water and with huge desert – waterless regions. There is practically no water on the surface of the terrain and the dry riverbeds only remind on periodical water flows. However the groundwater reserves in so called Nubian sandstone are respectable but because of the oversized exploitation the constant lowering of water levels is present which causes considerable technical problems because of continuous need for deepening of exploitation objects and because of the great length of the water transport up to the consumer. The South of Spain is an important tourist and agricultural region, which uses greater water quantities in all the seasons of the year. From the available aquifers, great deal of coastal ones is under the great influence of the sea. There are the big installations for water desalinization, which prepare water in summer for the water supply of towns and tourist regions and in winter for the agriculture. Desalinization of the sea water creates great technological, financial and ecological analyses, which solution of water supply will be optimal in future, most probably the water transfers from other areas. There is a similar situation on Malta as it is on the South of Spain. The South of Italy has water problems as well, partly because of the aquifer salinisation, caused by the oversized groundwater exploitation. The water transport from another side of the Adriatic Sea has been considered for years. Problems with water exist in Greece as well, especially on the islands in Aegean Sea. They solve a part of these problems by transporting water from the continental area onto the islands. According to that, the potential market already exists today and the needs for water grow and the complete opening of the market has to be expected in the following decade. Our islands in the Adriatic Sea do not present less problem, the problems with the potable water already exist and the full development of the tourist economy and agricultural production will be realized only by providing enough quantities of high quality water from the coastal area, which becomes and interesting theme in the frame of this project.

The transport technologies are in a steady development and very expensive constructions of pipelines are gradually abandoned and the very economical ways of water transport over the sea are increasingly used. Just because of these reasons the water resources of the Adriatic area have been considered in details in the frame of this work, which is possible to be used economically and technically for transport to our islands and to all the areas of the Mediterranean.

2. Natural water resources in the Adriatic catchment area

Croatia has about 169 x 10^9 m^3 of water yearly at its disposal (D. Gereš, 1997); transit waters about 127 x 10^9 m^3 yearly and about 42 x 10^9 m^3 waters yearly from the territory of Croatia. The renewable water stocks are estimated at totally 30 x 10^9 m^3 yearly, from which about 11 x 10^9 m^3 yearly is attributed to the karst areas, which can be presented through the average value of 362 m^3/s of water. To illustrate this, it can be pointed out that the needs of public water supply in Croatia are about 1,5%, and for the karst area about 2% of the total water quantities. Regardless the riches of the total water resources the situation with water is not simple. There are numerous problems which point at the need of a meaningful approach with water resources, especially in the karst areas of Dinarides. The richness of waters in Croatia can be thanked primarily to great quantities of annual precipitation, which, in the mountain areas of Velebit and Gorski Kotar, reach the values of over 4000 mm a year, which belongs to the range of the highest annual precipitation quantities in Europe (Figure 1). Towards the inland the precipitation quantity decreases up to 700 to 800 mm and in the karst regions of the Adriatic catchment area up to 1250 mm yearly. Great problem is the irregular seasonal precipitation distribution with long dry periods in summer months and with the concentration of precipitation in autumn, winter and spring periods. Snow –cover has special importance in the mountain regions of the Adriatic catchment area, which retains the underground water accumulation at the beginning of the summer period.

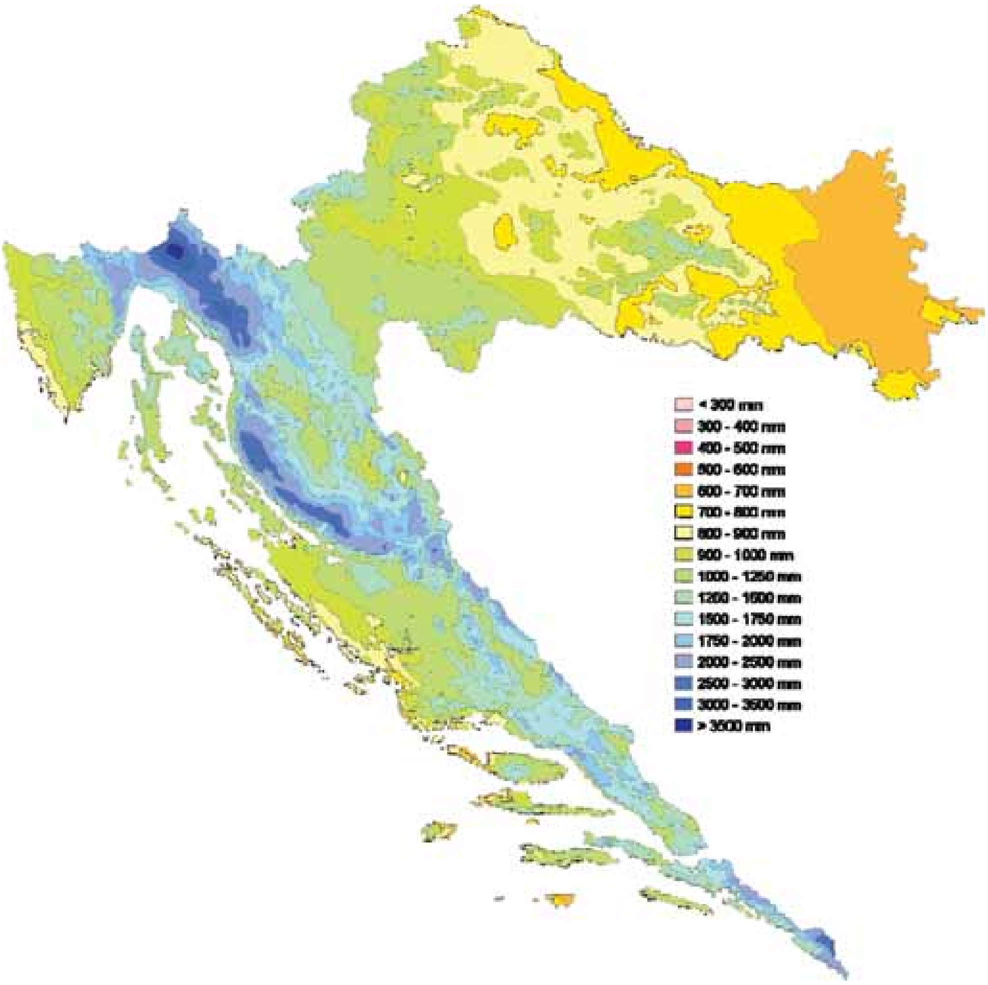

Fig. 1 – The map of the average precipitation in the Republic of Croatia 19961-1990 (State Hydro Meteorological Department, 2002)

In consideration about the commercialization of the part of the rich water reserves of the Republic of Croatia, the water resources of the Adriatic catchment area should get advantage, because they are waters which naturally gravitate towards the coastal region and the transports of greater water quantities into the water deficient areas of the Mediterranean and Adriatic islands are economically profitable only by sea. The Adriatic catchment area covers a part of the mountain area of Dinarides with characteristic karst development of the water bearing systems comprising the region of Istria, Croatian Littoral, a part of Gorski Kotar,

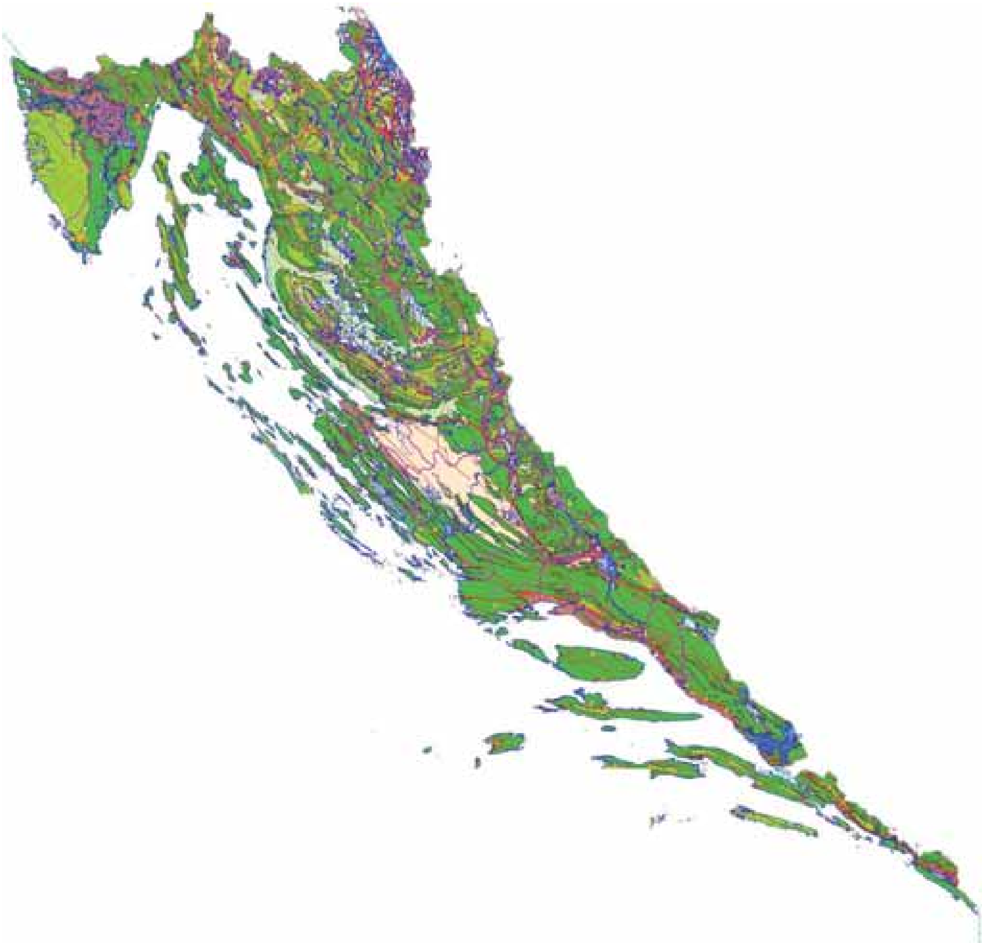

Fig. 2 – View hydro geological map of Dinarides
(Biondić, B., Brkić, Ž., Biondić, R., 1996)

Lika, Ravni Kotari, Dalmatia and Neretva – Dubrovnik region. The watershed towards the Black Sea catchment area is linked to the anticline geological structures in the regions of Gorski Kotar and Lika, and it goes into the area of the neighbouring state of Bosnia and Herzegovina towards the South (Figure 2).

The basic characteristics of the karst aquifers are the appearances of great karst springs, high velocities of the underground flows through the joint and cavernous openings, the appearances of sinking the surface streams into the underground and a rare net of the surface flows. The drainage systems have great sizes, often greater than 1000 km^2, the mountainous regions are rich with precipitation and the run offs are great and fast. The problems exist in long summer periods which last sometimes over 3 months continuously. With relative low natural retention abilities of the karst underground the springs have great discharge amplitudes and numerous springs run dry over several months a year. The karst aquifers are mainly open towards the terrain surface and because of that they are naturally vulnerable to the pollution (B. Biondić, R. Biondić, F. Dukarić, 1998). The coastal areas and the Adriatic islands present a special problem, because they have come into the direct contact with the sea after raising the sea level after the last glaciation. The sea water with higher specific gravity has filled the deep parts of the karstified underground and it presents great problems today during the exploitation of the floating fresh water.

From the geological aspect the relation of the macrostructure units of Dinaric and Adriatic (M. Herak, 1986, 1994), the two neighboring carbonate platforms which are in mutual tectonic contact, is very important for the Adriatic catchment area. How much this tectonic zone is important for the interpretation of hydro geological relations is best shown with the fact that the greatest majority of the large karst springs is formed in the zone of this tectonic contact (Rječina, Novljanska Žrnovnica, Krka, Ombla). The catchments areas are in the mountainous part of the Dinaric and the discharge is on the tectonic contact of Dinaric and Adriatic, where the younger clastic rocks make the barrier for the underground flows from the great karst catchment areas (Figure 3). The karst catchment areas of smaller size are formed in the zone of Adriatic and on the islands. It is important to point out that the complete drainage systems are within the Adriatic catchment area in the regions of Istria, Croatian Littoral and Lika. On the South the Adriatic catchment area expands into the neighbouring state of Bosnia and Herzegovina. On the very South in Dubrovnik littoral only the springs are practically on the territory of Croatia. It is a very important element in choosing the springs for a commercial usage, because it complicates the water protection as well as the way of usage because of the possible interest division.

In the Adriatic catchment area, in accordance with the WMD 13 groundwater bodies can be separated, which present the basis for water resources management in the Adriatic catchment area. **The groundwater bodies in the region of Istrian peninsula** (Dragonja, Mirna, South Istria, Rijeka bay) are in a boundary conditions of usage for their own needs, and the part of the water resources is under the high burden of the urban areas and the areas under the agricultural production. In fu-

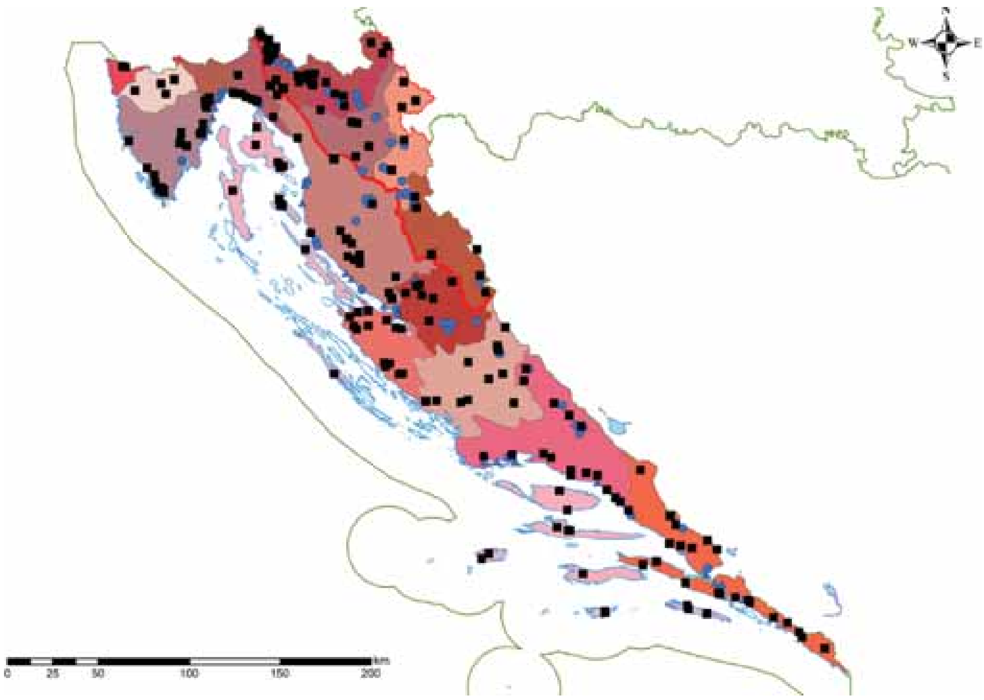

Fig. 3 – Groundwater bodies in the Adriatic catchment area

ture one has to think even about the water transfer from Gorski Kotar, which is rich with water, towards the Istrian peninsula because of the continuous growth of tourism, cities and agricultural production, so it is impossible to think about the surplus of the groundwater reserves for the commercial usage in this region. **The groundwater bodies in Croatian Littoral** have far greater available water reserves for possible commercial usage than those in Istria peninsula, because they are connected with the underground inflows from the mountain area of Gorski Kotar. It refers primarily to the springs in the town of Rijeka, (Zvir I, Zvir II, Marganovo), which even today show certain surpluses with their capacities. In summer these quantities are about 2200 l/s. The spring Rječina with its annual discharge of about 7,6 m^3/s is specially interesting, but this spring has sometimes got no water for 3 summer months, so it can come into the plans of commercial usage only in case of building the planned storage basin in the upper part of the river. The springs in the Bay of Bakar are not interesting because of considerable discharge decreasing during the summer dry periods and because of frequent salinity increase. **The groundwater body Lika** is surely one of the most interesting regions for commercialization of a part of the available reserves because of the mountain areas of Velebit and Velika Kapela, rich with precipitation and because of the completeness on the territory of the Republic of Croatia. The spring zone Novljanska Žrnovnica with the minimal discharge of 400 l/s. which supplies Novi Vinodolski and Crikvenica with water is especially interesting (B. Biondić, R. Biondić, H. Meaški, 2007). With its surpluses and high water quality it could be interesting for the water transport towards the northern Adriatic islands. The greatest natural spring of the groundwater body Lika is the spring zone of the river Gacka which, with its discharge quantity of about 3 m^3/s in the dry periods is surely interesting for this project, but at the distance of some ten kilometers from the coast. The waters from the spring zone of the river Gacka join the waters from the river Lika and are jointly conducted through the canals and tunnels to the power house of the hydroelectric power plant Senj in the place Sv. Juraj. For the water supply for the settlements in the foot of the mountain Velebit and on the islands of Rab and Pag 600 l/s water from the system of the hydroelectric power plant Senj are used. **The groundwater body Zrmanja** is the next great drainage system in the direction towards the South of the Adriatic catchment area. This is the first greater permanent river which flows into the Adriatic Sea starting from the Bay of Kvarner. The greatest part of the drainage area of this water body is in the area of Štikada, Gračac and Bruvno (South Lika). In natural conditions the waters of the upper retarding step on the northern side of the mountain area of Velebit had sank into a series of sinkholes and they recharged the karst springs on the right coast of the river Zrmanja. After the construction of the hydroelectric power plant Velebit near the town of Obrovac great part of water is used for the production of electric energy, by which the inflows to the natural springs (Krupa, Krnjeza, Dobarbica, Muškovci) are insignificantly decreased. With the construction of the retention basin in Muškovci, the total water quantity is increased, from which is only partly used for the water supply of the broader region of the town of Zadar (620 l/s), after the production of electric energy. There are considerable water surpluses which can be interesting for the transfers into distant locations and on islands. **The groundwater body Ravni Kotari** has a more local character and it has not got more significant water quantities, especially not the surpluses interesting for the project. The groundwater exists but a great problem is a part under the risk of the sea influence, especially in the condition of the increased exploitation during the dry summer periods. **The groundwater body Krka** has an important place in the drainage of the mountainous part of the mountain Dinara and of Ravni Kotari. Significant quantities of water flow in the river Krka, which rise in numerous strong karst springs formed in the boundary area of the structural units of Dinaric and Adriatic. The drainage areas expand deep in the territory of the state of Bosnia and Herzegovina. After passing the Knin polje in the region of Ravni Kotari great quantities of water comes into the area of the National park Krka, in which every commercial usage of the water resource is not permited. Downstream the Visovačko Lake and Skradinski buk the fresh water system is under the influence of the sea and it is practically not interesting for the project. In the coastal area there are some captured springs for water supply. All of them are too small for the creation of interesting water surpluses. **The groundwater body Cetina** is a very interesting unity because of the great quantities of fresh water which flow into the sea in various ways. First, there are natural springs Jadro (about 3 m^3/s), Žrnovnica (about 500 l/s) and Studenci (about 300 l/s), whose locations are at the distance of 1 to several kilometers from the possible loading place on the coast, and second there is the system of hydroelectric power plants, which ends with the last retarding step Zakučac, which is about 2 kilometers far from the coast. The springs in the upstream part of the river Cetina in the area of the town of Sinj are rich with water, but too far away from the coastal area. The other part of the water body is either under the strong influence of the sea (coastal spring Pantan) or it has small capacity usable only for the local water supply. It has to be pointed out that the highest retarding steps of the catchment area are on the territory of Bosnia and Herzegovina as well as the part of the hydroenergetic system on the river Cetina. The natural springs in the broader coastal area and the hydroelectric power plant Zakučac are interesting for the project. **The groundwater body Neretva** is the greatest water body on the eastern part of the Adriatic Sea. It expands deep into the territory of Bosnia and Herzegovina and only smaller part of that body is on the territory of Croatia. River Neretva enters into Croatia upstream of the town of Metković, but because of the citiy Mostar upstream, the river waters are practically unusable for commercial purposes. Another situation is with the natural springs along the left and the right river banks. The quantities of the spring water along the right river bank (Prud, Klokun, Modro Oko) are very interesting for the project because of the great karst area of about 1160 km^2 of Dalmatinska Zagora in the direction to Imotski polje which is drained towards the river Neretva. The discharge base is the river Neretva as well as the Baćinska Lakes near Ploče in the coastal zone. There are two big problems connected to those spring zones. First is a deep intrusion of the sea water upstream the river Neretva and the second pollutions of the communally unregulated towns and settlements in the catchment area, especially in the region of the neighboring state of Bosnia and Herzegovina. The perspectives of bringing the parts of those water reserves to the commercial purpose are weak. On the left bank of the river Neretva, there is only a small catchment area on the territory of

Croatia and every consideration about the commercial usage of the parts of the water reserves includes the cooperation with the neighboring state Bosnia and Herzegovina. It refers firstly to the spring Ombla near the town of Dubrovnik (about 3,4 m^3/s minimal), which is in the first circle of interests for different forms of the commercial usage with its quantity, quality and position. The problem is the fact that only the spring is located in Croatia and the whole drainage system is in the neighboring state of Bosnia and Herzegovina, what could be the reason of difficulties to establish the effective protection of the catchment area.

3. Water quantities on the hydroelectric power plants

Hydroelectric power plants use the greatest part of the water resources in the Adriatic catchment area and they are surely great potential in the entering process of the Republic of Croatian onto the international water market. In the Adriatic catchment area numerous hydro energetic systems have been built from Croatian Littoral to the very South of the coastal area of Croatia (Elektroprojekt, 2000). Going towards the South the available water quantities on the hydroelectric power plants increase, but the problem is in increasing share of the catchment areas on the territory of the neighboring Bosnia and Herzegovina. On the very South, only the parts of the feeding hydrotechnical tunnels and power plants are on the territory of the Republic of Croatia and the catchment areas are practically completely on the territory of the neighboring state of Bosnia and Herzegovina. When speaking about the water usage from the hydroelectric power plants, the usage of water after the production of the electric energy should be taken into consideration, when these reserves are practically lost and in most cases they flow out directly or after a short surface flow into the sea.

Hydroelectric power plant Vinodol in Tribalj near the town of Crikvenica uses the waters from the highest parts of Gorski kotar in the zone of the watershed between the Adriatic catchment area and the Black Sea catchment area. Waters are accumulated on the water flows Lokvarka and Križ brook in the Black Sea catchment area and on Ličanka, Lepenica and Potkoš in the Adriatic catchment area. The greatest storage basin is Lokvarka in Gorski Kotar with the capacity of 35,3 million m^3 of water, whose waters are transported by the tunnel 3.456 m long from the Black Sea catchment area into the Adriatic one, into the storage basin Bajer near the town of Fužine which has capacity of 1,5

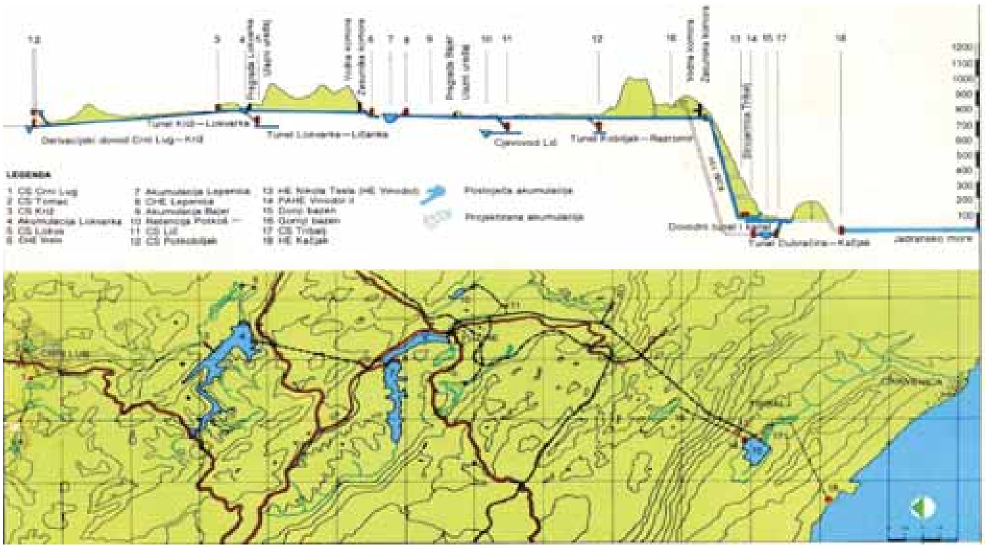

Fig. 4 – Presentation of the structures of the hydroelectric power plant Vinodol (ELEKTROPROJEKT 2000)

million m^3. All those waters together with the waters from the storage basin Lepenica which has capacity of 5,5 million m^3 are transported by canals and tunnels into the power house of the hydroelectric power plant Vinodol in Tribalj (Figure 4). The reception storage basin is built in Tribalj for the waters from the system of the hydroelectric power plant Vinodol, which are used for the water supply of the island Krk. The water quality is relatively high for the open system.

Hydroelectric power plant Senj near the settlement of Sv. Juraj uses the waters of the greatest part of the Lika region, which belongs to the Adriatic catchment area. These are the rivers Lika and Gacka, which sank in natural conditions into the karst underground and recharged the coastal spring's zones from the town of Novi Vinodolski on the North to the town of Karlobag on the South.

The waters of the river Lika are retained in the storage basin Kruščica which has capacity of 142 million m^3 and transported from Lipovo polje by the tunnel into the valley of the river Gacka where they are joined with the waters of the river Gacka. From the place of joining the waters of the river Gacka and Lika in Vivoze near the town of Otočac are transported by canal and tunnel to the compensation basin Gusić polje with the capacity of 1,2 million m^3, and further by the hydrotechnical tunnel

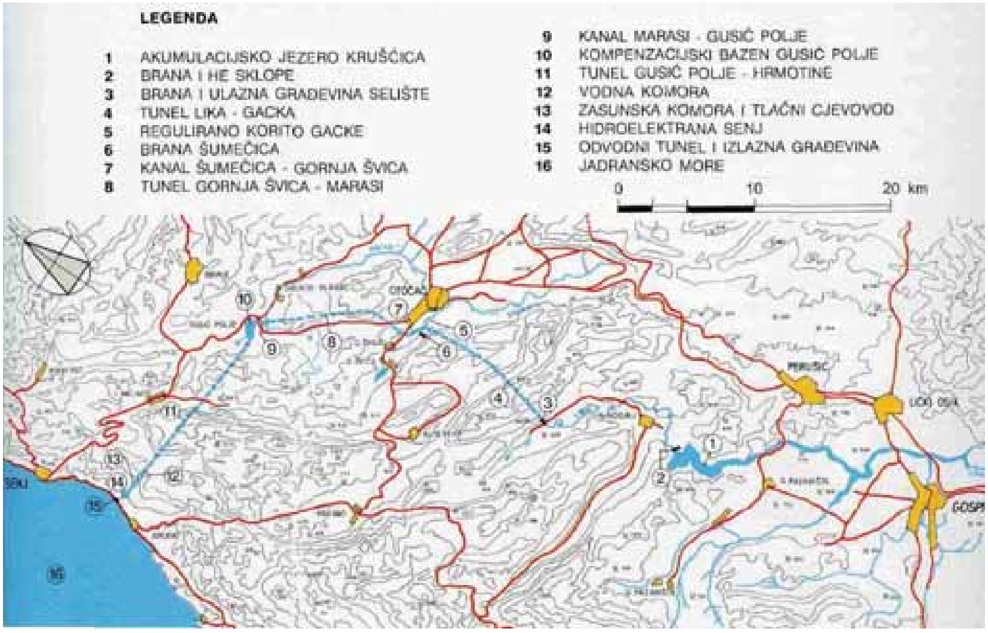

Fig. 5 – View sketch of the hydroelectric power plant Senj (ELEKTROPROJEKT, 2000)

to Hrmotin where the part of the water is separated for the water supply of the Southern Littoral and islands of Rab and Pag. The greatest quantity of water is pulled down onto the installations of the hydroelectric power plant by the high pressure tunnel. The installed discharge on the exit of the hydroelectric power plant Senj is 60 m^3/s and this water flows freely into the sea.

Reversible hydroelectric power plant Velebit uses the waters from the catchment area of the river Zrmanja, mainly situated in the southern region of Lika. Water resources are the rivers Obsenica, Ričica and Otuća with the storage basins Obsenica of 2,7 million m^3 and Štikada of 13,65 million m^3.

The facility of the hydroelectric power plant is in Muškovci in the valley of the river Zrmanja where the storage basin Razovac of 1,84 million m^3 is built. The medium recharge to the hydroelectric power plant is 11,94 m^3/s of water. A part of water from the lower basin Razovac is returned onto upper horizon during the night by means of the cheaper electric current and a part of water from the storage basin and from natural springs

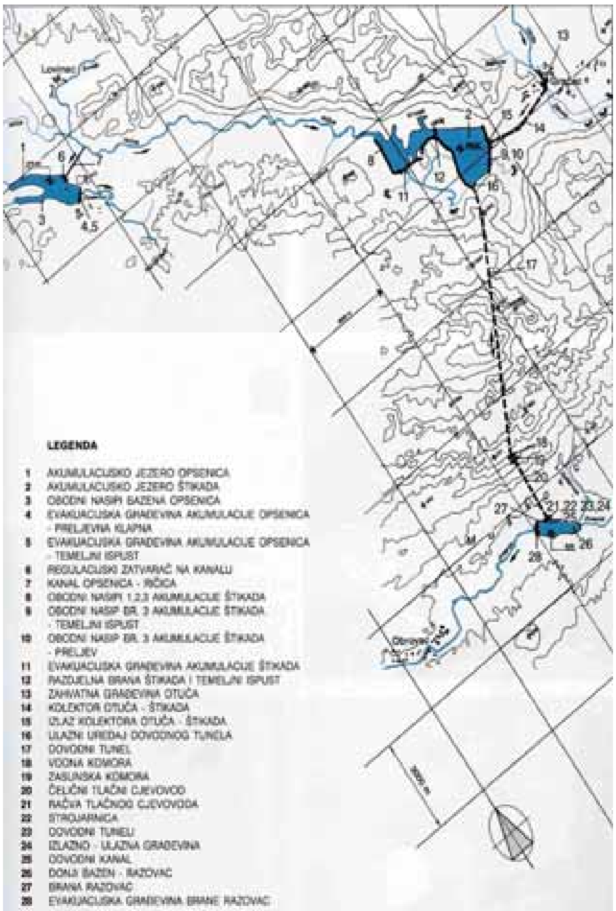

Fig. 6 – View sketch of the reversible hydroelectric power plant Velebit (ELEKTROPROJEKT, 2000)

along the right river bank of Zrmanja is used for the water supply of the town of Zadar.

Hydroelectric system on the river Cetina consists of several storage basins and hydroelectric power plants in the catchment area of the river Cetina. Those are the storage basin Buško Blato with the capacity of 800 million m^3 in the high part of the catchment area on the territory of the neighbouring state, and the storage basin Peruča with the capacity of 365 million m^3 in the spring zone of the river Cetina and the series of smaller storage basins along the river Cetina. Those are the storage basin Mandak with the capacity of 3,5 million m^3, compensation basin Lipa with the capacity of 1,6 million m^3, Đale with the capacity of 3,7 million m^3 and Prančevići with the capacity of 6,8 million m^3. For the project of water export the last retarding step of the system of the hydroelectric power plant Zakučac is the most interesting one, which works with the inflows of 107,5 m^3/s. After the production of electric current all the water flows into the riverbed of Cetina some 1 km upstream from the mouth of the river into the sea.

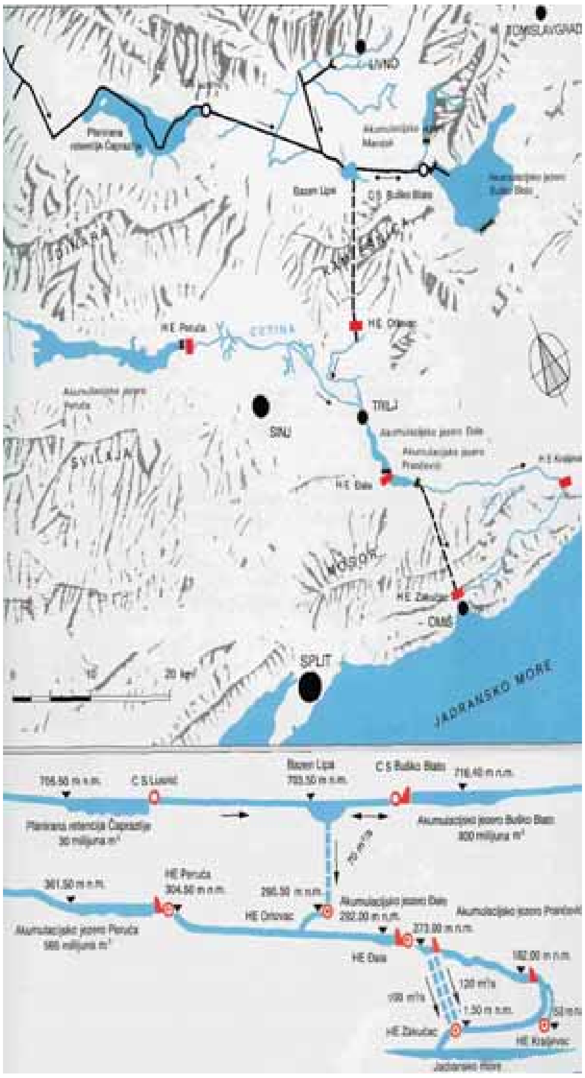

Fig. 7 – View sketch of the system of hydroelectric power plants on the river Cetina (ELEKTROPROJEKT, 2000)

Hydroelectric power plant Plat near the city of Dubrovnik situated on the sea coast at the settlement Plat not far from the town of Cavtat uses the waters from the storage basin Bileća with the capacity of 1.100 million m^3 and the compensation basin Gorica with the capacity of 9 million m^3 situated in the neighbouring country Bosnia and Herzegovina. Only the power house and a part of the supplying hydrotechnical tunnel are placed on the territory of the Republic of Croatia. The recharge to the facility of the hydroelectric power plant is 90 m^3/s and after the reconstruction, this quantity will be increased to 135 m^3/s. After the production of electric current the waters flow freely into the sea.

Fig. 8 – View sketch of the system of the hydroelectric power plant Plat (ELEKTROPROJEKT, 2000)

4. Evaluation of the water quality

Evaluation of the water quality of the natural springs was based on the trend analysis of the chosen quality indicators, by assessment of the chosen indicators range and by calculation of the water quality index (B. Biondić, J. Božičević, V. Andročec, S. Kapelj, R. Biondić, 2006). **Rijeka springs** (spring of Rječina and Zvir) show occasionally greater bacterial pollutions especially during the high water waves when it comes in combination with the increased turbidity of the spring water. In connection with this the mild trend of decrease of the spring water saturation with oxygen was noticed, but the other chosen indicators point at the gradual decrease of burdening the aquifer caused by human activity. **The spring zone Novljanska Žrnovnica** shows extraordinary favourable values of the water quality. Unfortunately, it is not the case with the water from the river **Zrmanja**, which is used for the water supply of the town of Zadar. The analyses show the increase of the organic substances in water. **The springs zones Jadro and Žrnovnica** show a mild trend of water quality deterioration, which is displayed in a mild increase of the nitrogen in water and in an important trend of the bacterial pollution increase as the reflex of the gradual increase of the human activity in the catchment area. **The springs zone Ombla** shows a mild trend of increase of the biological consumption of oxygen and bacterial pollution, but other parameters are relative stable. On almost all the springs the consequences of the increase of human activities in the catchment areas of all the observed springs zones are present, but the most positive indexes of water quality were obtained for the springs Rječina and Novljanska Žrnovnica (Figure 9).

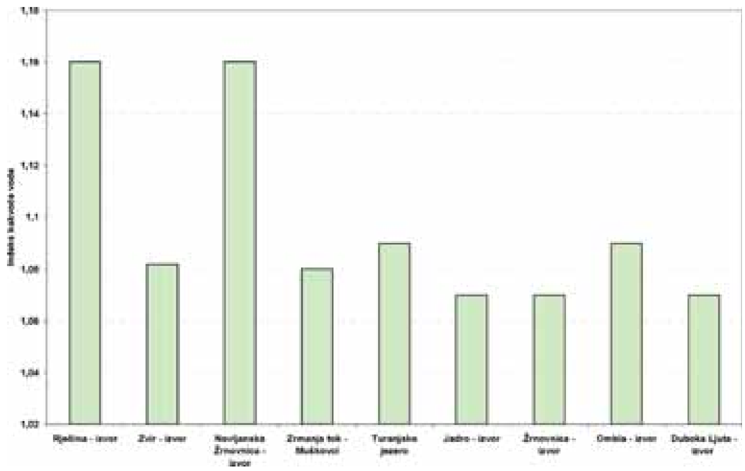

Fig. 9 – Index values of the water quality for the observed springs zones

5. Choice of the perspective sites

As the places of a possible usage of a part of the water resources, the following sites have been chosen:

1. Springs in the broader area of the town of Rijeka

2. Springs zone of Novljanska Žrnovnica

3. Hydroelectric power plant Senj (waters from the rivers Gacka and Lika)

4. Reversible hydroelectric power plant Velebit (catchment area of the river Zrmanja)

5. Springs zones Jadro and Žrnovnica

6. Hydroelectric power plant Zakučac and the springs zone Studenci (waters of the river Cetina)

7. Springs zone Ombla

8. Hydroelectric power plant Plat near Dubrovnik

Valorisation of the chosen sites was done according to the following parameters, which are important for the final choice of the sites: **the available water quantities, water quality, protection system of the water resources, the distance from the possible aimed transport point** with the evaluation from 1 to 5 for each particular parameter (Figure 10).

It is important to point out that for all the chosen natural sources there are protection zones in accordance with the Regulations about the protection of the spring's zones for potable waters in the Republic of Croatia (Figure 11). The water resources of the hydro power plants are out of the protection system and because of that they have lower grades regardless the part of very favourable parameters. It especially refers to the hydroelectric power plant Plat which has a very favourable position in relation to the water transport into the Mediterranean countries.

Rank	Water object (name)	Available quantity (points)	Quality (points)	Distance from the seacost (points)	Protection (points)	TOTAL (points)
1	Novljanska Žrnovnica	4	4	5	4	17
2	spring Zvir, Marganovo	4	4	5	3	16
3	Ombla	5	4	5	1	15
4	Jadro	4	4	4	3	15
5	Žrnovnica	4	4	4	3	15
6	HE power plant Dubrovnik	5	3	5	1	14
7	spring Studenci	3	4	3	3	13
8	HE power plant Zakučac	5	2	4	1	12
9	spring Rječina	1 (need accumulation)	5	1	5	12
10	springs in place Muškovci	2	4	2	3	11
11	HE power plant Senj	4	2	3	1	10
12	HE power plant Obrovac	4	2	2	2	10
13	spring Turanjsko jezero	2	2	3	3	10
14	HE power plant Vinodol	4	2	2	1	9

Fig. 10 – Table of the chosen water resource evaluation

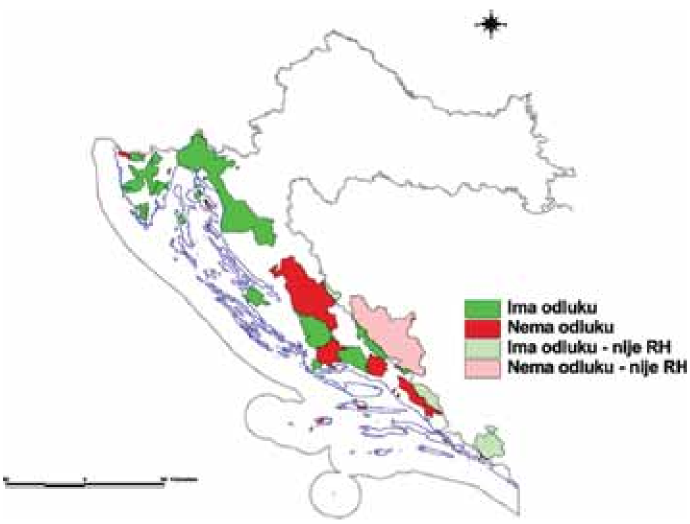

Fig. 11 – Protection zones of the potable water springs zones in the Adriatic catchment area

6. The needs of the Adriatic islands for the potable water

The limiting element of our islands development is the lack of potable water (D. Ivičić, B. Biondić, 1998). This is the area of the potential tourism development which is developed in proper sense only on smaller number of the islands connected with pipelines with the land, and greater part of the islands, especially the outer ones has practically no water or they have considerable deficit in potable water. With the water transfer from the land it is possible to give to the outer islands the chance for the tourist development. The fact that in the present day development conditions about 200 l/s water is insufficient shows how great the problem is the water supply of the islands today even without the development elements, which cannot be predicted without the development strategy of the islands. It can be supposed that in future, the insufficient water quantities will be even double than the mentioned ones. The water supply problem of the outer islands is in the great number of relative small consumers on the large area, in very poor or none reception capacities and in a relative short period of greater need for water. The possible needs for water for the agricultural production, which practically does not exist today on outer islands or which is developed in such ranges that it can be covered with the existing limited water qualities are not included into the mention quantities. The usage of water in agriculture is a chance of economical value of the water supply of the outer islands, because the functioning of the system during a great part of the year should be ensured.

The situation with the potable water on the outer islands is the following one:

Islands of the northern Adriatic – islands of Cres- Lošinj and Krk have their own springs of potable water, the islands Rab and Pag are connected to the land springs and the needs of the outer islands are about **25.000 m^3** water monthly

Islands of the medium Adriatic – islands nearer to the land are connected with the land water resources with pipelines and on 12 outer islands there is the monthly lack of water of about **165.000 m3**.

The islands of the southern Adriatic – They are mainly connected with the land water resources, except the island of Vis, which has its own springs, but in the tourist season it has the monthly lack of water of about **70.000 m^3**.

7. Water transport

The potable water in Croatia is today commercialized as the product through water bottling, which can be bought in every shop. A part of the bottled water is exported on foreign markets, even in USA. There is more than 100 billion litres of the bottled water on the market in the world today and those numbers increase from day to day (C. Ferier, 2001). From the graphic presentation about the consumption of water in the world it is visible that the greatest quantities of the bottled water are used in Western Europe (46% of the world production). This is the question of a high life standard of the inhabitants and of the bad water quality in the public water supply systems. The countries MENE, which are our potential market, use only 6% of the world bottled water. But this is the question of purchasing power of inhabitants and the needs are far greater. The problem of the bottled water is ecological one because after the usage there are huge quantities of non biodegradable plastic containers.

However, transports of huge water quantities and the supply of communal and the irrigation systems in the Mediterranean countries are the interest of this work (N. Adler et all, 2003). The interests of the South of Italy for water transport from the East part of the Adriatic into the water insufficient area of the region Apuglia are known from earlier. In this connection the water resources of Albania, Montenegro and the springs zone Ombla in Croatia have been taken into consideration. Even ideas for building the pipelines over the Adriatic exist, but they remained only the ideas, because of high costs of construction. Up to the nineties in the previous century, the great ships mainly of the combined transport of petroleum and water which presented great technical and ecological problems were exclusively used for water transports at long distances. The waiting of ships for loading of water brought considerable economical losses of the shipping companies, which could not be refunded by water selling. In the nineties in the previous century the development of so called **Waterbag technology** started (Figure 13) in the water transport. Up to now the system have been developed which enable the transport up to 30.000 m^3 of water at long distances. Connecting the plastic bags, the transports of greater water quantities is also possible. The plastic bags have different sizes and they are produced in the sizes according to the needs of the potential consumer.

The key factor of the business economy of water transport is the shortest possible water transport up to the loading station, the water quality, the

Fig. 12 – Waterbag with the capacity of 30.000 tons pulled by tug

rational transport up to the final destination, the corresponding reception capacities and the distribution net at destinations.

For the water supply of the Adriatic islands the usage of the plastic bags is also suggested because of the cost effective loading and transport as well as the possibility for using the plastic bags as the reservoir for particular islands or settlements where the concentration of the potential consumers exists. In this way, it is possible to avoid the construction of the magisterial pipelines along the islands. The island of Mljet can be used as an example, on which there are only several hundreds of inhabitants in the area 60 km long, and greater number of smaller plastic bags could be used. The island of Susak needs about 7500 m^3 water monthly in the period of maximal consumption, which could be solved by using one plastic bag with the capacity of 7000 m^3 with three transports. The example of the very distant island of Vis is characteristic. It has its own springs of potable water but during the maximal consumption it is short of about 20 l/s water which could be supplied with one plastic bag with the capacity of 30.000 m^3 in three transports.

Similar water transport system can be made for transport to more distant destinations, but it has to have greater sizes and the transport means have to be stronger. Greater water quantities in one transport can be achieved by connecting the plastic bags of great sizes into convoys which is done in Australia and New Zealand. For great transports, the most rational solution of loading is the springs zone of Ombla or the outflow of the hydroelectric power plant Plat near Dubrovnik, which considerably shortens the transport length into the Mediterranean countries and because of the great quantity of water, the quick loading is possible.

8. Potential water market

Economic analysis shows the profitability of entering into business with fresh water, with all the caution measures which the world water market demands, in which the potable water has greatly the dimensions of social values, except the bottled water which is on the world market outside the social limitations. Water still has not the value level of petroleum which is often the theme of the politicians and forecasters of the world occurrences. The price of potable water is still on rather low levels and the exploitation and transport costs are relative high. It is important to mention that the water prices vary from country to country and that the prices in the European countries are far higher than the prices in the countries of Africa and Near East, where the great part of the inhabitants does not pay for potable water or the price is the consequence of the low income of the employed inhabitants (M. Ahmad, 1998). The world experiences show that the complete installations and filling of water are profitable within the price of 0,3 US$ per m^3 without transport cost, but in calculation one should be very careful because the profitability is connected with the delivered quantities (A.H. Bicak, G. Jenkins, 1999).

All the Mediterranean countries surely present the potential market in which the real contacts should be made with the nearest neighbours – with Italy, especially with the southern area, where great quantities of water for agriculture are missing. The South of Spain has also great problems with water. They solve them with desalinization of the sea water in great installations of the complex technological processes and high energy consumption, which are built by the subventions of the European Union but which profitability is questionable. The potential partner can be Malta, which gets its potable water by sea desalinization, as well as other Mediterranean countries. One should have in mind that France and Turkey are great exporters of water and the entrance into the world water market is a complex question. One must have in mind the great role of the Government in negotiations and preparations of the entrance into the water market.

The situation is far simpler with our islands because the water delivery onto the islands which have not sufficient water has all the characteristics of monopoly market and the water price per m^3 is higher than anywhere else on the Mediterranean. It reaches almost the price of 9 US$. The water supply with plastic bags would decrease the water prices on islands and it would open the development possibilities, because the water supply should not depend on periodical arrivals of water bearing ships.

9. Conclusion

The Republic of Croatia in the Adriatic belt has at its disposal considerable water quantities on the natural springs and on hydro energetic structures, whose power houses are in the coastal area. After the production of electric energy more than 260 m^3/s of water run off into the sea today. The natural spring zones can practically supply enough surpluses of high quality water for export with more rational usage and with the recovery of losses in the distribution nets. It is especially important because of the protection, because the hydro energetic systems have no obligation of preventive protection if a part of water is not used in water supply. The problem of protection is the stretching of the catchment areas into the neighbouring state of Bosnia and Herzegovina, specially referring to the spring Ombla and hydroelectric power plant Plat, where the whole catchment areas are practically in the neighbouring state and the protection of water resources depends on regulations which are not under the control of Croatia.

From the considered spring zones, the spring Novljanska Žrnovnica has the highest quality evaluation, which, with its free capacities can be appropriate for the water supply of the north and medium Adriatic islands in combination with the Rijeka springs and for transports at distant destinations. But for long transports the spring Ombla and the hydroelectric power plant Plat near Dubrovnik have advantage because of the shorter transport, but with the protection problems and the possible division of interests.

Potential market is surely the Mediterranean where the water transports already exist and all the strength and knowledge should be used to introduce our water surpluses on the free water market. Water transports are modernized from day to day and they become more effective and consequently more economic and according to our opinion the usage of the plastic bags of different sizes offers the best solutions. The water supply of the outer islands in the Adriatic which have not sufficient water should be included into the system. That which can be concluded is the fact that the water surpluses in Croatia should be involved into the economical activities as the renewable natural resource of high value as soon as possible.

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The Preparations for Danube – Sava Multi-Purpose Canal

Summary

The paper deals with the current state of preparations for the canal construction: exploratory works, development and planning documentation projects and preliminary works. It also focuses on construction dynamics adjusted to state irrigation programme.

***Key words**:* Danube – Sava multi – purpose canal, inland navigation, development and planning documentation projects, construction

1. Chronology of development and planning project documentation of DSMC

Development – planning documentation and traffic development strategy of Croatia from 1999 defined the development of Croatian inland waterways along with Danube – Sava multi – purpose canal – DSMC project was. The DSMC project was completed late in 1998 and early in 1999 the State administration for environmental protection reached an

AGREEMENT stating that DSMC was environmetally friendly project. Unfortunately, from 2001 to 2004 the activities on completion of study and project documentation of DSMC were interrupted by the decision of the then Ministry for public works, rebuilding and construction. Since 2005 the works on completion and upgrading of development and planning documentation, studies and projects for DSMC were resumed to the level necessary to obtain location and preliminary building permission – with completion term in 2007. According to accepted and signed AGN agreement, next to the navigable sections of the rivers Danube, Sava and Drava the DSMC project fell also into the system of European navigable ways by the parameters of V.b class of international inland waterways. Bearing on mind economic and environmental benefits of inland waterway traffic, the significance of DSMC lies in connecting Croatia with the European system of inland waterways. It also acts as an integral part of successful economic development and incorporation with the states of Danubian and Adriatic region.

Study and project documentation for DSMC from 1995 to 2006

In 1988 started the works on **"Development Planning of Danube – Sava Multipurpose Canal Corridor"** as a result of many initiatives for documentation basis, and by the decision reached by the local municipality. The decision was made according to the then legal Law on development planning and space arrangement by the municipalities of Vinkovci, Vukovar, Županja and Slavonski – Brod. The development plan based on **Preliminary canal project: "Danube – Sava Multi-purpose canal, a solution variant",** books I – III", Hidrozavod DTD, Novi Sad, elaborated in 1985, and revised by the Institute of Civil Engineering in Zagreb. It was completed in 1997, but never adopted, since according to the then "Law on development planning " (NN number 30/95) there was no obligation of development plans for infrastructure corridors. Later, such regulations were introduced, but the adoption of Development plan was not initiated. During the creation of the first phase of corridor' s Development plan it was noticed that the Preliminary design from 1985 did not represent suitable basis for further planning and design, with regard to insufficiently detailed project and numerous modifications coming up in the meantime. Late in 1995, parallel with formation of Development plan started the completion of **"Annex to preliminary design of the Danube – Sava multi – purpose canal"**. The project was completed in 1998. "**Preliminary design of the port of Vukovar"** on the D-S canal was completed in 2000. Until the year 2000 twenty two institutions and companies with 156 renowned professionals and researchers of all needed fields took part in terrain works and creation of study and project documentation within the Annex of preliminary design of DSMC. Within the Annex, the **Environmental Impact Study of D-S canal** was developed. The environmental protection committee reached the DECISION on 16 March 1999 to determine the DSMC project as environmentally friendly, while including the environment protection monitoring in the programme implementation. From 2000 to 2005 the monitoring was conducted with results confirming the impact of DSMC on forest ecosystems, whereby pointing at its significance for control and maintenance of underground water level on gravitation area of agricultural soil.

Location permit for canal construction D-S was demanded during 1999. The then Ministry of development planning did not incite the local permit procedure as the planned operation and documentation were not adjusted to legal framework and existing development and planning documentation. In this way all the activities for obtaining the D – S local permit were interrupted. Moreover, the conditions needed for canal construction were not mature. After the interruption in 2001 the activities and completion of project documentation were resumed only in 2005.

Activities and operations on completion and upgrading of study and project documentation of DSMC in 2006 and 2007

After several expert debates (2004 and 2005) conducted by heads and chief executives of activities in working out of study and project documentation supplied by explanations of authorized ministries (MPŠVG, MZOPUG, MMTPR) the programme proposal was accepted in collaboration with the Agency for navigable inland waterways in May of 2006:

The completion of development and planning documentation for the project study level (*preliminary design upgrading, environmental impact estimation, completion of expert documentation for location permit and obtaining of local permit*), **geodesic works, upgrading of geotechnical investigation works, preparation of geotechnical investigation works for the main design, upgrading of preliminary design, and completion of legal procedure (obtaining of preliminary permit) for the construction of DSMC.**

After completed tender on 29 June 2006 the Agreement on execution of mentioned operations was signed between *the Agency for navigable inland waterways – PERFORMER and the Institute of Civil Engineering of Croatia, in collaboration with the Faculty of Civil Engineering University* *of Zagreb, Water Management –project office d.d., Zagreb, Institute for Geodesic Operations d.d. Osijek, Institute for Development Planning Osijek and Elektroprojekt d.d. Zagreb*. In order to complete the project and other documentation, a solution on the use of earth material needed for the cut of DSMC and further construction of V.c motorway CORRIDOR should be submitted, along with the project of irrigation of agricultural soil.

The deadline for operations and upgrading of planning, study, project and other documentation for DSMC is late June of 2007 – including location permit procurement and by the end of September the procurement of preliminary permit.

Activities in elaborating the upgraded technical documentation of DSMC consist of the following steps:

1. Development planning documentation
2. Upgrading of preliminary design (from 1998)
3. Environmental impact estimation of DSMC (Upgrading of Environmental impact study from 1999.)
4. Completion of feasibility study – in accordance with development documentation (alterations and annexes)
5. Obtaining of location permit
6. Upgrading of preliminary design– with facilities on DSMC
7. Preliminary permit for DSMC
8. Upgrading of geotechnical study
9. Geodesic operations for DSMC.

2. Feasibility of Danube – Sava multi – purpose canal

Multifunctional significance of a future canal is contained in the following: irrigation, navigation and drainage, and in a number of subsidiary activities like: enrichment of small waters, technological water and positive environmental effects.

The strategic goal of **irrigation** of **35.750 ha** of agricultural soil would lead not only to the increase of the already highly productive traditional farming, but also to the alteration of market based vegetation plants' sowing structure. (Fig. 1).

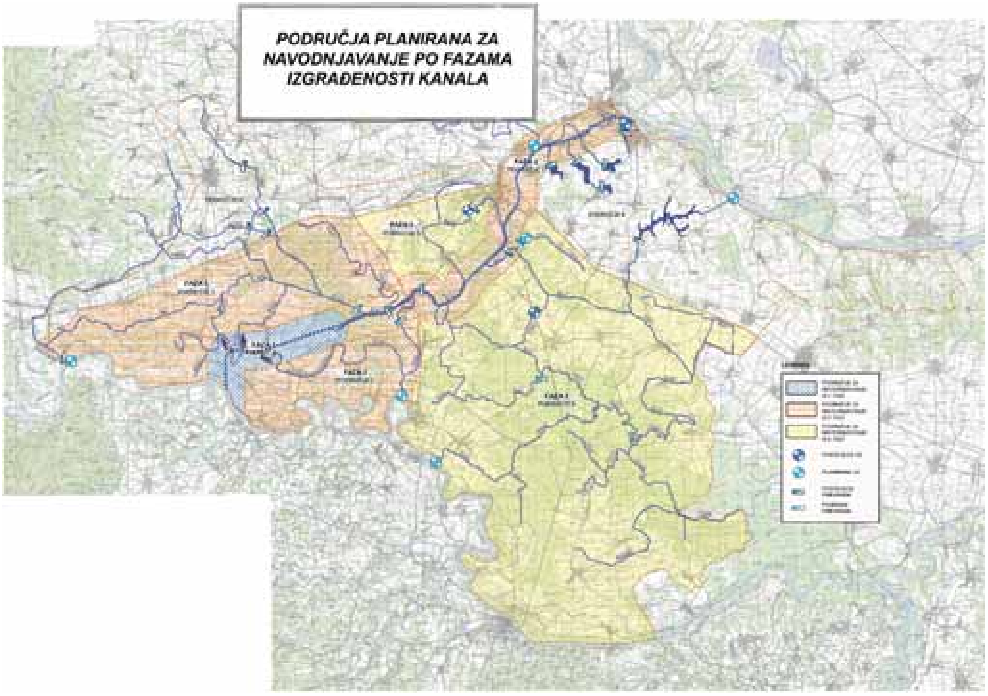

Fig. 1 – Areas planned for irrigation, according to canal construction phases

The canal navigation in the framework of Croatian strategic traffic policy should be regarded only from the aspect of constructing the 570 km long Podunavlje-Jadran traffic corridor. The river – railway connection is scheduled to consist of: 61,4 km of Danube – Sava canal (from Vukovar to Šamac), 306 km of canalized river of Sava from Šamac to Sisak with 2 water reaches (Županja and Jasenovac) and 200 km of Sisak-Zagreb-Rijeka double track railway (currently 230 + 50 km, mostly single track). The aim of ***drainage*** of the canal catchment is to arrange further the surface drainage on 173.000 ha and to ensure conditions of extending underground drainage on 62.000 ha of agricultural soil. The other aim is the elimination of temporary long lasting and uncontrolled floods of Spačvansko-studvanski basin and the regulation of its discharge water according to the needs of forest vegetation. ***The enrichment of small waters*** is connected with irrigation and environment of canal based settlements. The canal ensures also the use of technologic water

3. Basic construction elements

The future D-S canal would involve the construction of the following:

- **61,4 km of DSMC,**
- **8,6 km of DC**
- **Two ship locks,**
- **Six weirs,**
- **Three pumping stations,**
- **One siphon,**
- **20 road and**
- **3 footbridges and cycling bridges,**
- **4 railway bridges**,
- **770 m of pedestrian and bike approaches,**
- **30.036 m of road approaches,**
- **12.028 m railway approaches and**
- **A series of minor facilities on the canal and onshore**

The operations will encompass:

Digging and disposal of:

- **54 mil. m^3 of earth material**

Embedding of:

- **2.6 mil. m^3 of stone material**,
- **260.000 m^3 of concrete**
- **20.000 t of steel**.

Within the broader canal zone (±500[m] from the axis) there are 62 existing and 25 scheduled electric and phone cables. 38 of existing ones and 12 scheduled ones cross the Canal. In addition, in the broader zone of the Canal (±500[m] from the axis) there are 21 power transformers.

To connect the future D-S canal and accompanying facilities to the existing system of electric supply the following is needed:

- **To install 5 future power transformers into the system**

There are 2 existing gas pipelines and 2 next are scheduled, along with two oil pipelines within the broader canal's zone.

Within the broader canal zone there are 10 existing and 3 planned water supply systems. 9 of the existing water supply systems and 3 that are scheduled would cross the canal. Further, 7 main collectors are planned, 4 of them crossing the canal.

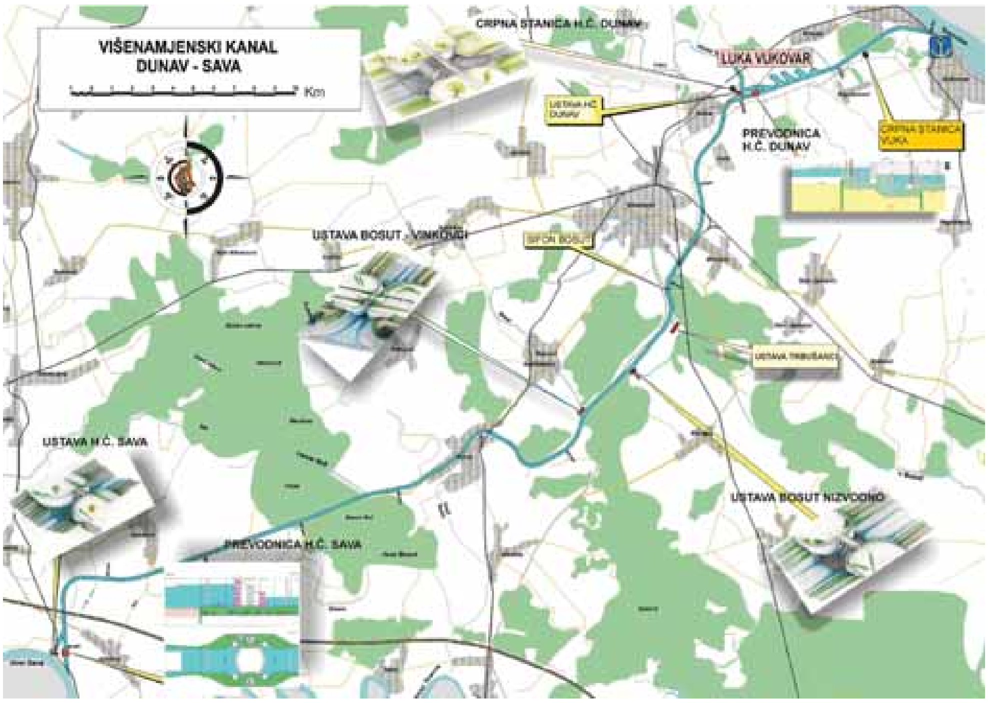

Fig. 2 – Danube-Sava canal route with facilities[3]

4. Construction phases

DSMC construction scenarios result from development strategy and programme, and particularly irrigation of agricultural soil, construction of Kneževo – Velika Kopanica road corridor Vc, snd improvement of forests' water regime to increase the crops and meet environmental needs.

The scenarios simulate possible final stages of canal construction and act as operable units:

- SCENARIO I – First 15 km of Canal from Sava to Konjsko canal for irrigation
- SCENARIO II – The whole DSMC constructed at the same time from Sava to Danube
- SCENARIO III – The whole DSMC constructed at the same time from Sava to Danube with the port of Vukovar on the Canal

The time period of 61,5 km Canal would stretch possibly according to the SCENARIO II, throughout 4 phases (Fig. 3), not necessarily involving the mentioned dynamics. Each of proposed development phases represent one hydro-engineering unit that could independently function until the extension in the next phase. As far as for the planned purposes, they are unlimited regarding the time. The development within each single phase could run throughout several stages depending on area development and scheduled utilization: irrigation, drainage and navigation. The traffic function would be partly introduced in the Phase II. and entirely in the Phase IV. Irrigation will be to a large extent realized already in the Phase I (Fig. 3).

The Investor defined the following phases development of the future D-S Canal on the basis of conducted analyses (technical, economic and management).

- **Phase I** is concerned with ensuring conditions for the irrigation of agricultural areas of the Biđ-Bosut field (BBP) and the forest area of Spačva. It would also encompass the canal construction along the planned route from the river of Sava to the link with the Biđ watercourse (the length of 15 km), to ensure conditions for water supply from the river of Sava into major recipients on the greater Biđ and Bosut areas. The riverbed cut

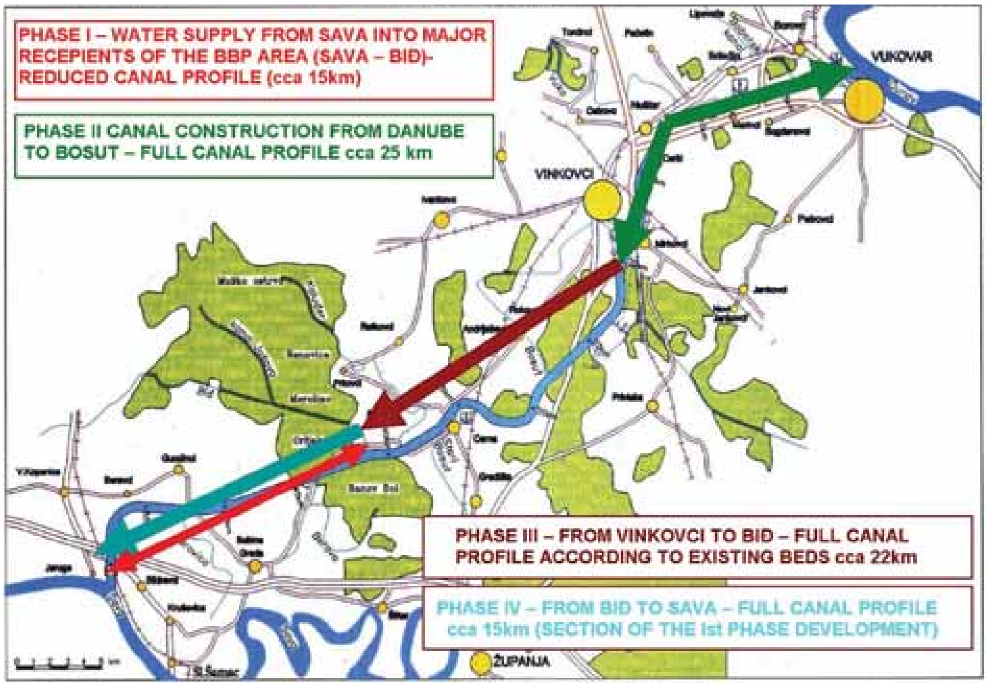

Fig. 3 – The Danube – Sava canal construction phases[4]

would be conducted in reduced dimensions. At the link with the Sava river on the diversion channel of Sava, the weir and pumping station would be built, over which the needed water quantities would be conducted into the Canal and farther into the system of existing BBP canals not only in this phase(but also later). At that period only the weir and pumping station of the Sava junction will be built. On the D-S's canal profiles with the existing traffic network the temporary culverts would be constructed.

- **Phase II** is the largest and most important, as it contributes to the regulation of water regime of large and small waters on the BBP area and ensures conditions for the navigability to Vinkovci from the direction of Danube. These operations would ensure drainage of massive waters from BBP into the Danube besides the existing drainage into the Sava. It will all make possible to manage large waters on the BBP area, water supply into the BBP system and from the Danube in order to enrich small waters to enable irrigation of Biđ-Bosut field and Spačva-Studva forest complex. This phase would cover approximately 25 km of future D-S canal with riverbed's full profile. Most of water facilities will be built, some of them outside the borders of mentioned 25 km of the Canal. The crossings of traffic and infrastructure links according to their location and dynamics are considered on the section in question considering special characteristics of DSMC from Development plan.
- **Phase III** includes the extension of the navigable way from Vinkovci to Cerna. The DS canal would be constructed along the existing watercourses: Bosut, Bazjaš and Biđ in the length of cca 22 km, in the full riverbed profile. The landing at Cerna and weir at Vezovac will be erected. The crossings of traffic and infrastructure links according to their location and dynamics are considered on the section in question considering special characteristics of DSMC
- **Phase IV** leads to the full operability of Danube – Sava navigable way. It overlaps in developmental aspects with the I. phase section. The cca 15 km Canal's full profile would be constructed, e.g. it would contribute to a large riverbed profile extension from the I. phase. The Sava junction lock would be constructed. The crossings of traffic and infrastructure links according to their location and dynamics are considered on the section in question considering special characteristics of DSMC. The construction of Zagreb-Lipovac motorway over the Canal is considered as a demanding operation.

The operations of the Ist and IInd Canal's development phases overlap. Their construction is estimated to take between 8 – 10 years. The operations of the IIIrd and IVth canal's development phases can overlap as well, but at any time after or parallel with the IInd phase. It is difficult to estimate the start of this phase. However, the construction could take 4 to 5 years.

The Table I provides the illustration of Canal's development stages by listing future facilities, whereas the illustrations (Fig. 3 to 6), in the appendix show the operations according to development stages, along with the basic aims containing the phases of proposed solutions.

Table I. Illustration of development phases of DSMC through the list and position of designed facilities[2]

List of facilities				
	Zone borders of PPPPO* of DSMC (cca 500m left and right from the canal axis)		Outside the zone borders PPPPO VKDS-a (outside the belt of cca 1000m around canal)	facility's location (chainage)
I. Phase	I PHASE-DSMC of the lowered profile for the irrigation from Konjsko canal to r.Sava (KM 46+300 to 59+100) with the arrangement of the existing Konjsko canal and eastern Berava to joining with Bidom (KM 41+750 do 46+300)			
	nb of fa	Facilities		
		Sava- Konjsko canal		chainage VKDS from 46+300 to 59+100
		Arrang. of exist. riverbeds of Konjsko and East. Berava		cca chainage VKDS from 41+750 to 46+300
	36	Diversion channel of hydro-junct. Sava DKHS		chainage VKDS 59+100
	18	Weir and CS Sava hydrojunction		chainage DKHS 1+473 km
		Waste tip of Sava hydro-junction		chain. VKDS 61+000 km
	26		Pumping station Sitar+arrangement of link with Bosu	chain. Sava
	27		Pumping station Oprisavci+arrangement of link with B	chain. Sava
		7 road passages - temporary solution		
		1 railway passage - temporary solution		
II. PHASE	II PHASE - DSMC of full section from the mouth at Danube to the r. of Bosut (Bazjaš cut) - (KM 0+000 do			facility's location (chainage)
	fac.nb	Facilities		
		Danube-Bosut canal (cut Bazjaš)		stac. VKDS od 0+000 do 25+000
	31	official port of Vukovar		chain. VKDS 1+733
	31	Landing stage of Vukovar		chain. VKDS 0+485
	14	The mouth of Bob canal in DSMC		chain. VKDS 2+843 km
	28	Hydr-engineer. reach Bob. Canal		chain. VKDS 2+843 km
	23	CS Vuka		original chain. of Vuka 4+850km
	29		Training of Vuka riv.	original chain of Vuka 0+000 do 5+223
	30	Linking canal DKHD-Vuka (canals + collectors)		
	37	Diversion channel of hydro-link Danube(DKHD)		chain. VKDS 8+765 km
	11	Hydroengineer. reach on DKHD-u		chain. DKHD 0+340 to 0+365 km
	12	The mouth of Vuka in DKHD		chain. DKHD 1+315
	13	Hydro-link reach Vuka		original chain of Vuka 14+463 do 14+458 km
	20	Weir of Danube's hydro-link		chain. VKDS 9+580 km
	21	Weir of hydro-link Danube		chain. DKHD 1+700 km
	22	CS of hydro-link Danube		chain. DKHD 1+700 km
	26	weir of linking canal VKDS-Vuka		chain. DKHD 10+320 km
		Waste tip Vinkovci		chain. VKDS 17+500 km
		Waste tip Ervenica		chain. VKDS 11+750 km
		Waste tip Lužac		chain. VKDS 0+400 km
	19	Siphon of Bosut		chain. VKDS 20+654 km
	38	Trbušanci canal		chain.VKDS 20+654 km to Prokopa Trbušanci
	34	Landing stage Vinkovci		chain. VKDS 24+141 km
	15	Bosut weir-downstream		chain. VKDS 25+278 km
	16	Bosut weir Vinkovci		chain. VKDS 28+211 km
		9 road bridges		
		2 foot- and cyclebridges		
		2 railway bridges		
III. PHASE	III PHASE-DSMC of full section from Bosut (Bazjaš cut) to Bid - (KM 25+000 to 41+750)			facility's location (chainage)
	fac.nb	Facilities		
		Bazjaš- Bid canal cut		chain. VKDS od 25+000 do 41+750
	24	Vrezovac weir		chain. VKDS 32+130
	32	Cerna East landing stage		chain.. VKDS 33+751
	33	Cerna West landing		chain.. VKDS 38+634
	38	Cerna trade landing		chain.VKDS 39+850
		Linear waste tip along the Canal first +91m.n.m		chain. VKDSod28+860 do 31+400 od 32+693 do 34+075
		3 road bridges		
		1 footbridge		
		1 railway bridge		
IV. PHASE	IV phase-DSMC of full section from Bid to Sava r. - (KM 41+750 to 61+400)			facility's location (chainage)
	fac.nb	Facilities		
		Sava- Bid canal		chain. VKDS from 41+750 to 61+400
	17	Sava hydro-link lock		chain. VKDS 59+825 km
		Linear waste tip along the canal on the +91 above s.l.		chain.. VKDS from 46+000 do 56+130
		Waste tip of the hydro-link of Sava		
		6 road bridges		
		1 railway bridge		

*Development plan of specially marked areas of DSMC

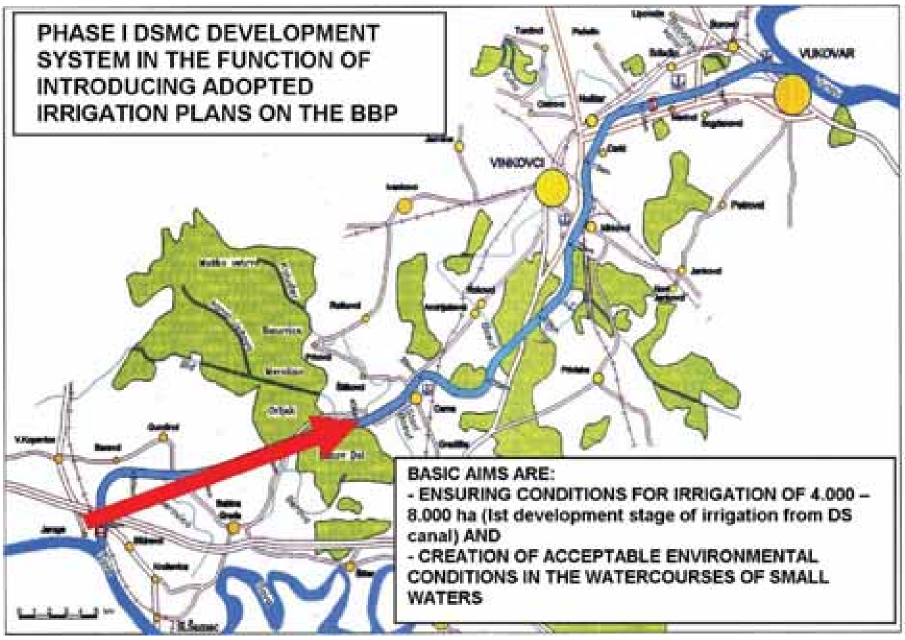

Fig. 4 – Ist.phase development of DSMC[2]

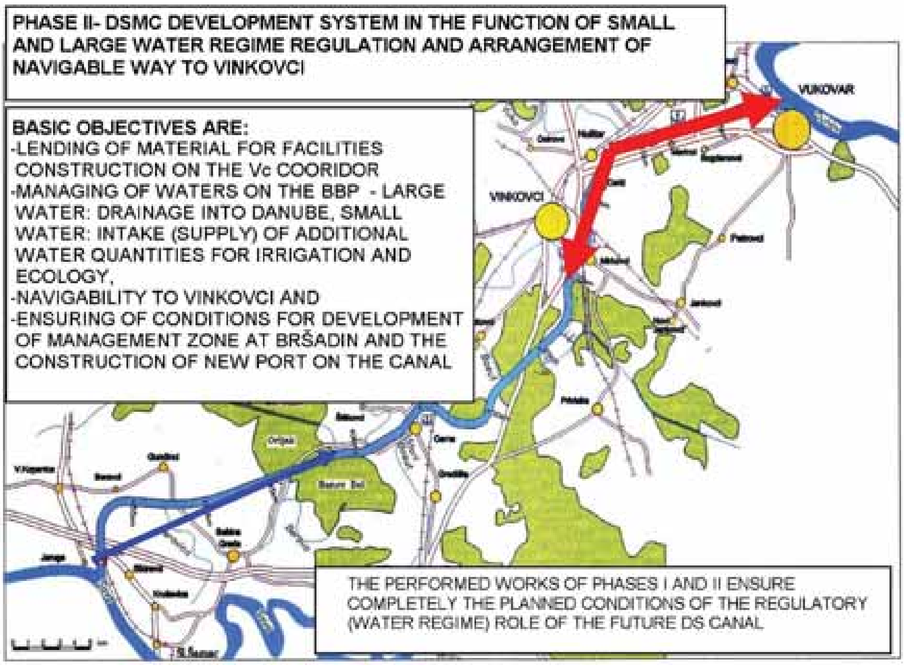

Fig. 5 – Objectives of IInd development phase of DSMC system[2]

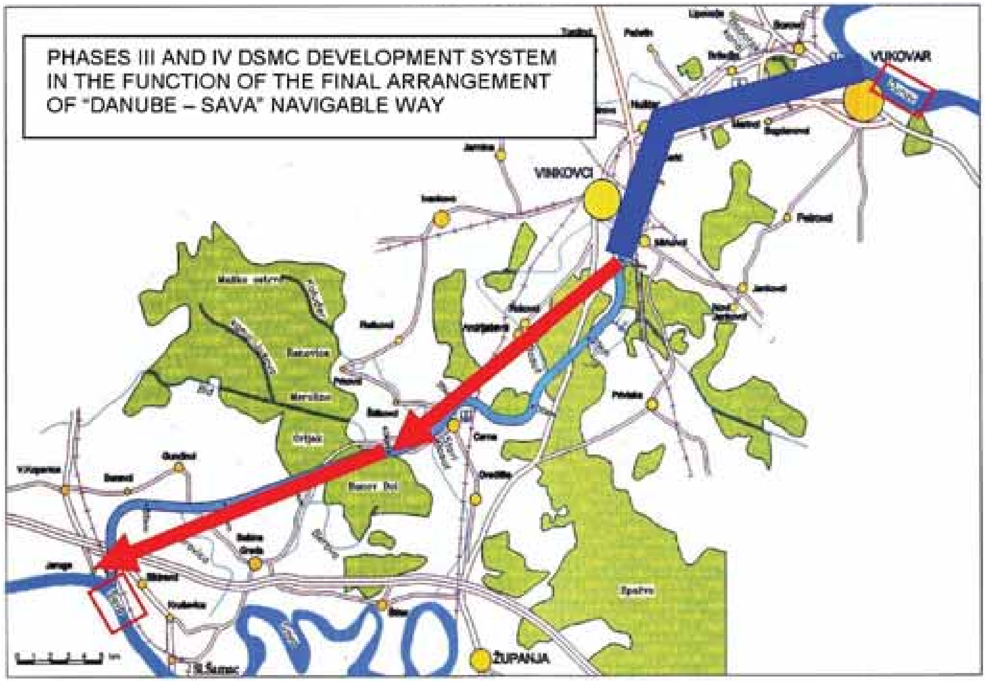

Fig. 6 – Objectives of IIIrd. and IVth development phases of DSMC system[2]

5. Construction expenses

Tab II – Investment costs into DSMC and the port of Vukovar

INVESTMENTS INTO THE PORT AND CANAL	SCENARIOS		
	I	II	III
Construction expenses of canal's infrastru. On the debit of RC	46 mil. EUR	827 mil. EUR	827 mil. EUR
Construction expenses of canal's infrastru. on the debit of RC	0	0	300 mil. EUR
TOTAL RC	**46 mil. EUR**	**827 mil. EUR**	**1.127 milijardi EUR**
Construction expenses of infrastr. on concessionaire's debit	0	0	450mil. EUR
INVESTMENT EFFECT ACCORD. TO SCENARIOS (with 5% of credit interests)			
Cash property refund (years)	4	26	28
IRR after 50 years	25,75%	5,48%	5,79%

Table III – Illustration of construction expenses of DSMC through development stages[2]

	Total construction expenses by phases (including electr..machinery and hydroeng. equipment)	Cummulative
	[€]	[€]
PHASE I	45.316.129	45.316.129
PHASE II	399.345.990	444.662.118
PHASE III	210.671.556	655.333.674
PHASES V IV	171.405.102	826.738.775

Investment comparison for 1m' of Canal:

– **Construction expenses for Danube –Sava canal (Vb)**
9,6 mil.EUR/km

– **Construction expenses of Main-Danube canal (Vb)**
10,24 mil.EUR/km

– **Construction expenses of Cernavoda-Constanta canal (VII)**
19,7 mil.EUR/km

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Development of River Ports in the Republic of Croatia

Summary

Inland water ports are key components of the entire transport system on inland waterways, and the success of complex transport process from the point of production to the point of final consumption is greatly dependent on them. Inland ports, situated on European waterways, with regard to the integral character of the transport and general economic market, are of particular importance. On the long-term basis, orientation of the European Community is to establish balance of transport development, stressing inland waterways and railways as alternative means of transport. This opens the opportunity for expansion of ports on inland waters. This refers mainly to ports in Eastern European Danubian Countries, where this fact is expected to influence directing of transport from Near East transport markets to the Danubian corridor and further to Western European countries.

In Croatia, four port authorities are organized on inland waterways, as follows: in Vukovar for public ports on the Danube and the future Danube-Sava multipurpose canal, in Osijek for the Drava ports, while the jurisdiction on the Sava river is shared by the port authorities Sisak and Slavonski Brod. The Croatian ports system practically consists of four ports open to public transport of national importance: Sisak, Slavonski Brod, Osijek and Vukovar. Three of them (Slavonski Brod, Osije and Vukovar) are situated in the

close vicinity of the transport corridor V c, while the ports Sisak and Slavonski Brod are situated along the transport corridor X. Their development will be greatly influenced by the importance of the transport corridors in the general traffic of the region, and vice versa. Master plans have been prepared for the ports Slavonski Brod, Osijek and Vukovar which imply their expansion, both as regards the reloading capacity and the operating space. Each of them has its specific properties resulting from the present situation, available space and physical and tranpost characteristics of their respective waterways. For the Sisak port the development plan has not been elaborated yet. Planned development of the Vukovar port includes modernizing and construction of additional port capacities in the existing port area, expansion of the port perimeter and integration with the industrial and economic zone of Borovo, investments in port infrastructure, inclusion of the port in the development of the industrial hinterland, modernizing of road and railway infrastructure in the port and in the access to the port, including connection to the major transport corridors (V c, X). The development plan of the Osijek port includes expansion of the port area to the total of 110 hectares and inclusion of the stretch from the Drava river km 12+600 to 15+490. The Plan also envisages inclusion of the island created by shortcutting the old Drava meander, and the present port area of 58.3 ha (aquatory 20.4 ha + territory 37.9 ha) will be extended to 10 ha of new territory. The development of the port Slavonski Brod is greatly dependent on the reliability and safety of navigation in the Sava river. The only present capacity in this port is reloading of crude oil in local transport to the Sisak port. In the final stage of development, the port Slavonski Brod would include 9 berths, specialized for reloading of general cargo, containers, gravel and sand, ro-ro transport, reloading of cereals, and for trans-shipment. The new Vukovar port on km 9 of the Danube-Sava Canal is envisaged within the scope of the Multipurpose Danube-Sava Canal Project. Development of this port depends on the development of transport and economic requirements and technical conditions. The forecast of future port traffic is about 5.7 million tons per annum in 30-years period (4.16 million tons per annum of water transport, and 1.56 tons of land transport). The port zone for water transport (trans-shipment) would consist of 3 port basins with 24 berths. The hinterland port zone would be connected to land transport, and would include the land terminal, production zone, trade and business zone, and commodity reserves. The facilities resulting from construction of this business zone would allow the increase of the traffic and production over 8 million tons per annum.

Key words: Croatian inland waters ports, Vukovar port, Osijek port, Slavonski Brod port, Vukovar canal port

Introduction

In Croatia, four port authorities have been organized on inland waterways, as follows: in Vukovar, for public ports on the Danube and on the future multipurpose Danube-Sava Canal, in Osijek for ports on the Drava river, while the jurisdiction over ports on the Sava river is shared between the port authority Sisak and the port authority Slavonski Brod. The Croatian port system practically consists of four ports open to public transport of national importance: Sisak, Slavonski Brod, Osijek and Vukovar.

The ports, together with inland waterways, constitute a system. At present, in Croatia this system is divided into the Sava system (Sisak and Slavonski Brod) and the Danube system which includes the Vukovar and Osijek ports. Coordination of development strategies of the Sava ports is the precondition for their competitiveness on the market. On the other hand, the Danube port system, after revitalization of the transport on the Danube, is facing the increased demand for transport, and its position is quite different. Connecting of these two systems by the Multipurpose Danube-Sava Canal will generate the preconditions for important development of ports in the Sava system.

Although the sum of traffic of all four ports together is below 2.0 million tons per annum, during the past seven years a growing trend has been noticed, first of all as the result of growth of transport in the Danube (Table I).

Analyzing individual ports, there is an evident growing trend of traffic in ports of the Danube corridor, in particular the Vukovar port. It is to be

Table I – Transport of cargo in inland ports open to public transport, in tons.

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Osijek	264.000	184.000	197.000	256.414	355.856	477.545	464.105
Sisak	169.000	210.000	205.000	201.000	198.000	198.000	140.000
Slavonski Brod	169.000	210.000	205.000	201.000	198.000	198.000	140.000
Vukovar	44.000	75.000	110.000	153.245	301.304	803.250	1.108.261
Total	**646.000**	**679.000**	**717.000**	**811.659**	**1.053.160**	**1.676.795**	**1.852.366**

expected that the growing trend will be continued in the following years, with minor or major fluctuations. At present, the ports Sisak and Slavonski Brod depend exclusively on transport of crude oil on the relation Slavonski Brod – Sisak, which is the only cargo in public transport, recorded in these ports.

Port Vukovar

The port Vukovar is situated at Danube river km 1335, in the area of the so-called Middle Danube. It is located on the crossroad of commodity flows west-south between Croatia and Bosnia and Herzegovina, and north-east between Hungary, Serbia and Romania. Vukovar is the river port which may service Class V vessels, and the navigability and reliability of the Danube practically 365 days per annum make it more important than the other river ports in Croatia.

The traffic demand is up to 1.6 million tons per annum, however reloading capacities do not allow servicing of such large traffic. The present port perimeter covers the area of about 26 ha, limited in the north by the Danube, in the south by the public road connecting Vukovar and Osijek/Vinkovci, in the east by the residential zone, and in the west by the area of the commercial-industrial zone ("Borovo" zone). The port is on the Danube river bank, 450 m long, with 4 berths. Out of this, 3 berths have sloped waterfront, and one berth semi-vertical waterfront. On the bank margin there is a railway track. The port has 13.500 sq.m. of open storages and 2.400 sq.m of closed storages.

Construction of the planned Danube-Sava Canal and the position of its confluence with the Danube would reduce the operating area of the port by approximately 6 ha, to about 20 ha. Namely, the project includes demolition of a part of the port (about one-fourth of the area) which is operationally functional. With respect to the importance of the Vukovar port for traffic, implementation of the Danube-Sava Canal project (according to the existing technical documentation) should be preceded by carefully programmed schedule of construction of additional port capacities in order to compensate the loss of area and allow full functioning of the port on the entire port area. As the compensation for the lost space, the first section of the canal would serve as the operating waterfront for reloading of the cargo.

According to the development plant of the Vukovar port (October 2004) the basic development concept of the port may be summarized as follows:

- Modernization and construction of additional port capacities in the existing port area – in Vukovar town zone – Priljevo ("New port east"),
- Expansion of the port area and integration with the industrial zone Borovo ("New port West"),
- Investments in port infrastructure in the port area which will be in the construction zone of the Danube-Sava Canal should be reduced to essential maintenance,
- Inclusion of the port in development of industrial hinterland,
- Modernizing of the road and railway infrastructure in the port and in accesses, including connection to the main transport corridors (Vc, X),
- Implementation and, as necessary, modification of port management in accordance with market demands.

This plan does not include the concept of construction of the so-called New Port Vukovar on km 9 of the Danube-Sava Canal in Bršadin, which is planned under the project of the Multipurpose Danube-Sava Canal. The above development concept of the Vukovar port, however, does not exclude construction of additional capacities on canal km 9, when the conditions are mature, and provided such concept is evaluated commercially and marketwise.

The Master Plan contains the development concept of the Vukovar port in two phases, as follows:

- Phase 1 – implementation of terminals and facilities in the existing port and in the New Port East, as shown in Fig. 2
- Phase 2 – implementation of terminals and facilities in the New Port – West, after inclusion of the industrial zone "Borovo" into the Vukovar port zone, as shown in Fig. 2

Although there are changes in further steps that are now in progress, the basic concept of the port from the Master Plan has mainly been respected. At present, the environmental impact assessment and the preliminary design for construction of Phase 1 infrastructure are being elaborated. This includes three terminals with vertical waterfront approx. 395 m long, and development of semi-vertical waterfront 60 m long which makes total vertical waterfront of about 455 m (in Fig. 1. the area of the multipurpose terminal 1, terminal 2 for bulk cargo, and terminal 3 for pallets and part-load cargo). It also includes development of the sloping

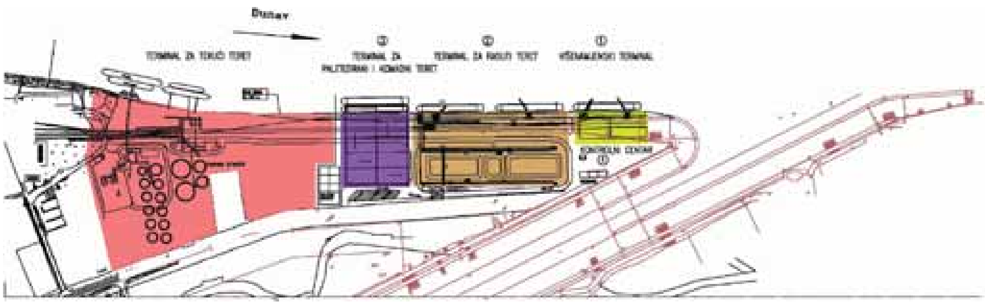

Fig. 1 – Phase 1 of port development.

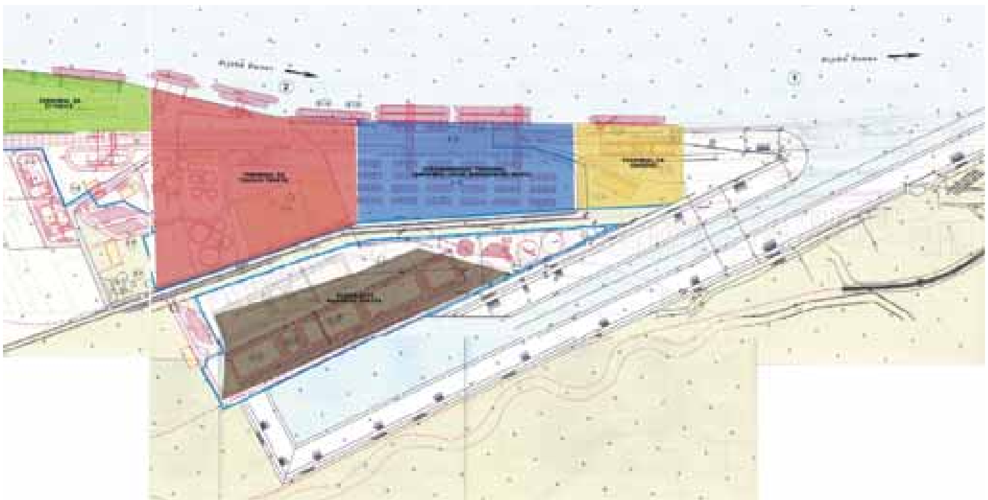

Fig. 2 – Phase 2 of port development – New Port West; alternative solution of Phase 1 construction of New Port East – integrated with the mouth of the Danube-Sava Canal.

waterfront upstream from the end of vertical waterfront, in the length of approximately 425 m (in Fig. 1. the area of the terminal for liquid cargo).

Port Osijek

The port Osijek is included in the system of the Danube international waterway, situated in two locations on the right bank of the Drava river: the older location in the zone 17-19 river km, and the new location in the zone 12-15 river km. The Ordinance on inclusion of the Osijek port in the system of public ports also includes the new port location at Nemetin, and abandoning of the old location is to be expected. Besides this, according to urban development plans of the town of Osijek and of the County Osječko-Baranjska, the area of the old port will be set aside for urban development of the town of Osijek.

The present port has the total area of 56.1 ha and includes the stretch from the Drava river km 12+600 to 14+450. It does not include the island formed by cutting of the old Drava meander, and involves the following:

- the existing basin aquatory of 20.4 ha in the old Drava meander, km 12+600 to km 14+000
- territory of 35.7 ha, i.e. zone of the south bank of the old Drava meander

The development plan of the port (Fig. 5) includes expansion of the port area to the total of 110 ha

- and the port will include the stretch from the Drava river km 12+600 to 15+490, as well as the island formed by cutting of the old Drava meander, and will consist of the following parts:
- present port areas 58.3 ha (aquatory 20.4 [ha] + territory 37.9 ha),
- present south side of the island territory of 10 ha,
- new territory of 10 ha, formed by backfilling of a part of the present Drava river channel upstream from the island between km 14+000 (east) and km 15+490 (west),
- new territory northwest from the present port limits, of 31 ha in the stretch from km 14+450 to km 15+490,
- new territory for development of railway reloading facilities, 0.7 ha,
- the present duty-free zone Osijek, 8 ha, and area reserved for its development in the northwest, 2.5 ha, do not belong to the Osijek port.

Present activities regarding development of the port consist of a number of designing works. The procedure of preparing of the environmental impact assessment has been completed, and the final design of the bulk cargo terminal (Fig. 3) is in the final stage of elaboration, as well as the preliminary design of infrastructure on the south bank (Fig. 4). The preliminary design of the western industrial zone is also in progress (Fig. 5).

Fig. 3 – Bulk cargo terminal in Osijek port.

Fig. 4 – Area of south bank of Osijek port.

Fig. 5 – Final phase of development of Osijek port.

Port Slavonski Brod

The port Slavonski Brod is situated on the left bank of the Sava river, east from the town Slavonski Brod in the area Ruščica near the industrial zone, and encompasses the port area of 108 ha. Reliability and safety of navigation in the Sava river is the major factor influencing the attractiveness of the port, and international traffic has been completely stopped. The only activities in the port are related to reloading of crude oil in local transport. Construction of the Multipurpose Danube-Sava Canal would result in incomparably better conditions for development of the port.

The future of the port Slavonski Brod is based, first of all, on the fact that it is situated in the border zone towards Bosnia and Herzegovina, and in direct vicinity of the hub of traffic corridors X and Vb.

For Slavonski Brod, the Sava river represents an inadequately utilized traffic potential, which should be properly upgraded by establishing of the port. The basic preconditions for this development have been achieved, which may be summarized as follows. First, signing of the European agreement on main inland waterways of international importance (AGN), by which Croatia has declared the waterway on the Sava river from Jamena to Sisak, km 207+00 to 583+00 as the international waterway of Class IV (E 80-12) and taken the responsibility for its development, marking and maintenance. Second, Slavonski Brod is situated on pan-European traffic corridor X, in close vicinity of its crossing with corridor Vc, which provides stability of commodity flows.

At present, activities in the port Slavonski Brod consist of reloading of gravel and crude oil. It is estimated that other types of traffic will be developed in future, such as: general cargo, including containers, bulk cargo, timber, RO-RO, cereals, liquid cargo, and dry cargo.

The development of the port Slavonski Brod is dependent on a number of factors, from social and political to infrastructural. At present, only infrastructural factors may be reliably analyzed. In this context, the greatest influence on the development of the port will be that of the future Danube-Sava Canal. Its construction and reaching of full operation would allow the transport of important contingents of goods (estimated traffic in the canal after 30 years is 7 million tons per annum). With respect to the fact that traffic in the Sava without the canal is possible but the capacity is limited, the dynamics of the port Slavonski Brod is predictable. Thus, the wharf on the Sava in Slavonski Brod will be the first phase of the Slavonski Brod port project, with construction of vertical waterfront for one berth. Dimensions of the waterfront are dependent on the size of vessels and on the environmental conditions

In the final phase, the port Slavonski Brod would have 9 berths. The structure and number of berths are shown in Fig. 6.

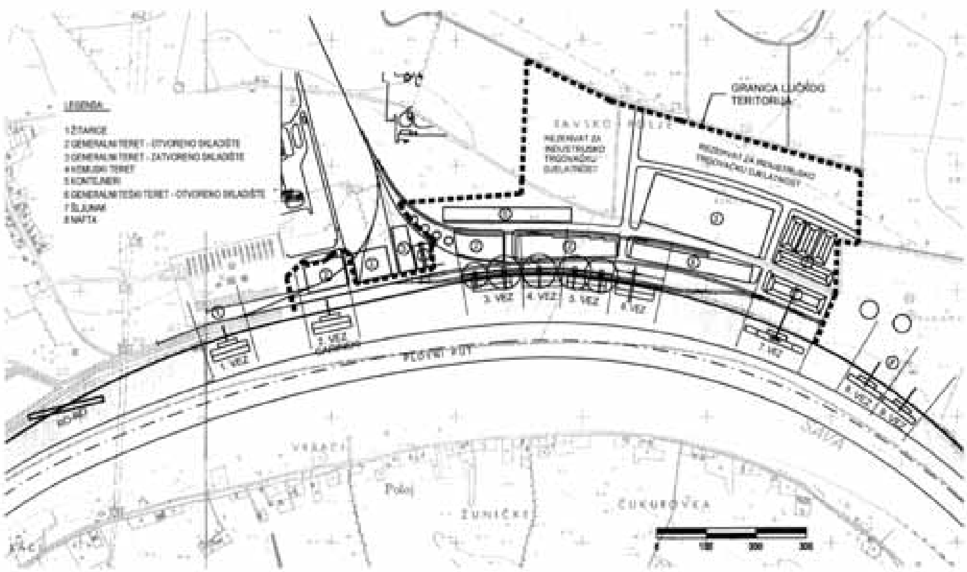

Fig. 6 – Final phase of development of the port Slavonski Brod.

The port territory will include storage capacities for various types of goods. Besides this, in the hinterland zone there is space for development of industrial and trading activities.

Present activities regarding development of the port consist of design works. The preliminary design of extension of the present waterfront by two berths is completed (Fig. 7), and elaboration of the final design of the two berths is in progress, as well as the preliminary design of infrastructure of the entire port area.

Fig. 7 – Design of berths No 4 and 5 in port Slavonski Brod.

Canal port Vukovar

In future, Croatia plans to develop a strong traffic corridor Croatian Danubeland – Adriatic Sea, with the multipurpose canal as a part of it. The mouth of the canal will be at the Danube river km 1334+700. As the present port Vukovar will not be able in future to fulfill the planned functions, there is an ideal solution along the canal mouth for development of the new port of 750 ha. The future Vukovar port will be situated from canal km 6+400 to km 8+450, measured from the Danube. The pert area will be limited from the north by the railroad Vinkovci – Vukovar and the community Bršadin, from the west by the Vuka river channel, from the south by the canal, and feom the east by the future road bypass Borovo–Vukovar (Fig. 11).

The port Vukovar has a strategic traffic importance in transit of goods at the crossroads of traffic ways between east and west, and north and south. The projections of future port turnover are about 5.7 million tons per annum in 30-years period (4.16 million tons river transport, and 1.56 million tons by land). The riparian port zone for river transport (reloading of cargo) will have 3 port basins with 24 berths. The plans also include a smaller basin fro ship overhauling. The hinterland port zone is connected to land transport, consisting of the land terminal, industrial zone, commercial and business zone, and commodity reserves. Business capacities resulting from construction of the business zone will allow increasing of traffic and industrial production to 8 million tons per annum. As regards land commodity transport, the future port will rely on the Vinkovci railway station and the future national road on the direction Budapest – Ploče. The plans also include three road hubs for connection of the port with the Croatian and the international road network. According to the construction schedule, it may be expected that the port Vukovar will start to develop before construction of the canal. Then it

Fig. 8 – Project of canal port Vukovar.

will be necessary to construct the first 9 km of the canal, from the Danube, with corresponding hydrotechnical and urban environment.

The entire port complex connects river, railway and road transport, as well as industry and trade. According to the purpose, the port will be divided into two basic zons – the *riparian zone* (160 ha), south of the traffic corridor 1, and the *hinterland zone* (240 ha industry, 60 ha recreation, 40 ha shiplock, 250 ha reservation), north of the main port transport corridor 1 (Fig. 8). In the first zone, water transport is taking place (goods crossing the canal bank line), and the other zone serves for land transport which has nothing to do with the waterway.

Conclusion

Croatia, as a country with comparatively developed network of rivers, does not use adequately this nazural potential for inland waterways. River ports of national importance (Vukovar, Osijek, Slavonski Brod and Sisak) are situated in very different traffic and natural environments. Three of them (Slavonski Brod, Osijek and Vukovar) are situated in the vicinity of the Multipurpose Danube-Sava Canal. Their development will greatly depend on the role of the Canal in the overall traffic in the region, and vice versa. Each of them has its specific features resulting from the present situation, available space and physical and traffic characteristics of the respective waterways. According to the comparative advantages, the port Vukovar, viewed on a short-term basis, is the most promising. However, due to territorial constraints, its expansion is questionable. The port Osijek has sufficient space for development, but is subject to limitations related to the navigability of the Drava river. The port Slavonski Brod is, at the moment, isolated from the European waterways system, and its priority is solving of this problem either by construction of the Danube-Sava Canal or by putting of the Sava waterway to the Danube into working order. The Canal port Vukovar is related to construction of the Danube-Sava Canal; however, even in conditions without water transport it may start functioning through development of the hinterland zone with land terminal, industrial zone, business and trade zone, and the commodity reserves zone.

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Current State and Future of Croatia's Inland Navigation

Summary

The paper addresses the state of inland navigation waterways in the Republic of Croatia, with special reference to their technical characteristics.

First, the paper presents the current situation including Croatian official classification accepted by both the Sava Commission and the United Nations' The Economic Commission for Europe in AGN agreement. Croatia signed the AGN in 1997, and it became effective in 1999. According to the *Agreement* the following inland waterways are listed into the system of European inland navigation waterways: E 80, the river Danube, VIc class; E 80-08, Drava to Osijek, IV. class; E 80-12, the river Sava from Račinovci to Sisak, IV class and E80-10 – a future multipurpose Danube-Sava canal from Vukovar to Šamac, the length of 61,5 km, V-b class. Current situation does not meet fully above mentioned data in the cases of the rivers Sava and Drava. In the Strategy of physical planning of the Republic of Croatia higher navigation waterways classes were planned; e.g.V.b. The paper includes the basic review of the rivers Danube, Sava, Drava, Kupa and Una.

Further follows the short-term and long-term development of inland waterways in Croatia, contained also in the AGN Contract of United States.

The short-term development entails the improvement of navigable waterways on the Danube, Sava and Drava through the river training works, while the long-term development involves the canalization of both the Sava and the Drava. As the Croatian navigable network is sparse and connected over Serbia, the artificial multipurpose Danube-Sava canal would be the means of connection within the Republic of Croatia becoming denser in this way.

The Croatian interest and development activities are directed towards the Danube-Sava multipurpose canal, whose construction has begun, but only in the irrigation part. The activities and plans concerning the Danube-Sava multipurpose canal and the river of Sava as part of the state politics of the Republic of Croatia will be presented into details. The time schedule of 61,5 km Canal would stretch possibly throughout 4 phases. Each of proposed development phases represent one hydro-engineering unit that could independently function until the extension in the next phase. The development within each single phase could run throughout several stages depending on the area development and scheduled utilization: irrigation, drainage and navigation. The traffic function would be partly introduced in the Phase II (8-10 years) and entirely in the Phase IV (15-20 years). Irrigation will be realized already in 2-3 years.

Key words: inland waterway, classification, Danube, Sava, Drava, Kupa, Una, Danube-Sava multipurpose canal, parameters of inland waterways

1. Introduction

In Croatia inland navigation has not been developed although it could represent a significant economic activity. There are 3 navigation waterways declared as international, in a full (Danube) or partial length (Drava and Sava). Croatia's inland waterways represent an economic potential, but the morphology of their natural river beds, with exception of Danube, does not allow for sufficiently high international class guaranteeing economic exploitation to stiff pushing convoys. The reason that inland waterways' classes of Sava and Drava rivers are not being raised lies in big investments needed to achieve navigable clearances through massive hydro engineering construction. On the other hand, the Croatian navigable waterway network is sparse, and only the construction of the artificial Danube-Sava multipurpose canal can contribute to its connectivity and density. Neither are developed the inland waterways' ports, at least not as international production and cost and freight centres. Analogously, the inland waterways traffic is distinctly low, as it is the local traffic on short distances. The total length of inland waterways in Croatia is 918,1 km, and only 219,8 km, or 24%, satisfies the international navigable waterways' requirements. On the other side, on 12% of Croatia's inland waterways' length there is only sporadic navigation with small navigable units under international classification.

2. Present classification of inland waterways in the Republic of Croatia

Present classification of Croatian inland waterways is defined in the Rule book on Classification and Opening of Inland Waterways on Inland Waters [1] as shown in Tables 1 and 2, and on Fig 1. The Rules are based on the study [2], and this one on the studies [3,4 and 5].

The mentioned Croatian classification is carried out according to the standards of UN/ECE classification 1992 adopted in Europe on the basis of AGN contract [6] from 1996. The minimal international class IV can be applied only for the existing inland waterways. The upgrading of the existing class IV could at least show the way to the rise to class Va, and the construction of new international inland waterways should lead to class Vb.

Table 1 – Major parameters of Croatia's inland waterways

Class NWW on regular river	Width NWW in bends	Depth NWW at V65% [1 and 2]	Depth NWW at LNWL=V95% [8 and 11]	Minimal radius
	[m]	[m]	[m]	[m]
I	35	1,5	1,1	250
II.	45	1,8	1,5	250
III.	45	2,3	1,8	300
IV.	70	3,6	2,3	360
Vtha	90	3,7	2,4	360
Vthb – canal	55 (37,5 straight)		4	800
VI. c	150	4,4	4,1	750

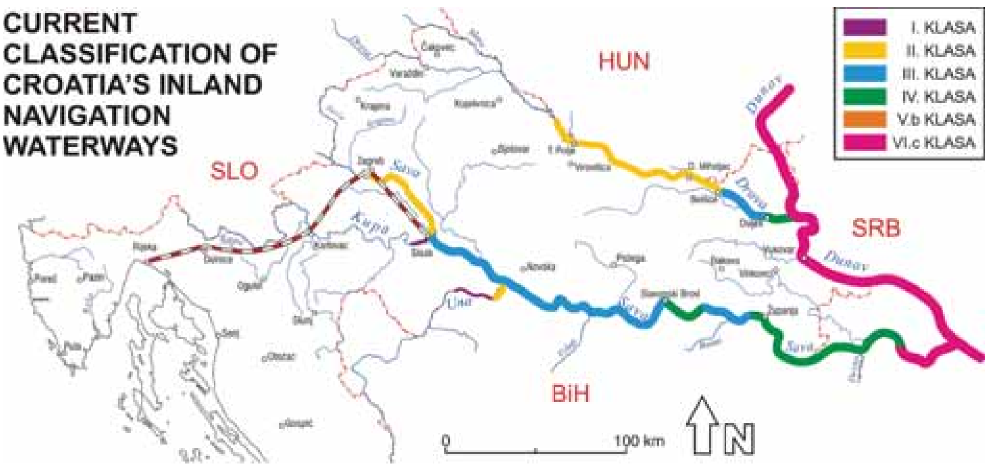

Fig. 1 – Current classification of Croatia's inland navigation waterways [1]

Table 2 – Current classification of Croatian inland navigation waterways [1]

Rriver	**Section of the river**	**Length of navigation route (km)**	**Inland navigation waterways**
Danube	1295+501 (Ilok) – 1433+000 (Batina)	137.5	VIthc class
Sava	203+300 (Račinovci) – 305+700 (Sl. Šamac)	102.4	IVth class
	305+700 (Sl. Šamac) – 330+200 (Oprisavci)	24.5	IIIrdclass
	330+200 (Oprisavci) – 363+200 (Sl. Brod-grad)	33.0	IVth class
	363+200 (Sl. Brod- city) – 583+000 (Sisak)	219.8	IIIrd class
	583+000 (Sisak) – 651+000 (Rugvica)	68.0	IInd class
Drava	0+000 (Danube's mouth) – 14+050 (Osijek Nemetin port)	14.0	IVth class
	14+050 (Osijek Nemetin port) –55+450 (Belišće)	41.4	IIIrd class
	55+450 (Belišće) – 198+600 (Ždalica)	142.6	IInd class
Kupa	0+000 – 5+900	5.9	Ist class
Una	0+000 – 4+000	4.0	IInd class
	4+000 – 15+000	11.0	Ist class
Total length of navigation routes		804.1	
Total length of navigation routes – international classes		286.9	

The Danube

The Danube stretches on Croatian territory from Batina to Ilok, km 1433+00 to km 1295+501. In its total length of 137,5 km the Danube is an international navigable waterway of the class VIc with free navigation for all flags. The navigation route is marked and the Republic of Croatia is internationally obliged to maintain it. The actual minimal parameters of Danube's navigable waterway in Croatia in current condition, according to "pilot" [7] and "distance tables" [8] of the Danube Commission are slightly lower than those defined by the class:

- Minimal width of navigation route: 140 m
- Minimal depth of navigation route:2,5 m
- minimal radius of navigation route: 600 m
- height of free clearance under the bridge: 8,15 m
- width of free clearance under the bridge: 97,7 m

The Drava

The river Drava is defined today as an international navigable waterway of class IV [1] between the mouth into the Danube and Osijek port at Nemetin (chain. 14+050). The class is determined by a project [9]. According to it, water facilites (riverbed and groyne regulation) are designed and partially constructed on the critical points to reach the class IV.

A section from Osijek (chain. 14+050) to Belišće (chain. 55+450) was analysed within the study [2 and 5]. The study includes much longer section Osijek (chain. 14+050) – Donji Miholjac (chain.. 70). A morphological and statistic analysis of the inland waterway depth of existing Drava riverbed for water tables of different durations was conducted. According to the class III criteria Fig. 2 makes clear that corresponding 50×1,8m navigable clearance at LNWL – low navigable water level of 95% duration – $V_{95\%}$ can be realised at 88% of Osijek-Donji Miholjac section's length. The same Figure 2 illustrates that 50×1,8m navigable clearance at 100% of the section's length can be implemented at the water level of 75% duration. Hence, the conclusion can be drawn that the regulation of inland waterway on less than 12% of the navigable way's length between Osijek and Donji Miholjac can reach class III at LNWL=$V_{95\%}$. The alternative is not to undertake the river training, but to limit the navigation to 75% days a year, which is also acceptable according to AGN contract [6]. This section can be defined as class III in both cases, but as a re-

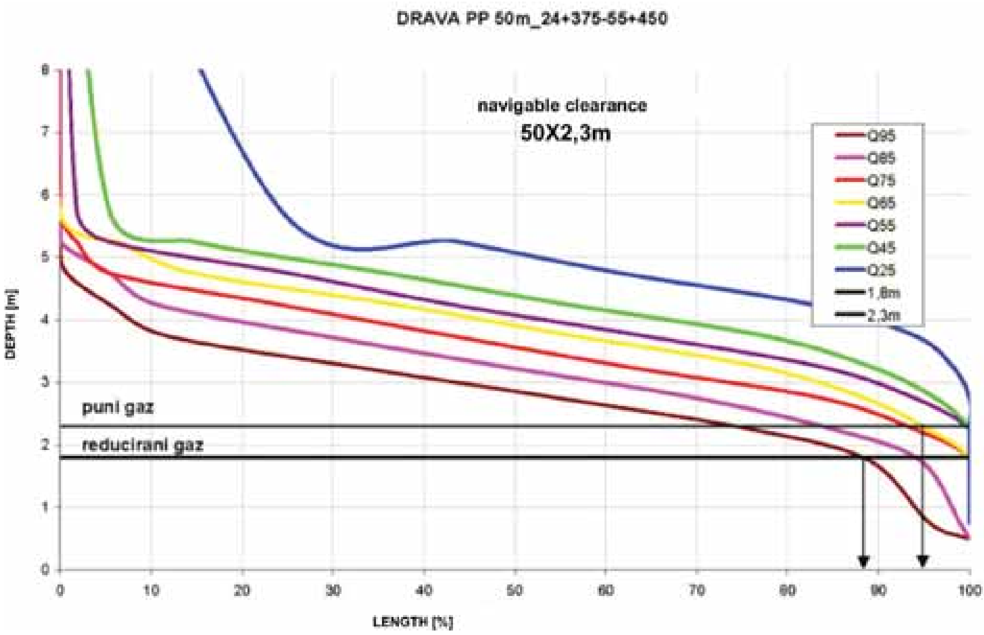

Fig. 2 – A depths representation on the Drava river, section Osijek – Donji Miholjac, with 50 m navigation route width [2]

gional and not international class, in fact as an intrastate Croatian and Hungarian section. The III class was shortened up to Belišće due to economic reasons, owing to which the regulation of worse section of Beličće-D.Miholjac becomes avoided.

A section to Belišće (chain. 55+450) to the Ždalica river (chain.. 198+600) was analysed within the study [2 and 5]. A significantly shorter section Donji Miholjac (chain. 70) – T. Polje (chain. 161+260) was analysed, and the conclusions extended to the section Belišće – Ždalica due to economic reasons. Figure 3 shows that the navigable clearance 50×1,8m, belonging to the class III of inland waterway can be realized only on 73% of the Donji Miholjac- Terezino Polje section's length at $LNWL=V_{95\%}$, and on 100% of the section's length at the water table of only 25% duration. Accordingly, the navigable way does not satisfy class III conditions on this section, and is therefore declared the class II of inland waterway. The same was confirmed by the analysis of the existing Drava's riverbed for the class II with 50×1,5m navigable cleareance at $LNWL=V_{95\%}$. The sporadic navigation takes place upstream form T. Polje and reaches the mouth of the Ždalica river (chain. 198+600). According to estimations the class I conditions were met in this part of Drava river.

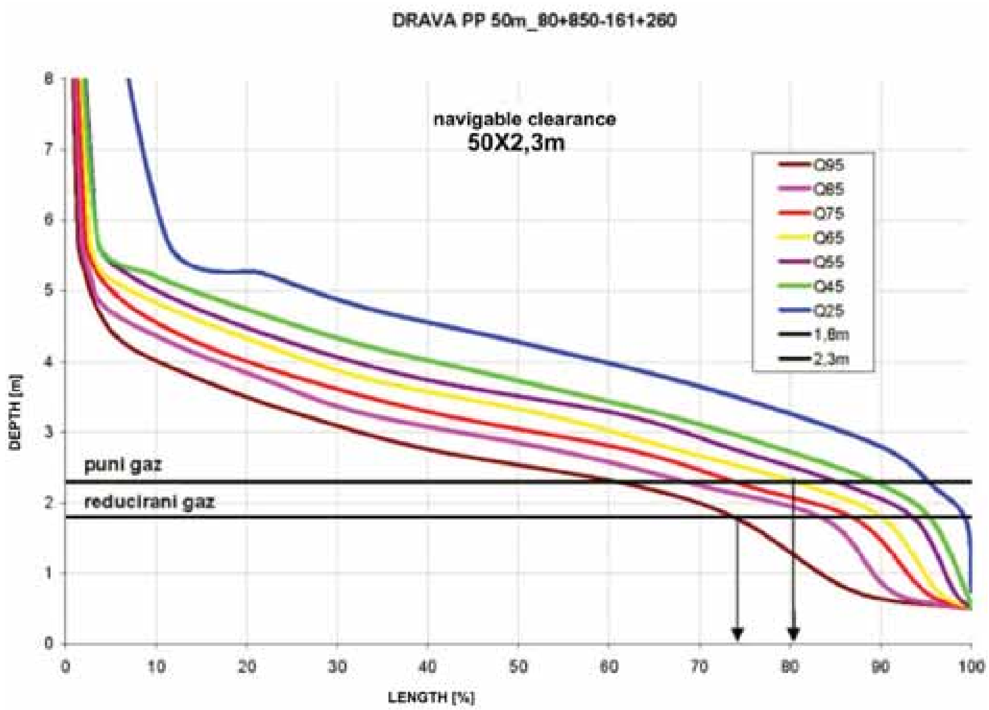

Fig. 3 – A depths representation on the Drava, section Donji Miholjac – Terezino Polje, with 50 m navigation route width [2]

Morphologic and statistical elaboration of the navigable route radius on both sections (Osijek – Belišće and Belišće – Terezino Polje) showed that the minimal radius for class III R=300m was not met on only approximately 1 km of the section where R=200m. Therefore, the meander cut-off or the introduction of one-way navigation should be undertaken. Owing to under-representation of weak radii it was not the reason for lowering the class.

The Sava river

On the Sava river, from its total length in Croatia which is 515 km, the navigation route stretches for 376 km; e.g. from Račinovci to Sisak (chain. 207 to chain. 583). Next to it, there is a sporadic navigation up to Zagreb (Rugvica km 651) for a purpose of gravel exploitation in a small percentage of the days in a year. Between Račinovci and the mouth of Una (rkm 207 to rkm 507) the Sava is an navigation route between of the coastal countries: Croatia and Bosnia and Herzegovina. The navigation route is marked. Still there is no agreement with Bosnia and Herzegovina about its maintenance. There is an obligation of marking and maintaining the Sava WW. from the Croatian side as defined in the Law on Inland Waterways and Law on Waters. The border with Bosnia and Herzegovina was defined by International Agreement in 2001 as an navigation route's axis designated in a project [10].

Within the study called The Regulation of the Sava's Navigation route and Determination of the Line of the Permanently Navigable Sava from Račinovci km 202+500 (P1) to Sisak 588+208 (P1933) [4] the navigation route depths of the existing Sava's bed according to IV criteria was morphologically and statistically analyzed into details, with accompanying 70×2,5m navigable clearance, for the water tables of different water level durations. The analysis was illustrated in Figure 4 showing that at 71% of length of the permanently navigable Sava in Croatia the navigable clearance satisfies 70×2m i.e. 2m draught at declared low water level

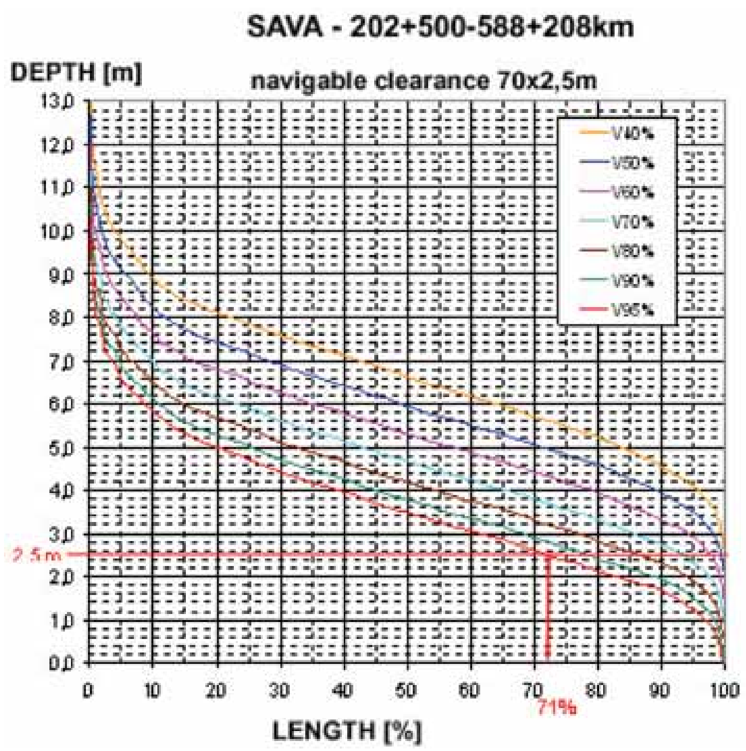

Fig. 4 – A depths representation of the Sava's class IV navigation route from Račinovci to Sisak: 202+500 (P1) – 588+208 (P1933) [4]

LNWL=$V_{95\%}$. At $V_{90\%}$ navigable depth is 2,8m and draught is 2,3m at 77% of observed navigation route's length. At $V_{80\%}$ navigable depth is 3,2m and draught is 2,5m (and more) 86% of length of permanently navigable Sava in Croatia. That means that permanently navigable Sava has a potential of class IV in the current natural condition.

29% of length of continuously navigable Sava from Račinovci to Sisak was determined in the detailed analysis of the existing Sava riverbed for class IV, whose current riverbed does not meet class IV and has two critical sections: 1. of 24 km length between Sl. Šamac (km 305+700) and Oprisavac km 330+200) and 2. circa 88 km length between Pakrac sector and Sisak. A sporadic limitation to one-way navigation is necessary on those sections today, but only for pushed convoys. The mentioned 29%, or 112 km of continuously navigable Sava should be regulated by means of construction works to meet class IV criteria, e.g. corresponding 70×2,5m navigable clearance at water level of 95% duration. This is acceptable from economic and morphological aspect, as no massive morphological works must be undertaken.

The radius analysis of the existing Sava riverbed, given in Figure 5, shows that 98% of section meets the minimal radius for class IV: naviga-

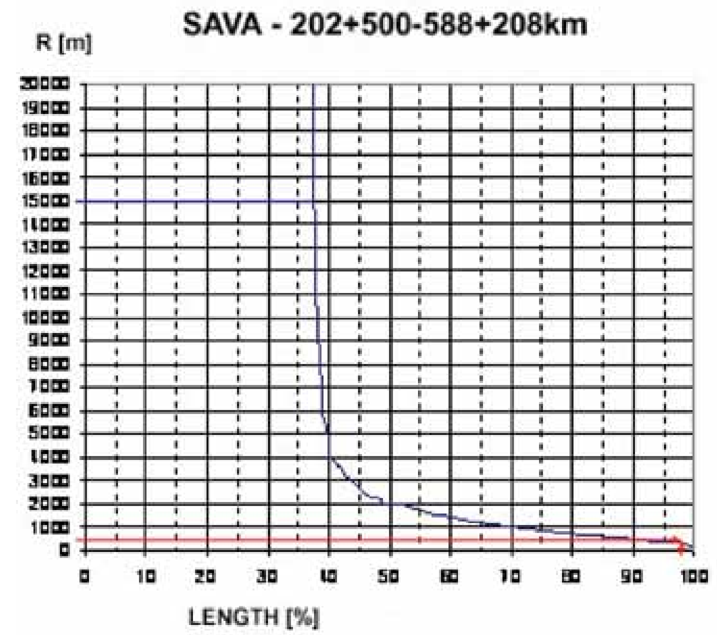

Fig. 5 – A radius representation of the Sava's class IV navigation route from Račinovci to Sisak 202+500 (P1) – 588+208 (P1933) [4]

tion route class: R_{min}= 360m. On 2% of observed section's length one should make a cut-off to enlarge the radius. At present it is being solved by limiting the pushed convoys' navigation to one-way traffic, as the radius enlargement requires cutting through the meander, which interferes with cross-border relations.

The navigation probability analysis of the river Sava in the current condition on the Sisak-Rugvica section was conducted in [11]. The radius representation in Fig 6 shows that the criterion of the II class minimal radius of the navigation route R=250m is not satisfied on circa 8% of the section's length, e.g. on the total of 4600 [m] of the section: concretely on 15 curvatures. Figure 7 shows depth representation curvatures on this section, with 50m navigation route. It can be seen that the Sava river in natural condition does not satisfy class II of the navigation route on the observed route on circa 15% of the section's length. However, it can be defined as the class II navigation route under assumption of introducing one-way navigation on the critical section's length.

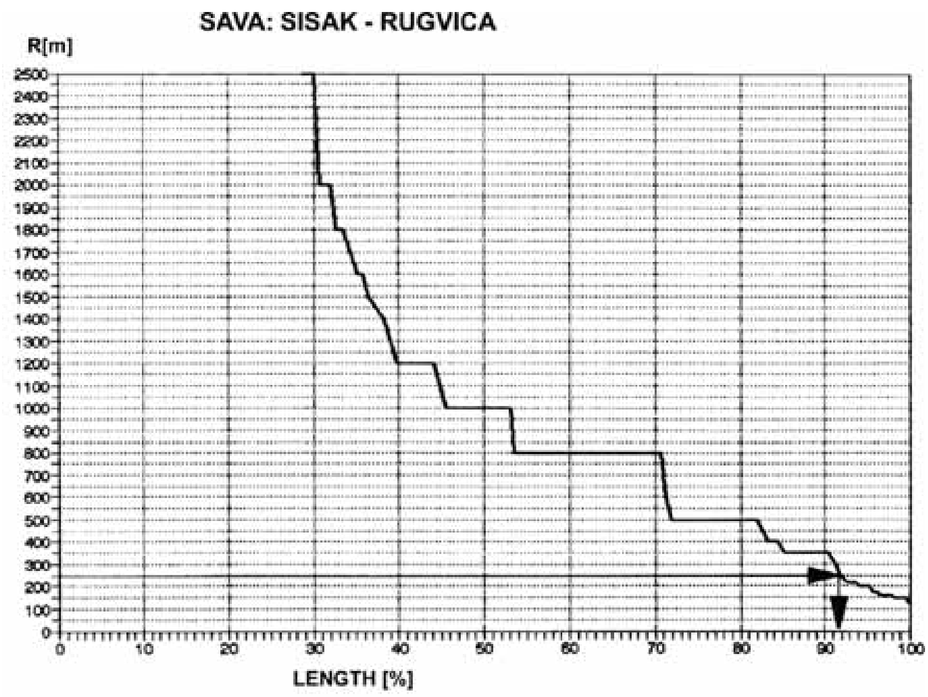

Fig. 6 – A radius representation of the Sava's navigation route on the Sisak-Rugvica section [4]

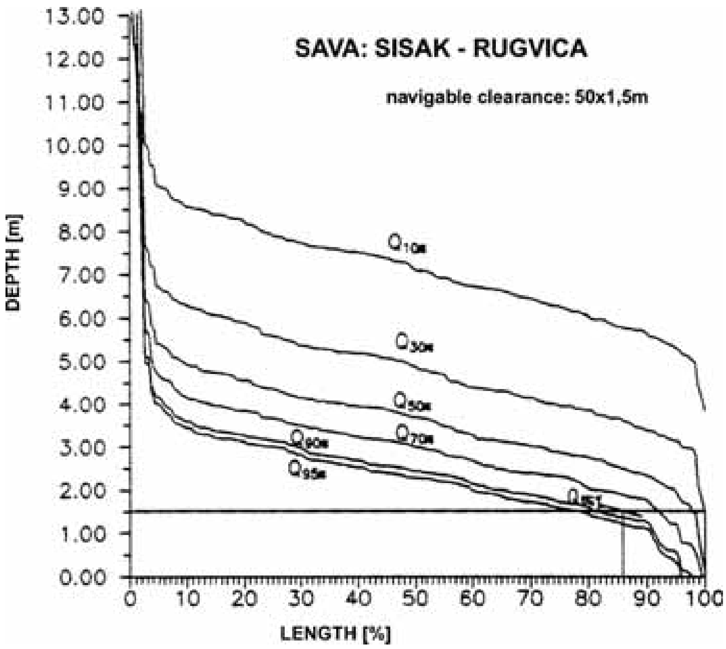

Fig. 7 – Curvatures representation of Sava's navigation route depth on the Sisak-Rugvica section, navigation route's width 50m [4]

The Kupa river

At present the Kupa river on the section from the mouth (km 0+0 to the port of Sisak (km 0+5,9) satisfies conditions of navigation class I according to its minimal clearances of the navigable riverbed (width 35 m on km 3+300) and navigable span width on the Sisak's Brick bridge (km 3+350) from 37 m. The navigation upstream of Kupa from the port of Sisak, with regard to many natural obstacles in the riverbed and current lack of interest for commercial navigation, is possible to be opened only for sports and recreational purposes.

The detailed morphological and statistical analysis of navigation route's depth of the existing Kupa riverbed (km 0+5,9) for class II of 50×1,5m clearance at LNWL=$V_{95\%}$, and for class IV with 75×2,3m clearance at LNWL=$V_{95\%}$ found out that 1,5km, respectively 25% of section meets a required clearance of class II of the navigation route (Figure 8). It all indicates that 4,4km (75%) of observed section should be corrected. Figure 9 shows that conditions for class IV of navigation route's observed section are not fully satisfying.

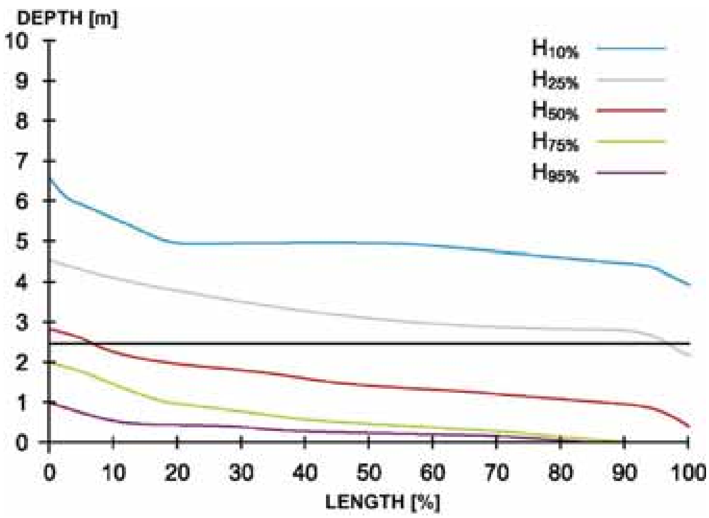

Fig. 8 – The curvatures represen-tation of Kupa's navigation route's depth for class IV[2]

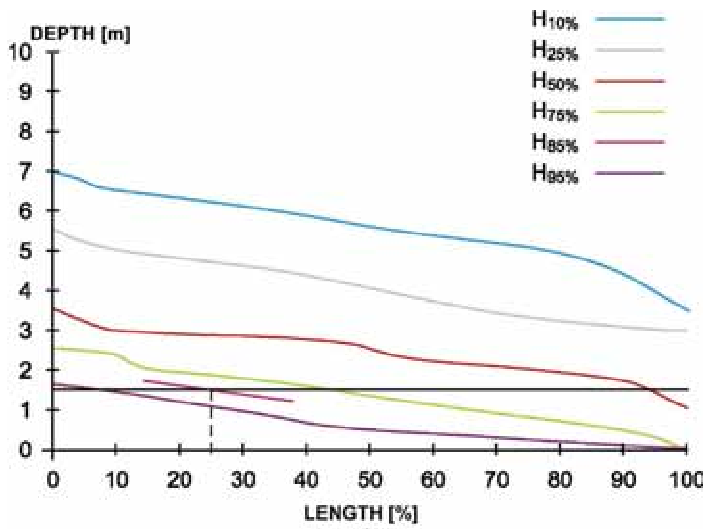

Fig. 9 – The curvatures representation of Kupa's navigation route's depth for class II[2]

The free profile height criterion has been satisfied with all existing bridges. There is a problem with the free profile's width at brick bridge in Sisak. However, the navigation is still possible although the criteria for class II are not being satisfied.

The Una river

The Una river according to its current minimal clearances of navigable bed at first 4 km (width 40 m and depth 345 cm at the water level of 60% duration and 35 m bridge span width) fulfils class I navigation conditions. Considering that for the higher navigation class the limiting factor is only the bridge span width, it is possible to determine the class II while introducing one-way navigation through the bridge span. With regard to navigation along the Una on the section from rkm 4 to km 15 there exists an interest in commercial navigation owing to gravel exploitation for local, sports and recreational purposes. For this reason the proposal for talks with Bosnia and Herzegovina should be organized. Due to legislative cause this section should be declared the class I navigation route.

3. Future classification

The classification of European navigable rivers and canals was defined in Geneva in 1996 when the *European Agreement on Major Inland Waterways of International Importance* (AGN) [6] was publicized. Croatia signed the AGN in 1997. The Agreement became efficient in 1999. According to *Agreement* the following Croatian waterways were listed into the system of European inland waterways as shown in Table 3 and in Figure 10:

Fig. 10 – Future classification of Croatian inland navigation waterways [6]

Table 3 – Croatian inland navigable waterway classes as declared in AGN Agreement [6]

E 80	the Danube from Batina to Ilok, km 1433+00 to km 1295+501, class IV
E 80-08	the Drava river to Osijek, km 0+00 to km 22+00, class IV
E 80-10	future Danube-Sava multipurpose canal from Vukovar to Šamac, the length of 61,5 km, class V-b
E 80-12	the Sava from Račinovci to Sisak, km 207+00 to km 583+00, class IV

4. Indirect improvement of current navigation routes

Instant improvement of existing Croatian inland waterways is focused on arrangement of navigation routes on rivers in terms of solving critical sections that are not in accordance with classes declared in AGN Agreement [6]. Here belong current activities on the Danube Sava multipurpose canal connected with documentation preparation and with conducting of legal procedures prior to construction decision, as well as to minor buildings of the irrigation system. Afterwards follows the costs estimation for short term arrangement of navigation routes according to the Five-year Plan of navigation routes and inland waterways' ports development [12].

Instant regulation of the Danube on the stretch between Batina and Ilok encompassing preparation works, design and arrangements was estimated at circa 30mil. €. It entails the completion of the winter accumulation Opatovac, construction of tourist wharfs at Vukovar and Ilok, working out of the project documentation, and carrying out of legal procedures for the development of the Vukovar port on the Danube and local landing places.

According to INWW Osječko – baranjska county from the year 2000, [13] class IV will be lengthened to the section Osijek port at Nemetin – Hidrogradnja landing (chainage 14+050 to chain. 22) in accordance with (AGN) [6]. It stems from the fact that the Drava river on the section to Osijek, km 0+00 to km 22+00, does not fully satisfy class IV requirements in the current condition according to the AGN. However, since 2003 the intensive work on deepening of Drava's navigation route has been underway, along with one groyne construction. In this way the class IV parameters declared by AGN Agreement for the navigation route to the Nemetin port would be implemented. According to the elaboration [12] for the regulation of Drava's navigation route the Republic of Croatia should invest around 15 mil.€ for mentioned current and indirect hydro engineering measures.

Instant measures to be applied on the Sava result from obligations which Croatia proclaimed in the AGN Agreement [6]. According to technical regulations of the AGN Agreement the class IV navigation route on the Sava from Račinovci to Sisak, km 207+00 to km 583+00, marked as E 80-12 was listed into the system of European inland waterways. It is in accordance with the regulation of the Sava's navigation route with standard stiff pushing convoy consisting of a lighter and boxer having dimensions: 5 × 9,5 × 2,5 to 2,8 [m], capacity 1250 to 1450[t]. Comparing with a higher level of regulation the navigation route should be of an international class Va. For concrete indirect construction measures of the Sava's navigation route's regulation for class IV according to given study [12] it was estimated that Croatia should invest some 50 mil.€. Unfortunately, those measures are far away from raising the class of Sava's navigation route to proclaimed class IV from Račinovci to Sisak. The measures can only contribute to the partial reduction of limitations; e.g. to reduction of the number of sections with one-way traffic. If we bear in mind that the navigation traffic on the Sava is very low, the limitation is of no significance. However, it prevents any development and traffic increase on the Sava. In future the Sava will stay class IV downstream and class III upstream as defined in [1] as well.

Over the past fifteen years the preparations for construction of Danube-Sava multipurpose canal have been underway. The multipurpose significance of the future Danube-Sava canal comprises three major functions: irrigation, navigation and drainage, and a series of other functions like: small water enrichment and its positive ecological effects, and technological water. The timetable of 61,4 km long canal construction from Vukovar to Sl. Šamac includes 4 phases (Figure 11) each representing a hydro engineering unit, which could independently function until construction extension in the next stage. The development within the phases can be differently planned depending on area's extension and planned purposes: irrigation, drainage and navigation. At present, the Ist phase of canal construction is underway involving irrigation of agricultural areas on the Biđ-Bosut fields (BBF) and forestry complex of Spačva. This phase involves the canal construction along the planned route from the Sava river to the link on the Biđ watercourse (length of 15 km), to ensure the conditions for water supply from the Sava into major recipients on the broader area of Biđ and Bosut. The riverbed excavation is carried out in reduced dimensions and without future bridges over the canal being replaced by temporary culverts. At the canal's link with the Sava the Sava hydro engineering knot is planned and consists of: canal lock, the Sava ship prelanding in front of lock with winter landings, derivation channel for the intake structure of the Sava river for irrigation, which will accommodate the weir and the pumping station. The Ist phase will encompass the derivation channel construction (the length of 2 km from scheduled

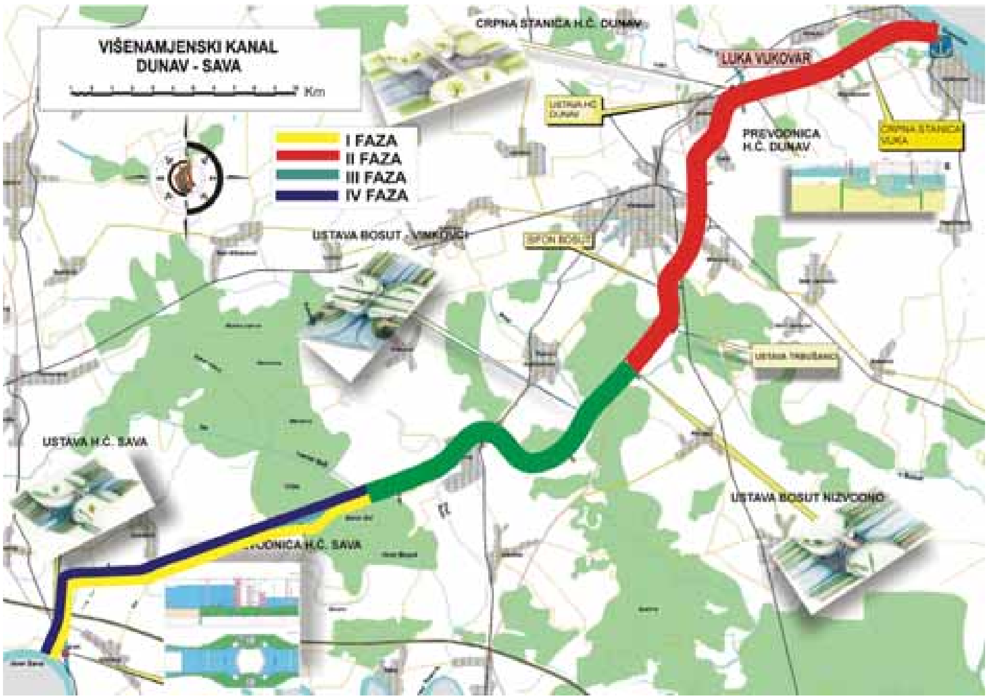

Fig. 11 – The Danube-Sava canal route according to construction phases

15 km), weir and pumping station, which will transport in this phase, and later as well required water quantities into the canal, and further on into the system of existing BBF canals. The construction is being carried out within the National Irrigation Plan (NAPNAV). It was estimated that the Republic of Croatia should invest up to 50 mil.€ according to elaboration [10] for the concrete short term water works construction connected with the Ist phase of Danube-Sava multipurpose canal.

5. Long term improvement of Croatian navigation routes

The long term measures of Croatian navigation routes improvement are directed toward a major improvement in the Croatian strategic traffic policy: e.g. the construction of 580 km long Danubian – Adriatic area traffic corridor (Figure 3::1). A combined river and railway connection would consist of: 61,4 km of Danube-Sava class Vb canal, 306 km of trained or canalized Sava from Šamac to Sisak class IV., Va or Vb and 210 km = 160km +

50km Sisak-Zagreb-Rijeka two-track railway (today 280km = 230km + 50km, mostly 1 track). Hence the regulation of the Sava's navigation route in the full length and completion of the Danube-Sava multipurpose canal. A long term regulation of Sava's navigation route to class IV implies: a standard stiff pushing convoy consisting of a lighter and a boxer with dimensions: 5 × 9,5 × 2,5 do 2,8 [m], capacity 1250 to 1450[t]. The Sava's navigation route regulation to class V a implies a two-way navigation of stiff pushing convoy with dimensions 110 × 11,4 × 2,5m, consisting of "Europe II" connected lighter series, capacity 1850 tons, and a boxer. In the further long term perspective the attitude about the more demanding raise of the Sava's navigation route to classes Va or Vb by canalization will be clarified. The class Vb includes a two-way navigation by 185 × 11,4 × 2,5m stiff pushing convoy consisting of two "Europe II" connected lighter series of 3700 tons capacity and of a boxer. For the time being, the latter will not be taken into account due to unattractiveness in terms of power supply. Such long term plans could be only implemented through the collaboration between Croatia and Bosnia and Herzegovina (and Serbia as well), which is going to happen in future under the auspices of the Sava Commission. The engineering estimation [14, 15] of the most probable development scenario of international Sava's navigation route (Serbia, Bosnia and Herzegovina, Republic of Croatia) implies that the Sava's navigation route class would be fully raised to class IV or Va in 10-20 years and the canal would be completely finished (for the class Vb as well) in 10 to 20 years (max15-30 years). Its traffic function would be implemented partially in the canal's IInd phase (8-10 years), and fully in the IVth phase (15-20 years). The construction dynamics of the Danube – Adriatic area corridor is illustrated in Table 4 throughout some possible scenarios, and construction costs are presented in Table 5.

The class Vb navigation route was adopted for a design of navigation elements of the future Danube-Sava multipurpose canal. It includes a two-way navigation of a 185 × 11,4 × 2,8m stiff pushing convoy consisting of "Europe II" two connected ligher series, and a 3700 ton boxer, or a 2000 ton self-propelled boat, with a minimal 800m curvature radius, 9,1m free profiles under the bridge and with 9km/h navigation speed.

In future with Drava's regulation it would be possible to raise the class of the navigation route to standard international class V.b from the Danube's mouth to the Nemetin port on 14. km. A long term regulation of the Drava involves the construction of the water reach Osijek on 32. km, which will ensure class IV to Belišće, and the limited navigation would be enabled to T. polje for the class III vessels and class II to Ždalica.

Table 4 – Construction dynamics of Danubian – Adriatic Area traffic corridor [14]

Construction dynamics of the Danubian – Adriatic area traffic corridor (a inland navigation part)				
Three possible scenarios of the traffic corridor's riparian part were considered: I scenario: Sava River Training IV, Navigaton classes from Račinovci to Sisak (without Danube –Sava Multipurpose Canal) II scenario: Sava River Training IV, or class Va of the navigability from Šamac to Sisak with Danube-Sava Multipurpose Canal of class Vb III scenario: Canalization of Sava river Va (or Vb) class from Šamac to Sisak with Danube-Sava Multipurpose Canal class Vb				
		5-10 years	5-10 years	5-10 years
I scenario	River Training of the Sava's navigation route on the Sisak-Jasenovac section			
	River Training of the Sava's navigation route on the Jasenovac-Šamac section			
	River Training of the Sava's navigation route on the Šamac-Račinovci section			
II scenario var1	River Training of the Sava's navigation route on the Sisak-Jasenovac section			
	I phase DSMC, reduced profile			
	River Training of the Sava's navigation route on the Jasenovac-Šamac section			
	II – IV phase DSMC, full profile			
II scenario Var2	River Training of the Sava's navigation route on the Sisak-Jasenovac section			
	I phase DSMC, reduced profile			
	River Training of Sava's navigation route on the Jasenovac-Šamac section			
	II – IV phase DSMC, full profile			
III scenario Var1	Water step Jasenovac			
	I phase DSMC, reduced profile for irrigation			
	Water step Šamac			
	II – IV phase DSMC, full profile			
III scenario Var1	Water step Jasenovac			
	I phase DSMC, reduced profile za irrigation			
	Water step Šamac			
	II – IV phase DSMC, full profile			

Table 5 – Costs estimation of Danubian – Adriatic traffic corridor construction [14]

Scenario	• Mode of arrangement of the river Sava • Navigation Class • Length in km	• Type of Canal Danube – Sava • Navigation Class • Length in km	Costs of the inland navigation waterway: complete hydraulic enterprise Sava+canal DS in mil €	• Mode of arrangement of the railway Rijeka-Zagreb • Railway Class • Length in km	Costs of the railway (complete traffic enterprise) in mil €
I-st	River training	-	14	Railway RI-ZG	2530
	IV-th			Double track	
	376 km (Račinovci-SI)			210 km	
II-nd	River training	Multipurpose canal	762	Railway RI-ZG	2530
	IV-th or V-th "a"	V-th "b"		Double track	
	274 km, (Šamac-SI)	61,4 km		210 km	
III-rd	River canalization	Multipurpose canal	1371	Railway RI-ZG	2530
	V-th "a" or V-th "b"	V-th "b"		Double track	
	274 km, (Šamac-SI)	61,4 km		210 km	

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Public Water Supply Systems in Croatia

1. Introduction

The provision of sufficient quantities of water and water protection, including protection of water from pollution and protection from adverse effects of water, are crucial for the development of any society. Needs for water – drinking water – have a constant upward trend, and such needs must be met by proper management of the available water resources.

Water management is based on the postulates of the survival of man and his environment, and on the basic principles stemming from the Constitution and acts of the Republic of Croatia, because human health, preservation of the environment, and the safety of lives and assets belong to the basic human rights.

Water use has existential meaning in human life, and it is at the same time essential in a number of production processes in almost every economic and other activity. In view of the various purposes of water use, the water balance of Croatia's living surface water and groundwater resources must be correctly and timely defined. An integral part of this process is the definition of present and future needs of individual users for water of adequate quality, having in mind different spatial distribution of the available water quantities in relation to the locations of users.

Water is a natural resource and an integral part of the living environment. Water is a precondition for life and socio-economic development. It is of vital importance for each society to provide sufficient quantities of water, including protection against adverse effects of water, and to carry out water protection.

2. Water balance in the republic of croatia

2.1. Surface water

On the basis of the calculated annual amount of precipitation, Croatia belongs to the countries very rich in water. However, water resources are not evenly distributed. Their distribution depends on climatic, topographic, hydrological, hydrogeological and other characteristics. Water run-off depends to a large extent on precipitation, but run-off is not proportionate to precipitation. The run-off coefficient is highest in the littoral part of Croatia (0.62) and lowest in the Pannonian part of Croatia (0.26). The spatial distribution of surface water (rivers, lakes, transitional waters) and groundwater and their connection are primarily defined by the morphological and hydrogeological characteristics of the Croatian territory. All water bodies belong to either the Black Sea basin or the Adriatic basin, and their watershed runs through the mountainous area. The Black Sea basin is dominated by large watercourses such as the Sava, Drava, and Danube Rivers with a large number of small sub-basins. The density and length of surface watercourses in the Adriatic basin are considerably smaller, but there are significant underground flows through karst systems. The total length of all of the natural and artificial watercourses on the territory of Croatia is estimated at 21,000 km.

2.2. Groundwater

In the Pannonian basin, groundwater is accumulated in alluvial aquifers of the Sava and Drava river valleys, i.e. in tectonic depressions, in which Quaternary deposits had settled. The thickness of deposits varies from 10 m to 100 m and more. Hydraulic conductivity is 10-300 m/day, while on the area of the City of Zagreb it ranges between 1,000 and 5,000 m/day.

Dinaric karst can be divided into three hydrogeological units: river karst, high karst, and the Adriatic karst belt. River karst contains permanent surface watercourses. The largest springs are lie at the border of this unit with the zone of high karst, which supplies springs with water. The high karst encompasses the central Dinaric belt. The belt's large area and large volumes of precipitation account for large quantities of groundwater. This water sinks into deeper layers and springs in karst fields (*polje*), thus creating sinking rivers. In the Adriatic belt there are huge quantities of groundwater formed in the zone of high karst. In this belt the impact of the sea is strongly felt. Local groundwater forms on the islands.

2.3. Total quantities of water available in Croatia

The balances of surface water and groundwater indicate that Croatia has available large quantities of surface water on its own territory, unevenly distributed in space and time. Croatia also disposes of large quantities of groundwater. The different level of exploration prevents joint balance of surface water and groundwater.

At present, 86% of water for water supply comes from groundwater sources. Renewable groundwater resources, which can be exploited almost permanently, are most significant for the provision of water in the supply of the population and industry.

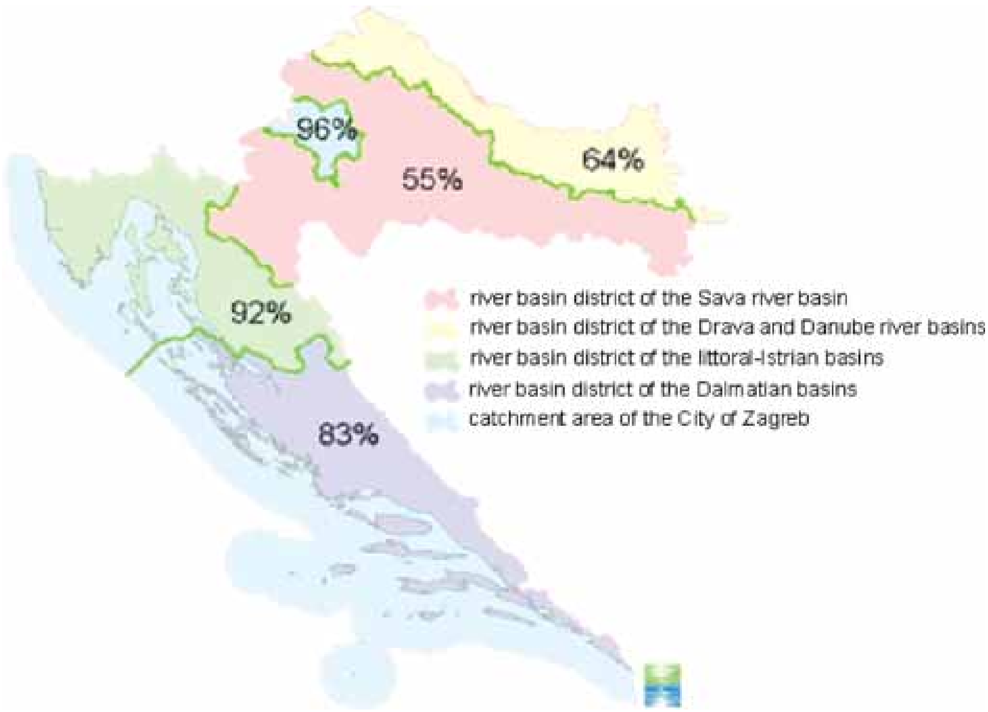
Due to complex hydrogeological conditions and insufficient and uneven exploration of aquifers, the identification of groundwater resources is largely based on estimates, and because of water management significance, it is only the renewable groundwater resources that were considered.

The greatest renewable groundwater resources in the Black Sea basin are associated with Quaternary deposits in the Drava and Sava river valleys, where aquifers of intergranular porosity had formed, and with aquifers of fracture-cavernous porosity in the southern parts of the Kupa and Una river basins. Significant quantities of water accumulate in carbonate aquifers of fracture porosity in the mountainous areas of northern Croatia. The main source of groundwater recharge on the Drava area is the infiltration of precipitation through a semi-permeable cap layer. In addition to the infiltration of precipitation, the renewable groundwater resources in the Sava aquifer are also under a significant impact by the recharge from the Sava River.

Renewable groundwater resources

	District	Alluvial aquifer	Carbonate aquifer	Total
		10^6 m^3/year		
Black Sea basin	Sava river basin	1,198.3	653.8	1,852.1
	Drava and Danube river basins	802.6	7.8	810.4
Adriatic basin	Littoral-Istrian basins	-	2,639.5	2,639.5
	Dalmatian basins	-	3,831.3	3,831.3
	Croatia	**2,006.9**	**7,132.4**	**9,133.3**

Due to specific features of karst aquifers, complex structural-tectonic relations, and instances of multiple springing and sinking of water at different horizons within the same basin, the separation of surface water and groundwater bodies is unreliable in a large number of cases, and in particular the identification of groundwater resources. Groundwater resources were therefore identified on the basis of minimum spring yields, capacities of water intake structures, estimated effective porosity, and retention capacities of aquifers.

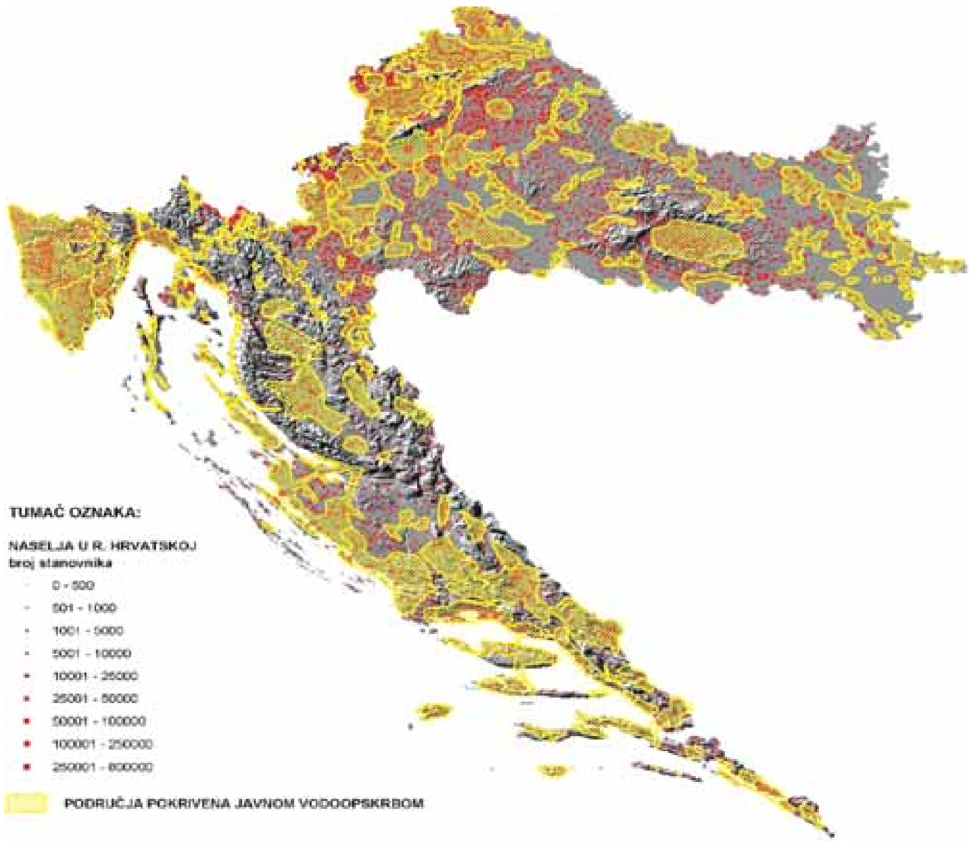


3. Water supply coverage and water consumption

The average level of population supplied with water from public water supply systems in Croatia is 78% (2007), which means that around 3.35 million people are supplied with water from public water supply systems. This average level has increased significantly in comparison to the year 1990, when it stood at 63%.

The water supply level is higher in the Adriatic basin (86%) than in the Black Sea basin (71%).

The average level of population supplied with water from public systems varies strongly between counties, ranging from the lowest level of 37% in the County of Bjelovar-Bilogora to the highest levels of 95% and 96% in the County of Istria and the City of Zagreb, respectively. The variations in the level of population supplied with water from public water supply



systems are even greater per individual municipalities and towns in relation to average county values.

A particular problem is the supply of water to the islands. It is solved mostly by conveying water from the mainland (e.g. the islands of Brač, Hvar, or Šolta), and to a lesser extent by supply from the island's own sources (e.g. on the islands of Cres or Vis), by collecting rain water into cisterns (individual supply), by water tankers (mostly for very small islands or accidents), through treatment of brackish water through desalinization (the islands of Lastovo or Mljet), or by combining various sources (e.g. Krk, Pag, Korčula).

The quantities of water delivered to households and industries were reduced significantly until the year 1998, and in the recent years consumption has stabilized in the range of 365-375 million cubic meters (m^3). In 2007, the total of 265 million m^3 of water was delivered through public

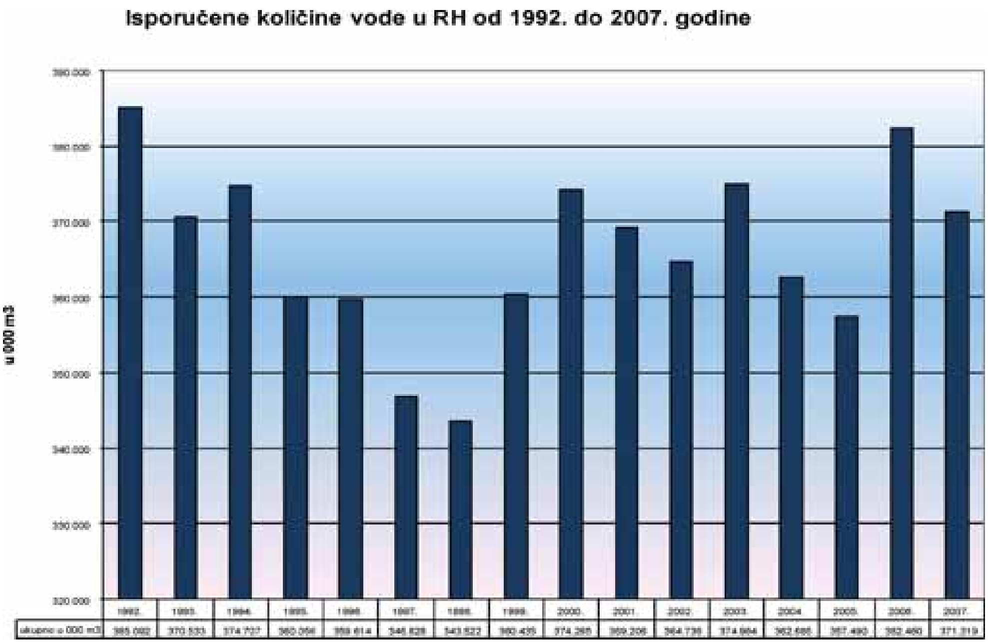
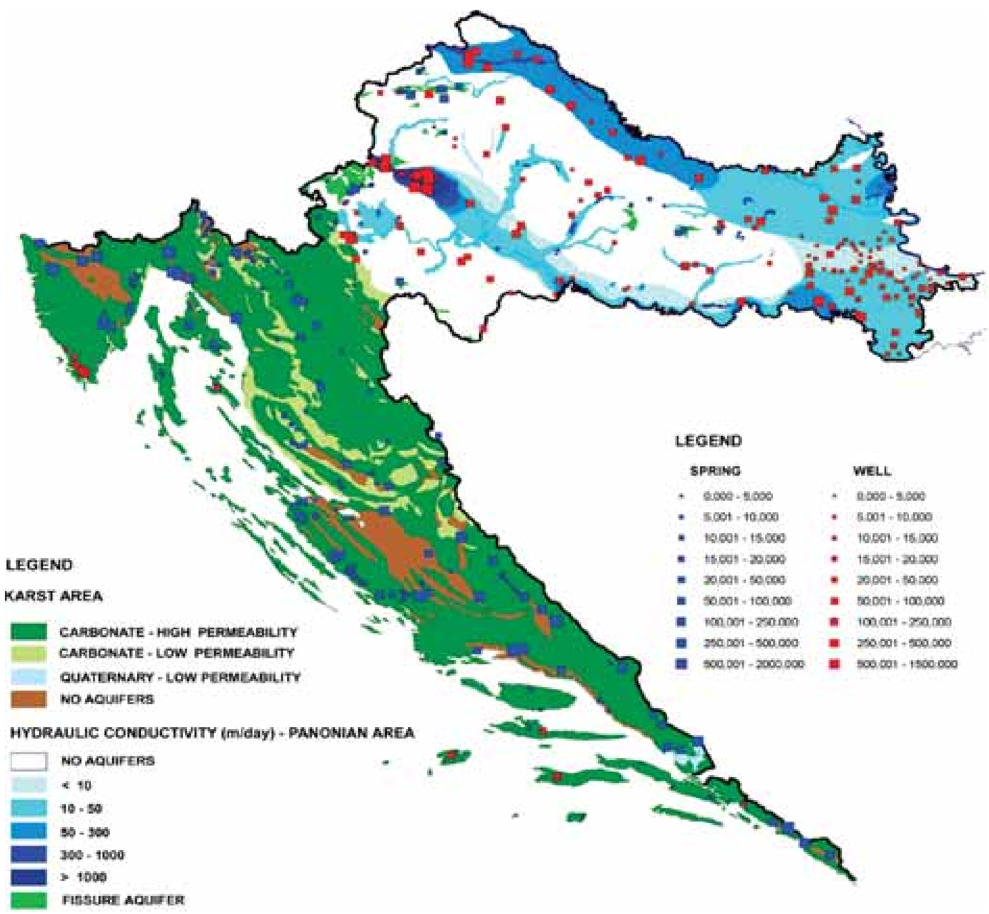


Table and graph – Water quantities delivered in Croatia in the period 1992-2007; Total (m^3)

water supply systems, 84 million m^3 of which was delivered for the purposes of industry and public institutions. At the same time, industry used 106 million m^3 of water from its own water intake structures.

The average specific consumption of water in households amounts to 149 l/c/d.

Large part of the population outside of public water supply (22%) is supplied with water through the so called local water pipelines; there are several hundreds of them on the territory of Croatia, primarily on the area of the Black Sea basin. Local water pipelines are managed by their direct users which financed their construction. Water is abstracted from sources (mostly from wells) which are not registered within the water use system (there is no water rights permit and no concession). In local water



pipelines there is no system established for the control of water quality, which is carried out on the basis of needs and estimates of users.

4. Drinking water intakes and quality

Groundwater accounts for around 86% of all abstracted water quantities, while the remaining part comes from the abstraction of surface water from watercourses and multi-purpose reservoirs. An important measure of protection of drinking water aquifers is the implementation of decisions on sanitary protection zones, which apply to around 52% of well fields at which 80% of water is abstracted.

Drinking water protection or, more specifically, the implementation of protection measures within the zones of sanitary protection, is rendered difficult on all the well fields in the karst and alluvium, in particular on those locations where water supply sources lie in the vicinity of large towns, because they are threatened by the process of urbanization, industrialization, agriculture, wild waste disposal sites, and wastewater.

Some larger public water supply systems are at constant potential risk of ensuring water of adequate quality in the event of accidental pollution because their water supply is based on only one source, or because part of their catchment area lies beyond the Croatian border, which means that they are not under direct supervision of Croatian water management services.

A mandatory measure for ensuring drinking water quality is disinfection, which is carried out in all public water supply systems. However, when needed, water undergoes purification/treatment depending on the characteristics of raw water. The content of iron, manganese, ammonium, and arsenic

Treatment of water for public water supply (plants > 10 l/s)

Water Management Department	No. of plants	Treatment in 2003 (10^6 m^3/year)
Sava river basin	34	16.70
Drava and Danube r. basins	14	17.33
City of Zagreb	2	8.00
Dalmatian basins	2	12.30
Littoral-Istrian basins	12	37.62
Croatia total	**64**	**91,95**

in groundwater abstracted in the Black Sea river basin is most often reduced through purification. On the wider Zagreb area, purification is applied to solve the problem related to anthropogenic pollution. In the Adriatic basin, water from the karst underground is used for public water supply mostly without undergoing any treatment, but with mandatory disinfection, while surface water mostly undergoes purification. On the islands of Lastovo and Mljet there are water desalination plants with a capacity below 10 l/s.

In the public water supply network, water is constantly monitored by public health services, the sanitary inspection, and public health control laboratories. The control is carried out in accordance with the *Ordinance on sanitary quality of drinking water.* According to the results of controls, the average number of water samples not complying with the sanitary standards is below 10% on the national level. The most frequent causes of water not meeting the sanitary standards are microbiological parameters, ammonium, nitrates, organic compounds, and turbidity. A particular problem is present on the area of the Counties of Vukovar-Srijem and Osijek-Baranja, where the number of non-complying samples according to chemical parameters is significantly higher. For example, in the County of Vukovar-Srijem, where 65% of the population is supplied with water from the public water supply system, over 30 water pipelines have been constructed (including the town of Županja) in which water is not of the required quality. The situation is similar, although to a slightly lower extent, in the Counties of Slavonski Brod-Posavina and Požega-Slavonija and in some other areas. By putting into operation the first phase of the Regional Water Supply System of Eastern Slavonia, this problem will be solved in the beginning of the current year.

5. Water price

In 2008 in Croatia there were 132 utility companies supplying water to the population and industries. Depending on the availability and quality of water resources, and on the policy of the local community and organization of utility companies, the price of water supply and sewerage for households ranged in Croatia in 2008 from HRK 3 per m^3 to HRK 17.5 per m^3, i.e. HRK 9.85 per m^3 on the average. The average price for industries amounted to HRK 17.87 per m^3. In some cases the price of water includes wastewater collection as well.

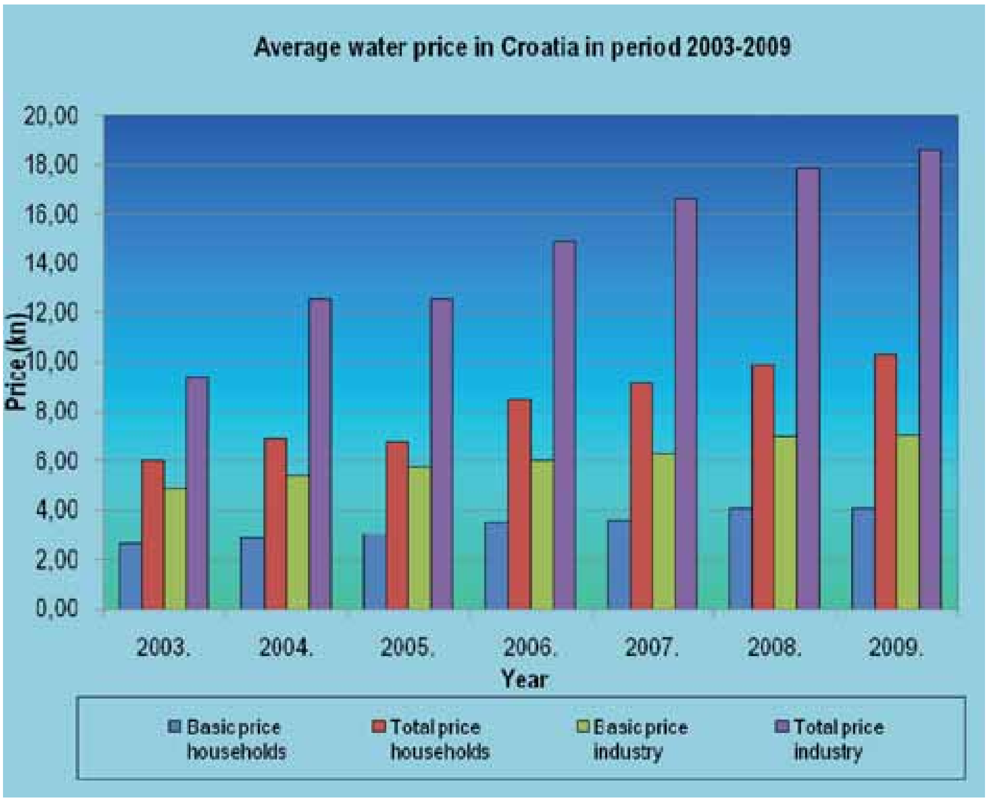
The current water prices, fixed by local (regional) self-government and towns, contain operating costs (including VAT), the water use charge (HRK 0.80 per m^3), the water protection charge (HRK 0.90 per m^3), and occasionally a charge for the development of infrastructure. The level of the water price is very often affected not only by the actual costs, but also by political structures, which causes difficulties to utility companies because the water price does not cover total costs. This leads to insufficient maintenance of the systems and low reliability of water supply, which is typical especially for poorly populated areas.

The prices of utility services should express the real value of fixed and variable costs of maintaining the system (personnel, electricity, other operating expenditures, as well as amortization of fixed assets).

However, local self-government units very often pursue an underestimated pricing policy, which is to a lower extent due to specific spatial and technical qualities and to a larger extent due to differences in the indicators of efficiency and cost-effectiveness. The results lie in the fact that fragmented service areas of utility systems cannot cover fixed and variable costs of their systems, granted (through various forms of subsidy) by the government; real prices in small communities are "socially unaffordable" even for larger communities. In many cases the prices of services do not reflect real costs, and they very often don't even include amortization. The gaps are filled through a "commercial" activity of utility companies.

The underestimated pricing policy has further consequences: systems lack maintenance; the constructed structures are devastated or are not used, they suffer damage and eventually stop being usable; interventions are made only on the system's hot spots; operating plants become outdated and undergo amortization several times; large quantities of water drain from the transport system into the underground (average losses: 45%). In some utility companies the water price doesn't even cover recurring costs (costs of electricity and regular overheads), which leads to termination in water supply because of unpaid bills.

It is obvious that water prices cannot be completely identical, but they must be formed under identical economic criteria which enable reimbursement of all system operation and maintenance costs and of the costs of necessary development. In the communities where economic logic is not fair (for example due to uneven distribution of water resources) or not applicable (for example due to social reasons or special state interests) it has to have a remedy in two principles: the solidarity prin-

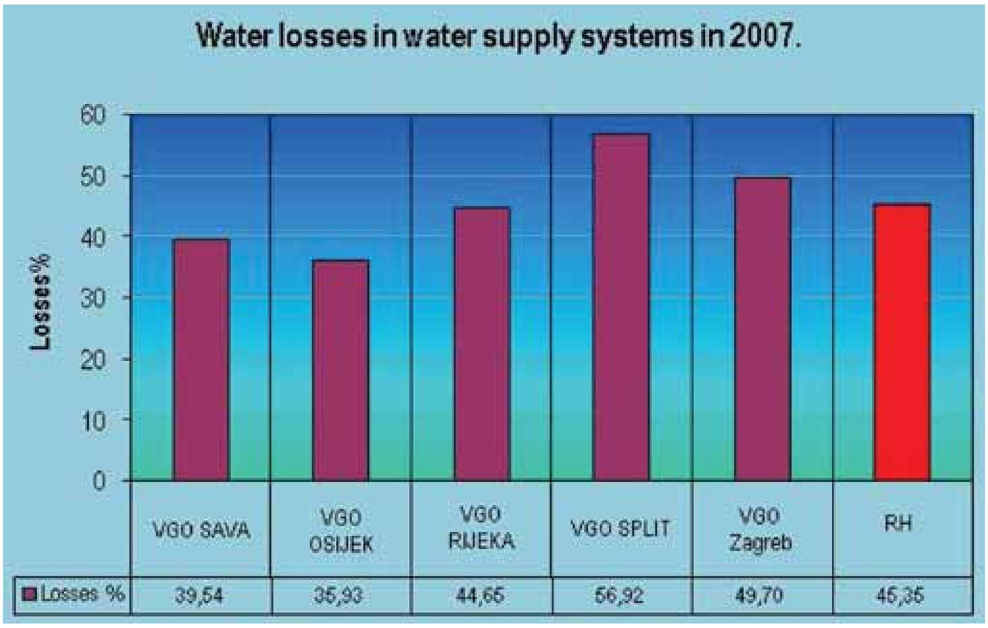


ciple and the principle of socially affordable prices for a local beneficiary body.

It should be pointed out that some local self-government units have already introduced an economic price of water with an integrated development component, which is in practice reflected in the increased level of population supplied with water on such areas, proper water supply throughout the year, and small water losses in the system.

6. Water losses in water supply systems

The average water losses in water supply systems in the Republic of Croatia are 45%, which means that this percentage of the abstracted water is not supplied to consumers. In absolute terms, in the year 2007 467 million m^3 of water was abstracted, 240 million m^3 was supplied, and 226 million m^3 of water was lost. According to the experience of West European countries, water losses should not exceed 15%, having in mind that this percentage includes certain amount of water used for the washing of streets, flushing of pipelines, etc., and inevitable network losses. Detailed measurements taken at individual water supply systems have shown that water is lost mostly from old pipelines or from poorly constructed pipe-



lines made from weak materials which over time use the required properties, from network nodes that haven't been maintained, at branch pipes for house connections, etc. Hence, the replacement of decrepit water supply pipelines and fittings is a priority task within the system of water loss reduction measures, and if these pipelines are replaced, high quality materials have to be used.

The reduction of losses is a permanent activity which requires the preparation of expert studies, installation of measuring and regulating equipment, telemetric system management, detection of losses and their elimination.

7. How water supply is organised

7.1. Activities of Hrvatske vode

Hrvatske vode is a legal entity established for the purpose of performing the activities through which state and local waters are managed.

One of the activities of Hrvatske vode is water use – identification of water resources, control of the status of water resources, adjustment of water use plans adopted by other legal entities and control of their implementation, and other measures for rational water use for the designated purpose.

Pursuant to the Water Management Financing Act (*Official Gazette* No. 107/95, 19/96, 88/98 & 105/05), the water use charge is one of the sources from which water management is financed, and it is paid into the account of Hrvatske vode. The funds collected from this charge are, pursuant to the Act, special-purpose funds and they are used for the following purposes: collection and keeping of data on water resources and their use; control of the status of water resources and taking measures for their rational use; water exploration works; and construction of water structures for water use (water intake structures, drinking water purification plants, water storage tanks, and major pipelines), and for proportional participation in covering the expenditures for activities considered as public services.

7.2. Utility companies

The Water Act stipulates that the water supply activity (intake and pumping, purification, transport, and distribution of water to consumers) is carried out by legal entities organized in accordance with the Utilities Act.

As far as we know, in 2008 there were 132 registered companies (legal entities) supplying the population with water.

Having in mind the criterion that utility companies must meet certain conditions in order to supply the population with water (skilled personnel, equipment, laboratory, etc.), it can be said that it is mostly the largest utility companies that are able to provide proper service and safety in water supply.

It has to be pointed out 25 largest water supply companies in the Republic of Croatia deliver 81% of the total quantity of delivered water, and that 90 water supply companies deliver less than 1 million m^3 of water, which brings into question the economic efficiency of their operation.

8. STrategic goals of the development of water supply

8.1. Increase in the percentage of population supplied with water:

The total capacities of water intakes and the available water quantities still don't limit the development of public water supply. Difficulties arise from the spatial/temporal distribution of water intakes and users and from extremely high demands during a short summer period in tourist areas. The present level of the population connected to public water supply systems – 78% – is planned to be increased in the next investment cycle to 85-90%, thus coming closer to the European standards. The greatest average increase is foreseen in the Sava river basin (excluding the City of Zagreb) and in the Drava and Danube river basins, by extending the existing and constructing new water supply systems. On the areas where the percentage of population supplied with water is high the primary thing to do is extend the constructed systems to outskirts of towns by connecting the peripheral settlements into unique public water supply systems. Constant action is required, in cooperation with local self-government, on the renewal and coordination of plans for the development of public water supply, among other things in order to balance the percentage of population supplied with water on the level of Croatia in order to provide approximately identical conditions of living and development.

Rough estimates indicate that 15-20% of Croatia's population uses the so-called local water pipelines. Such local water pipelines should be gradually integrated into public water supply systems in order to control the quality of water and to charge the use of water resources. The integration of local water pipelines into public water supply systems would lead to increase in the percentage of population supplied with water and to increase in the safety of human health. Individual methods of water supply (wells, tanks and the like) should be gradually included into the public water supply system, primarily in order to control the quality of water, by means of which the safety of human health will additionally increase. This would also prevent the development of water-related diseases, which now occur occasionally because of the water of inadequate quality.

The specific problem of supplying water to the islands should be resolved by respecting economic justification for selecting one of the two basic approaches: delivery of water from the mainland (which is characteristic for island groups closer to the mainland) and an approach which implies the use of the island's own resources (including desalination of slightly brackish water), or transport of water by means of water tankers (characteristic for distant island groups). On such islands rational water use has to be encouraged.

8.2. Improving the management of public water supply systems

Significant improvement in the conditions and standards of water supply coverage depends on the improved management of public water supply systems, whose achievement is foreseen through the following:

- **Identification of distribution areas –** One of the key issues regarding public water supply is the identification of distribution areas as technological and economic units. On each distribution area one utility company should be established at some period with a unique price of water for the entire area. At present, it is only 30-35 (out of 132) utility companies in Croatia that meet the basic operating conditions. This therefore requires reorganization and optimization (consolidation) of utility companies, which would result in a considerably smaller number of companies in comparison to the present number.
- **Integration of water supply systems – regional systems** – Analysis of wider conceptual solutions for the purpose of integrating individual water supply systems into larger functional units in one or more basins is only in the beginning. In order to improve efficiency, and, in some places, limited capacities of the existing sources, it is necessary to integrate existing and new systems into regional systems, which will be able to deliver water from several directions (basins), regardless of administrative borders. The consolidation, or technical integration of existing and future systems, where economically justified, will solve a whole number of current problems related to uneconomical operation of smaller systems, quantitatively unsafe water supply, continuity of supply, the required water quality, and operating conditions, through which the overall efficiency of public water supply will increase. It is important to notice that the regionalization of public water supply will more and more be a national problem since it will cover increasingly wider areas and regions (a larger number of local government and self-government units, and a larger number of population).

8.3. Economic price of water:

The present predominantly social water pricing policy keeps bringing losses to utility companies and slows down or prevents their maintenance and further development. Progressive introduction of an economic price of water, which will cover real costs, and adherence to the basic "polluter pays principle", is necessary. In order for the economic price of water, which is expected to be considerably higher than the present price, to be realized by 2015, a gradual process of harmonization of the tariff policy has to start right now. In other words, one should foresee a transitional period long enough for such measures to be able to be implemented in practice.

It has to be noticed that the technological integration of systems and establishment of distribution areas with a unique price of water will facilitate the introduction of the economic price of water. Raising the safety of supply, construction and operation of water purification plants, strengthened monitoring, and control requirements will have an impact on the increase in the price of water. Gradual introduction of higher, more realistic, economic prices of water will undoubtedly reduce the current level of water consumption.

The principle of economic price of water is one of the basic principles of the EU Water Framework Directive. The term "water price" implies any cash expenditure burdening a cubic meter of water supplied to final beneficiaries, and which is directly or indirectly related to the protection of its quality and quantity, and with the construction and maintenance of water infrastructure which enables its exploitation and/or discharge in accordance with environmentally friendly standards. The prices of utility services ought to reflect the real value of fixed and variable system maintenance costs (personnel, electricity, other operating expenditures, as well as depreciation of fixed assets).

All of the above makes it clear that the introduction of the economic price of water is a necessity, but also that its introduction shall not put at risk the social situation of users, which makes it necessary to, among other things, define the deadline for the introduction of the economic price. It is clear that the Republic of Croatia cannot introduce the economic price of water by the year 2010, and that it should during the negotiations with the European Union insist on extending the deadline until the development and standard of users make such introduction possible.

8.4. Reduction of water losses from public water supply systems:

The reduction of water losses is a particularly important, permanent task of the utility sector in the first place. In order to increase the sustainability of existing water intakes, it is necessary to gradually reduce water losses from the current average of 46% to more acceptable levels (15-20%), following the example of the developed European countries which apply stricter criteria (7-15%). In this way considerable additional quantities of water would be obtained, and demands for new quantities and sources of water would be reduced. In other words, this would have an impact on the rational use of water resources, which is in line with the principles of good water management, which comes under the responsibility of the water management sector. In addition to that, this would also lead to the rationalization of the quantity of treated water which, because of the current losses, only partly reaches the consumers.

8.5. Meeting water demands:

A future increase in the demand for water in public water supply systems will on the one hand be affected by an increase in the percentage of population covered by water supply service and developmental needs in industry and tourism, while on the other hand a reduction in demands will be affected by the repair of water losses and the economic price of water. Since it is not expected that the number of population will increase in the next 15 years, total water demands for public water supply will mostly derive from the increase in the percentage of population connected to public water supply systems. Water demands are also expected to increase in smaller industrial facilities, commerce and crafts whose facilities are connected to the public water supply system. Larger industrial facilities will continue to try to ensure water for their needs from their own water intakes, which is for them a more economical solution. At present water is not a limiting factor for the development of industry and it is believed that it will not become one in the next planning period.

Increased water demands are expected in tourism as well, either because of a considerable increase in the number of tourists, or because of achieving a higher category of tourism. Since a seasonal type of tourism is expected to continue, there will still be difficulties in reconciling great differences between the consumption during the tourist season and out of the tourist season.

8.6. Increasing the safety of water intakes for public water supply:

Groundwater will continue to be predominantly used for the needs of public water supply, primarily due to the fact that groundwater intakes are sanitary safer than those of surface water because of mostly good natural protection against pollution. New intakes will be used as a replacement for polluted intakes, or for obtaining new quantities in accordance with developmental needs. For the systems associated with only one water intake it is necessary to identify a reserve source of water supply. Since in certain parts of Croatia aquifers and intakes are highly vulnerable due to anthropogenic pressures (underdevelopment of sewerage systems and plants, agriculture, etc.), appropriate measures need to ensure the required water quality. Polluted intakes have to be repaired, or water has to be treated in order to achieve the required quality. The ultimate solution is to deserve intakes in the areas where the processes of treating polluted water are lengthy, unpredictable, or economically unviable, and to use such water, if possible, for some other purposes (e.g. as technological water). Karst groundwater represents a particular problem – its natural treatment is minor, which makes it highly sensitive to all kinds of surface pollution. It is therefore necessary, for each particular intake, to comprehensively analyse and identify the acceptable level of water protection by combining protection measures in the basin and appropriate water treatment.

9. Conclusion

The supply of water to the population and industry must always have as its purpose satisfying the needs as much as possible. In that process, just like in other uses, one part of water is lost, and another one usually gets polluted with waste matter and is then returned back into watercourses or the sea, making them polluted and degraded, which puts at risk the conditions and possibilities of using water in any form. Intake of water, its transport, use, and pollution is a complex problem which has to be dealt with appropriately. The development of water use, in the process of which the sustainability principle is adhered to, must be directed at preserving and improving the efficiency of the present systems, as well as at the construction of new systems, and formulation of a framework required for the development of the society and economy, harmonizing thereby various water uses in order to avoid conflicts of interest between users, and to create conditions for the achievement of strategic goals.

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Water Supply System of Eastern Slavonia

Summary

The paper presents the development of the water supply system of Eastern Slavonia, from its hydraulic concept to starting of operation. Specific property of the area – lowland terrain, position of the regional well field Eastern Slavonia, large area, but also the present level of development, have all influenced the formation of the basic water supply structure, which will be modular in time, and its sections will be exposed to various pressure conditions, with the possibility of changing in phases.

Key words: well field yield, water quality, modelling, operating status, GIS, SCS, automation

1. Introduction

The area of Eastern Slavonia encompasses three counties: Vukovar-Srijem, Osijek-Baranja and Slavonski Brod-Posavina. The area is in want of water quantities of adequate quality. High concentrations of iron, manganese, inorganic ammonia, etc. but also arsenic, in relation to maximum allowed concentrations according to the present Regulations on Sanitary Condition of Drinking Water (OG 47/08) (hereinafter: the Regulations), but also according to previous regulations, occur on almost the entire area of Eastern Slavonia, making it necessary to carry out water treatment where possible, while many settlements continue to use water which does not meet the criteria of the said Regulations.

The above situation was the reason for hydrogeological surveys which were going on for a number of years with the objective to determine the most favourable location of the regional well field Eastern Slavonia, because already in the 1970-ies a gravel-sand aquifer with good hydrogeological properties was found in the wide area between Velika Kopanica, Gundinci and Kruševica.

Surveys were carried out on the locations Velika Kopanica – Babina Greda and Gundinci – Babina Greda, and in both locations large quantities of groundwater were found, although containing higher contents of iron, manganese and arsenic. Since 2004, surveys were carried out on the location south of the highway between the settlement of Sikirevci and the Sava river. This location was paid particular attention already after first results, as it met all prescribed conditions regarding both the yield and water quality. Even the iron, manganese and arsenic contents were lower than MAC (maximum allowed concentrations) for drinking water. Therefore, groundwater from the location Sikirevci is classified as best quality drinking water in Slavonia, and may be used in water supply systems without any treatment. This discovery considerably accelerated construction of the regional water supply system of Eastern Slavonia.

The beginnings of formation of the water supply system of Eastern Slavonia date back to 1980-ies, and the concept solution "*Regional Water Supply System of Eastern Slavonia", Hidroprojekt-ing, Zagreb, 1997,* established the multi-layered structure of the water supply system on three levels. The first level includes the basic transport system accepting water from each and every well field and transporting it in all directions, to all distribution areas. The second level consists of distribution mains, which distribute water from the basic system within the interspace. The third, lowest level includes individual local water supply networks in separate settlements, towns and distribution areas. Under the concept, modelling and dimensioning of the basic transport system of the entire area of Eastern Slavonia was carried out by placing of controlling and regulation facilities, while modelling of the mains water supply construction has not been conducted.

The problem of shortage of water of adequate quality is particularly pronounced in the area from Slavonski Brod to Vinkovci and to the east, where the level of connection to public water supply system is the lowest, and therefore phase one of development of the water supply system was

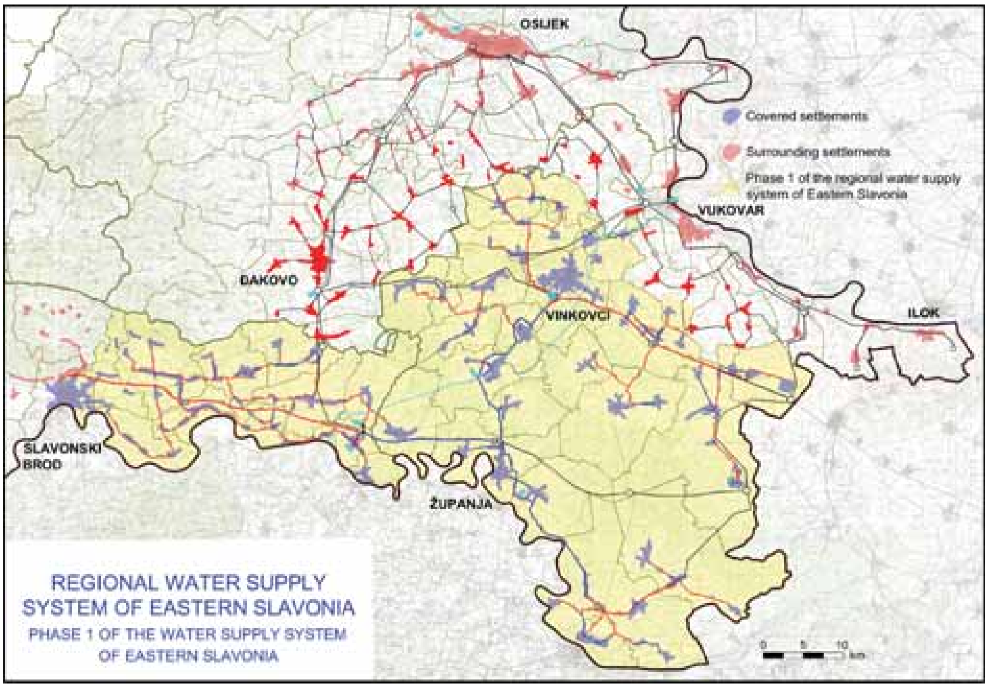

Fig. 1.1 – Phase one of the water supply system of Eastern Slavonia

defined (Fig. 1.1), and preparation of documentation and implementation were initiated.

Based on the results of hydrogeological surveys at the location Sikirevci, modelling of the basic and mains water supply construction for phase one was carried out within the project *"Hydraulic Analyses and Dimensioning of Mains Structures of Phase 1 of the Water Supply System of Eastern Slavonia", Hidroprojekt-ing Zagreb, 2005,* which will be the basis for detailed designs, obtaining of required permits, and for implementation.

Phase one of the water supply system of Eastern Slavonia solves water supply of a part of the County of Slavonski Brod-Posavina east of Slavonski Brod (municipalities of Bukovlje, Donji Andrijevci, Garčin, Gornja Vrba, Gundinci, Klakar, Oprisavci, Sikirevci, Slavonski Šamac, Velika Kopanica and Vrpolje), with water distribution in the area of Slavonski Brod and a part of the County of Vukovar-Srijem (towns Otok, Vinkovci and Županja, and municipalities of Babina Greda, Andrijaševci, Bošnjaci, Cerna, Drenovci, Gradište, Gunja, Ivankovo, Jarmina, Markušica, Nuštar, Nijemci, Privlaka, Stari Jankovci, Stari Mikanovci, Štitar, Tordinci, Tovarnik, Vođinci, Vrbanja, and a part of the municipality Bogdanovci).

In this area, there are two major utility companies ("Vinkovački vodovod i kanalizacija" d.o.o. Vinkovci and "Vodovod" d.o.o. Slavonski Brod) which are in charge of the basic and mains water supply construction, and the local town systems, as well as of a number of settlements in their respective distribution areas. Aside from the above companies, there are also utility companies in Županja, Gunja and Drenovci, as well as a number of local water supply systems.

The specific property of this large area (the route of the existing and planned basic and mains pipeline from Slavonski Brod to Vinkovci is about 82 km long, with additional 32 km from Vinkovci eastward to e.g. Tovarnik) is the marked lowland terrain. In such circumstances, special attention must be paid to defining of pressures in basic pipelines (low pressure, or pressures suitable for direct water supply), as well as to the number and location of facilities which will control the pressure conditions in water supply mains and provide water to cover hourly variations of consumption. A larger number of these facilities reduces the hourly loads in the long basic pipelines (by separating mains pipelines from these facilities, thus enabling the basic pipelines to transport the average daily consumption), but increases the number of facilities, which are, as a rule, more difficult to construct, and requires construction of parallel water supply mains.

Therefore, while preparing the concept of the system it was necessary to take into account all the above facts and respect the already existing sections, and everything had to be adjusted to the period in which consumption would vary in relation to the water requirements in the areas in which the system will be constructed, and in particular in relation to possible expansion of the system beyond the area covered by Phase 1.

For this reason, strengthening of the municipal utility sector seems unavoidable, in particular in terms of ensuring the necessary equipment and staff capable of managing the corresponding infrastructure cadastre (GIS), conducting adequate monitoring and measurements in the system, properly use the data from the the supervisory control system (SCS), conduct adequate modelling, etc.

2. Current state

A majority of the setllements and all towns in Eastern Slavonia already have local water supply networks. These networks are fed mainly from their own local sources. However, in most settlements there are problems related to inadequate quality and quantity of water, in particular during the summer months, and it remains a fact that only about 20 percent of the population in the area is supplied with good quality drinking water from public water supply systems. There is also expansion of urban distribution networks beyond their respective town perimeters, and connecting of suburban, and sometimes even remote settlements to the networks. This expansion of individual systems is unilateral and unilaterally functional. Therefore the necessity arose for the construction of a new water supply system which would solve the problem of water supply of Eastern Slavonia on a long-term basis.

In accordance with the concept of water supply of 1997, pipelines for a part of the basic transport system were constructed: Vinkovci-Cerna, Cerna-Županja-Bošnjaci, Bošnjaci-Posavski Podgajci, which were partially in function, and the pipeline Županja – Babina Greda.

Following the conceptual solution of Phase 1 of 2005, the Government of the Republic of Croatia adopted the program of construction of the regional water supply system as a strategic developmental project for this part of Slavonia, on its session held in Slavonski Brod. After that, the Agreement on co-financing of the regional water supply system of Eastern Slavonia, in the total value of HRK 397 million, was signed in December 2005 on the premises of the municipality of Sikirevci. The Government participates in the financing with 60 percent (with equal amounts of HRK 119.1 million from the Ministry of the Sea, Tourism, Transport and Development, and the Ministry of Agriculture, Forestry and Water Management), Hrvatske vode with 20 percent (79.4 million), and the regional development fund and the Counties of Slavonski Brod-Posavina and Vukovar-Srijem with 10 percent each (HRK 39.7 million). The program is conceived to include a major part of the County of Vukovar-Srijem and the eastern part of the County of Slavonski Brod-Posavina, covering about 275,000 inhabitants, and implementation of the project is planned in the period from 2006 to 2010.

Based on the Agreement, designing and construction of the basic water supply pipeline and water supply mains was initiated. Thus, by December 2008, drilling of all 8 wells of Phase 1 was completed, the access road to the well field was constructed, as well as connecting pipelines for the three wells in the well field, three wells were completed and equipped, and the basic pipeline connecting the well field to the existing pipeline Županja – Babina Greda was also completed. Other completed works include a part of the basic pipeline Vinkovci – facility "Slakovci", and water supply mains Rušćica-Oprisavci-Sikirevci-Kruševica, Bicko Selo-Trnjani, and Andrijaševci-Vođinci-Mikanovci. Works completed by December 2008 and further plans are shown in Figure 2.1. below.

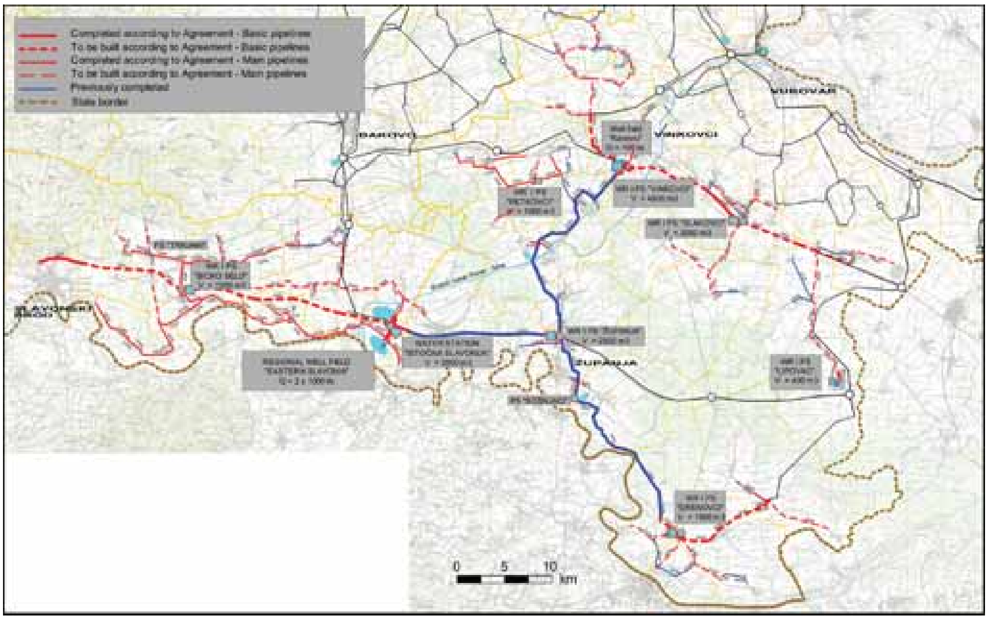

Fig. 2.1 – Completed works and implementation plans

3. Well fields

The existing well fields in the area covered by Phase 1 of the development of the water supply system are the well fields Jelas, Kanovci, Bošnjaci, Cerna, and numerous local well fields.

Well field Jelas is actually situated outside the project area and serves as the basic source of the water supply system of Slavonski Brod, which will be connected to the Eastern Slavonia system on its eastern boundaries. In the wider area of the Jelas well field there are 14 wells of average depth of 70 m, diameter ∅ 400 mm, and capacities between 40 and

100 l/s. The total capacity of the well field (intake and water treatment) is 400 l/s, but out of the total number of water intakes only six are in working condition due to the age, sand erosion and deteriorated water quality. Water quality has always required treatment (aeration, ozonation, filtration, etc.), to make the water potable in accordance with the Regulations. Until completion of the construction of the Eastern Slavonia system, water will be delivered to the western part from Slavonski Brod, while after construction water transport is expected from the Eastern Slavonia well field towards the Slavonski Brod system.

Well field Kanovci near Vinkovci has the capacity of 100 l/s, however its operating capacity is about 50 l/s, while approximately 90 l/s for water supply of Vinkovci are transported from the ***well field Cerna*** by the existing basic pipeline Cerna-Vinkovci. Water treatment was done in Kanovci. Due to poor water quality, well field Cerna is going to be abandoned after starting of operation of the Eastern Slavonia well field, while the Kanovci well field may be used through its own plant. The problem is that temporary operation of the well field Eastern Slavonia, as well as cleaning of the pipeline from the Eastern Slavonia well field to Kanovci was done through the Kanovci plant, by which the role of silt in water treatment was lost, and restarting of the Kanovci well field would require redirecting of water from the Eastern Slavonia well field through the pressure maintaining valve directly to the water tank, and bringing the plant into function.

Well field Bošnjaci is of considerable capacity, but the quality does not meet the Regulations. Since a treatment plant has never been constructed on this location and water is not being disinfected, this water is classified as technological, and as such delivered to the water supply system of the town Županja. When water from Eastern Slavonia well field is brought to this area, this well field will become a reserve.

With regard to the above, and to the fact that in the area of Phase 1 there are numerous local well fields with prevailing inadequate water quality, the major effort is made towards completion of construction of the so-called “zero” phase, when first quantities of water from the Eastern Slavonia well field would be let directly into the system.

Well field Eastern Slavonia covers a larger area, because hydrogeological investigations were conducted for a longer period on several locations. Still, basic indices that have influenced designing and construction of wells are given in the study “*Hydrogeological investigations with the objective od defining the exploitation reserves of groundwater at the* *potential regional well field Gundinci-Sikirevci", Croatian Geological Society Zagreb, 2005.* The investigations included piezometric boreholes, experimental wells, as well as water quality analyses. First investigations were carried out at the location Gundinci, and were later transferred to the location Sikirevci, where water quality and quantity results showed that this was the most suitable location for construction of the regional well field which will supply the area included in Phase 1 of develoment.

In the area between Sikirevci and the Sava river, a vertical cut through the strata shows three gravel-sandy layers. The first shallow layer is found in the depth interval 20-30 m, and it is 5-7 m thick on average. Beneath is a layer of hard plastic clay 3-4 m thick. The second gravel-sandy layer is in some places bound by clay material. It is isolated from the third aquifer by a layer of hard plastic clay 3-7 m thick at depths 40-50 m. In the third gravel-sandy layer there is a conglomerate (cemented gravel) layer, 10-20 cm thick, with calcite cement. The well depths are about 80 m, contacting the aquifer in three to four depth intervals.

Recharging of groundwater in the studied area is ensured by inflow from the Sava river, and in the north also by infiltration of rainfall. In operating conditions, vertical percolation and infiltration of rainfall may be expected to intensify, but it will remain less significant in relation to recharging from the Sava river. The character of the deposit may be illustrated by the fact that test pumping of 200 l/s from wells ZS-3 to ZS-5 resulted in lowering of the level by mere 5 m. Through modelling it was determined that for pumping of e.g. 600 l/s it takes about a year for the water from the Sava to reach the wells (distance about 1000 m). Still, due to the lack of corresponding recipients to accept large water quantities during test pumping, it will be necessary, after starting of operation, to carry out model verification which will facilitate better and more precise simulation of groundwater flow for the purpose of defining the limit capacity of the well field and of the protection zones. In determining the zones of sanitary protection, present analyses revealed vertical water flow longer than 50 days, and the second zone of sanitary protection has not been planned at all, i.e. it completely matches the first zone.

Water quality analyses at the location Gundinci show that water requires treatment due to increased content of iron (700-1000 μg/l), manganese (50-15 μg/l) and arsenic (up to 30 μg/l). Water quality at the location Sikirevci is considerably better, with all parameters far below

MAC, and water may be let directly into the supply system without any treatment.

With regard to expected water demand, the development of the well field is planned in several phases. On a long-term basis, pumping of about 1000 l/s is planned at the location Sikirevci from eight wells (although test results of individual wells show that even higher quantities may be expected), and equal quantity may be obtained by pumping at the location Gundinci. Recent investigations indicate that about 600 l/s may be provided at the location Kruševica. An environmental impact assessment for water pumping of 1000 l/s at the location Sikirevci was prepared and adopted.

The layout of wells and power transformer stations at the well field, as well as the existing connecting and supply pipelines, is shown in the figure below.

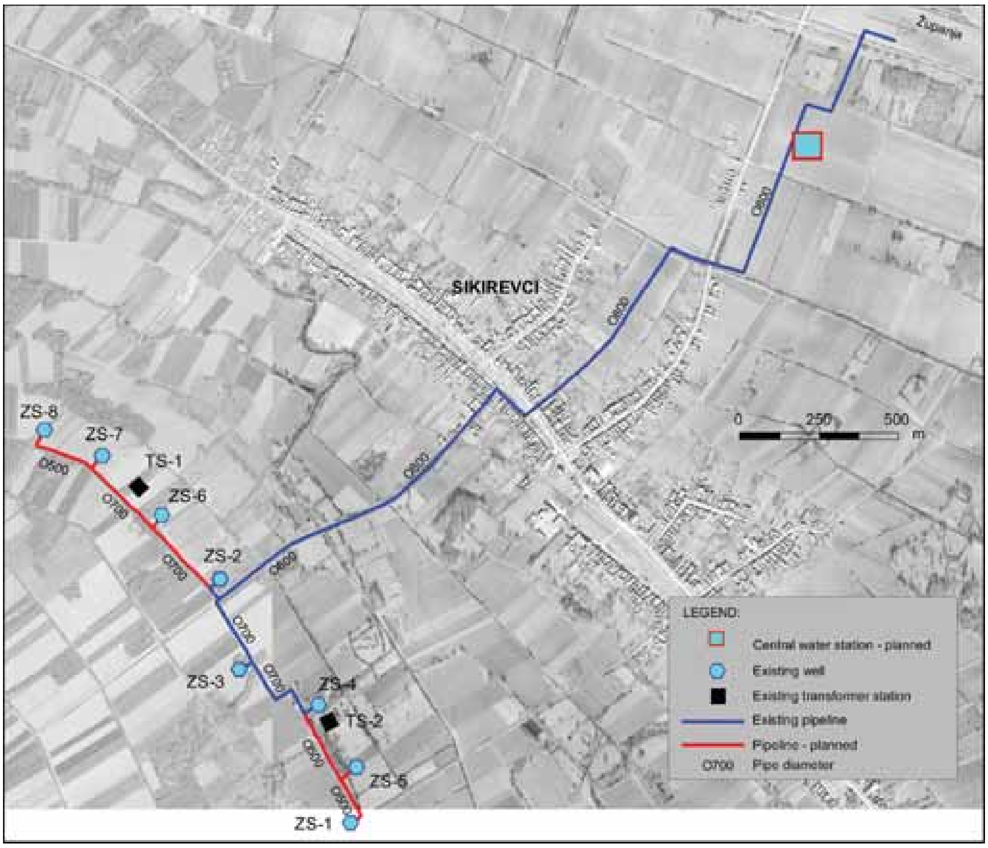

Fig. 3.1 – Well field Eastern Slavonia

4. Concept of Development

The basic assumption in the concept of the water supply system of Eastern Slavonia was to provide adequate quantity of sanitary drinking water to all settlements, in all conditions of consumption in time, ensuring required pressure conditions, respecting present development status and plans for expansion beyond the area under Phase 1 (Đakovo, Vukovar, Ilok and Osijek), and minimizing the time required for letting in first water quantities into the system and the construction costs. To make this possible, the water supply structure was analyzed in three levels (basic, mains, and local), and certain facilities will be modular, just like the system as a whole.

The basic conceptual solution of Phase 1 of 2005 estimates the planned number of system users at the end of the planning period in 2031 with corresponding consumption, as shown below.

Table 4.1 – Number of users and maximum daily consumption

County of	Inhabitants	$Q_{max,day}$ (l/s)
Slavonski brod – Posavima	105,645	426.9
Vukovar – Srijem	168,505	684.6
Total for Phase 1	274,150	1,111.6

Some settlements and large towns in the area (Slavonski Brod, Vinkovci and Županja) have developed water supply networks and a certain level of connection to public water supply, but some of the settlements still have no water supply systems. The above planned maximum daily consumption at the end of the planning period will be realized under the condition of 100 percent of connection and planned growth of the number of users and consumption, which are parameters that will be difficult to achieve, but are also variable in time, and therefore modelling of the system for different loads was carried out.

Generally it may be said that the system will be developed in the following phases, although in reality it will be expanded in a modular manner, depending on the requirements and timing of construction. The long-term period represents Phase 2 of development, when the system will be loaded by the total above consumption and will require construction of facilities according to Figures 1.1, 2.1 and 3.1. These are the facilities in the area included in Phase 1 (Figure 1.1), and particular attention was given to potential expansion of the system beyond the project area.

In order to avoid investing into system elements (in particular elements for increasing of pressure) which will be fully utilized only at the end of the long-term planning period, the system with reduced consumption has been modelled as well. Using the data on present consumption in settlements with organized public water supply, the present and planned long-term consumption were compared. When these annual data on consumption are increased by the assumed coefficient of seasonal monthly consumption, and compared with those planned for the planning period, the result is that the present consumption is about 69 percent of te planned future consumption. Therefore, 75 percent of the consumption planned for 2031 was adopted, for which detailed design documentation will be prepared, and which will represent Phase 1 of development (short-term) of the water supply system. However, it was taken into account that individual towns and settlement already have public water supply systems, and that their connection to the regional system will immediately generate consumption, while in some settlements, local systems have not been constructed at all. For this reason, the choice of pumps in pumping stations was made in the way to also "cover" considerably lower consumption than modelled.

As the water quality in constructed wells allows letting into the system directly without treatment, detailed hydraulic analyses were conducted, and it was decided that, in the so-called "zero" phase, water from the three wells will be let in directly into the system, all the way to the existing facility "Kanovci" for water supply of Vinkovci, also supplying the consumers along the basic pipeline. These analyses (modellings) were made with certain limitations, the most important being the limitation of power on low voltage cables connecting the transformer station with the wells, which are basically dimensioned to the power required to bring water, in the low pressure regime, to the central water station "Eastern Slavonia" (see Figure 3.1).

Modelling was conducted using the EPANET 2 software. Mathematical model EPANET 2 – Lewis A. Rossman, Water Supply and Water Resources Division, National Risk Management Research Laboratory Cincinnati, OH 4268 – version 2000 was developed by EPA United States and calculates distribution of flows and resulting pressures in branching and complex ring pipe network, consisting of a random number of sources, wells, pipes, nodes, water reservoirs, pumps and various kinds of valves. The Darcy –Weisbach formula for energy dissipation in pipes of round cross-section was chosen, as in this region it is traditionally used in engineering practice:

$$J_e = \frac{\lambda}{D}\frac{v^2}{2g}$$

where λ equals the coefficient of resistance to flow.

Line resistances in the water supply system of Eastern Slavonia determined the positions of main facilities: "Županja", "Bicko Selo", "Drenovci", "Retkovci" and "Slakovci". Namely, they are situated closer to the "large" consumers, but ensuring required pressure conditions at the ends of long pipelines (fire protection). Except the above facilities, the most important ones are the central water station "Eastern Slavonia" and the existing facility "Kanovci" near Vinkovci (see schemes below). All the above facilities consist of, among other things, a ground level water reservoir and a pumping station with one or several groups of pumps for one or more pumping directions, according to the said phases of development.

The basic idea of pressures in basic pipelines was low pressure, i.e. with the energy input adequate to bring required water quantities to ground-level reservoirs and pumping stations, from where water will be further transported by mains pipelines under the pressures required for direct water supply of settlements. This way allows considerable varia-

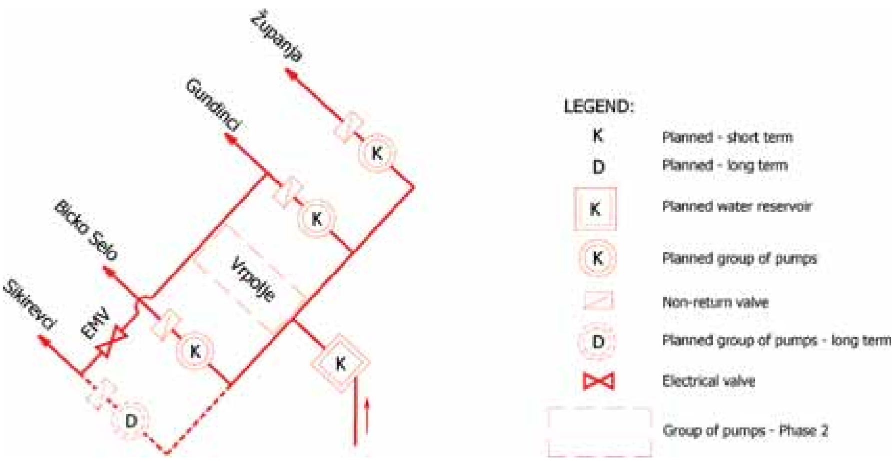

Fig. 4.1 – Scheme of the central water station "Eastern Slavonia"

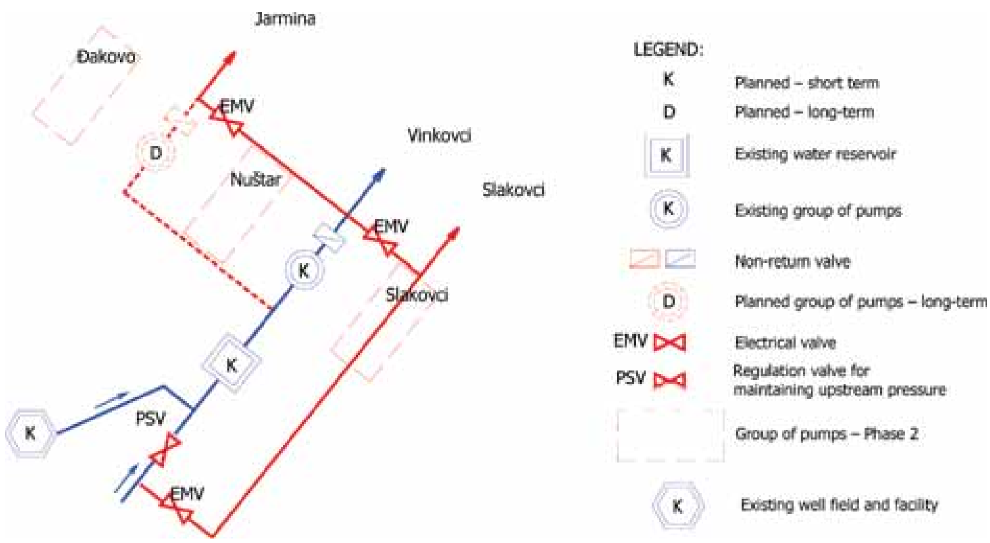

Fig. 4.2 – Scheme of the facility "Kanovci"

tion of consumption in time phases in basic pipelines with regard to output pressure heads in pumping stations, while the energy is not lost entering into reservoirs. However, this solution requires multiplication of pipeline network, i.e. construction of the mains network which would in some places be parallel to the basic pipelines.

With respect to the existing status of development of basic pipelines and water requirements in the area of Phase 1 of system development, construction of parallel pipelines will be avoided in the section from the facility "Županja" to the facilities "Drenovci" and "Kanovci", i.e. pressure conditions in these sections will allow consumption in towns and settlements along the way. To make this possible, regulation valves for maintaining upstream pressures will be built in at locations before the facilities "Kanovci" and "Drenovci". In these valves the flows will vary during the day by keeping the valve open and letting through more water when consumption in the system is lower, and by choking the valve during peak loads. An example of valve operation for conditions of Phase 1 before the facility "Kanovci" is shown below.

In order to reduce the loads of long basic pipelines, it is necessary to regulate filling of other reservoirs in the system. This will be done by building in of regulation valves for maintaining continuous flow at the facilities "Retkovci" and "Slakovci".

Fig. 4.3 – Variations of flow on the inlet (valve) into facility "Kanovci" from facility "Županja"

Such a system will be able to provide sound water supply in Eastern Slavonia on a long-term basis. Possibly, in some parts of the system, depending on the growth of consumption, it may be necessary to interpolate other facilities (water towers or pumping stations), but such modular development is possible under this concept.

5. Operation and maintenance

The basic conditions regarding the municipal utility sector in Eastern Slavonia, with emphasis on water supply, are defined by the Utilities Act (OG 26/03, 82/04 and 110/04). In addition to this Act, in is necessary to point out the Water Management Strategy (OG 91/08), which gives the guidelines of future development of the municipal utility sector in the Republic of Croatia.

The Utilities Act, and in particular the Water Management Strategy reveal a clear tendency towards long-term agglomeration and strengthening of utility companies. This primarily means formation and agglomeration of major, regional utilities for water management. Connecting of utilities in Eastern Slavonia would result in numerous advantages. The advantages are reflected, first of all, in the possibility of optimal development of water supply structure, rationalization of construction of major water supply facilities, reduction of overdimensioning, increased utilization and better protection of the system from non-stationary phenomena (damages, air in pipes…).

Collection of data on the current level of development of water supply facilities would be done in a high-quality manner, using GIS technology, which requires training the adequate staff team. Centralized management of the system, which would be made possible by implementation of an integrated supervisory control system (SCS) on the level of entire Eastern Slavonia, would allow real-time monitoring of operation of the the water supply system. Data from the SCS, used in combination with a calibrated mathematical model of the water supply system, become key factors for optimization of system operation, but also allow quicker control, which is particularly important when determining water losses.

Great attention is paid to non-stationary phenomena in the system, and for this purpose, studies for individual phases have been prepared (by Hidroekspert Split) which include calculations and analyses of pumps in the most important flow directions and, as a particular problem, occurence of air in the pipes, due to the lowland nature of the area.

Protection of the system from water hammers and ensuring flow characteristics of the pipes is planned by air valves. The existing pipelines on basic and mains pipelines in Eastern Slavonia are equipped with air valves DN 200 mm, suction-air type with two bulbs, installed in accordance with the designing principles of mounting of air valves:

- on all convex bends (watershed points)
- in horizontal sections, at spacing of approx. 500 to 800 m.

Horizontal, or almost horizontal sections determine the critical flow which will move the air bubble in the direction of the flow.

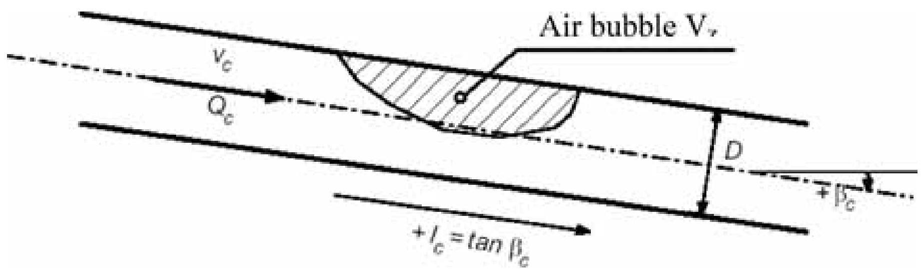

Fig. 5.1 – Air bubble in pipe

To determine the critical flow, the formula of the research centre HR Wallington, 2005, (adjustment V. Jović, 2006) may be used, as follows:

$$\frac{v_c}{\sqrt{gD}} = 0.56\sqrt{\sin\beta_c} + a$$

$$n = 4\frac{V_z}{\pi D^3}$$

$$a = -0.0755687\log^2 n + 0.0380147\log n + 0.606072$$

$$Q_c = v_c\frac{D^2\pi}{4}$$

Where the angle towards the horizontal (Figure 5.1) is positive for the pipe inclined downstream, and V_z is the volume of the air bubble. Calculation of the critical flow for moving of the air bubble of the volume of 0.5 cu.m. in the horizontal pipe is shown in the following table:

Table 5.1 – Critical flow

D **[mm]**	$\boldsymbol{Q_{\min}}$ **[l/s]**
200	18
500	260
800	858
100	1465

It can be seen from the above table that air in the horizontal sections of large-diameter pipelines is difficult to move, and requires only very high flows, and therefore due attention has been paid to installing of air valves.

In horizontal sections, a mild slope of the pipe towards the air valve is set to allow removing of all remaining air bubbles at flows lower than critical. If the flow is higher than critical, air bubbles will move with water to the first air valve. The air valve prevents further motion of the bubble by slopes of the upstream and downstream pipe section, and removes it.

Particular attention has been paid to the need for regular maintenance of air valves, because they provide protection against the water hammer.

Filling of the system and putting into operation must be done at the speed that allows free removal of air, which is generally done by filling the pipeline by a flow lower than the operating flow.

6. Financing and status of works

The estimated costs of construction of the system in Phase 1 (investment study for the entire system of Eastern Slavonia was done in 2003) are divided into five parts: well field and central water station, and the areas east, west, north and south. The value of the planned investment is shown below.

Table 6.1 – Estimate of construction costs

Area	Costs	
Well field and water station "Eastern Slavonia"	COSTS:	78.500.000,00 kn
West	Facilities	2
	Pipelines	l = 167 km
	COSTS:	148.249.000,00 kn
South	Facilities	3
	Pipelines	l = 48 km
	COSTS:	49.171.000,00 kn
Nort	Facilities	2
	Pipelines	l = 64 km
	COSTS:	52.260.000,00 kn
East	Facilities	1
	Pipelines	l = 75 km
	COSTS:	68.815.000,00 kn
	TOTAL COSTS:	397.000.000,00 kn

This cost estimate was the basis for signing of the Agreement on co-financing of construction (see paragraph 2 (Current State) hereof). After that, public tenders were advertised for designing of plants in the four respective areas, and separately for the well field and the central water station. Based on obtained permits and completed bidding procedures, works were carried out as shown in Figures 2.1 and 3.1. In addition to designing and construction of the basic and mains facilities, preparations are made for construction and/or expansion of local water supply networks.

The greatest efforts were invested in completion of construction and preparations for operation of the so-called "zero" phase, during which it is possible to let up to approximately 300 l/s of water from the well field Eastern Slavonia directly into the system. At the well field, three wells are completed and equipped and connected with pipelines and signalling cables. Two transformer stations have been erected on the well field, connected with double feeding to the high-voltage line. The pipeline from the well field to the future water station has been constructed and connected to the existing pipeline Županja-Babina Greda. Other completed works include the temporary chlorination plant on the well field, and on inlets of local networks Cerna/Šiškovci, Rokovci/Andrijaševci, and Županja/Bošnjaci /Štitar is almost completed. The pipeline to Ivankovo is completed, as well as regulation manholes before the facility "Kanovci".

Local automatic equipment has been installed on the wells in the well field (opening and closing of protective on/off valves at starting and switching off of individual pumps, synchronous operation, minimum pump RPM and constant outlet pressure). Administering of disinfecting agent (chlorine dioxide ClO_2) is done locally.

The supervising-control system (SCS) has been formed, with the following signals: positions of on/off valves in the well field and RO2 manhole (water supply to the water reservoir "Kanovci" from treatment plant Kanovci), pump operation in the well field, flows after pumps, pressure probe at the well field, flow in needle valve in RO1 manhole (valve for maintaining upstream pressure in the water supply to the water reservoir "Kanovci"), pressure probes and flow meter in RO1, water level in the water reservoir "Kanovci", and operation of the chlorination plant in the well field.

Rinsing of the pipelines represented a particular problem, especially in the section Cerna-Kanovci which had to be continuously in function, because a part of water for the requirements of Vinkovci was transported from the well field Cerna. Therefore, after rinsing of the pipeline from the well field to Cerna, water from Eastern Slavonia was let into the treatment plant in Kanovci, which started the test operation of the water supply system of Eastern Slavonia. Then water supply from Kanovci well field was stopped, and all water for Vinkovci was coming from the Eastern Slavonia well field through the plant.

After that, the chlorination plant in Sikirevci was also put into operation, where water is disinfected by chlorine dioxide at the inlet and transported to the existing and new local chlorination plants in the system, and further to the consumers.

The last step is automation of the system. System operation in the "zero" phase is modelled in several ways, and the final manner of water supply operation was proposed. The suggested algorithm allows including of wells into operation depending on the growth of water requirements, which may be caused by demand in Vinkovci (need for filling of the reservoir "Kanovci"), or in Županja and settlements "upstream" from the needle valve (regulation valve for maintaining upstream pressure). This is done by filling of the reservoir with larger quantities or meeting the requirements of "upstream" settlements by increasing the pump RPM and signalling to switch on the next pump. When consumption on the "upstream" section is reduced, the pump RPM drops, followed by the signal to switch off the pump. Second command to switch off the pump follows indirectly after the water level in the reservoir reaches the upper preset value, after which the outlet pressure in Sikirevci is algorithmically reduced. Resistance in the system may be overcome only with a certain quantity of water, and the pumps in synchronous operation reduce their RPM, and after a few minutes one of them switches off. All this functions with preset upstream pressure on the valve, which ensures stable pressure conditions in the entire system.

7. Conclusion

Construction of the regional water supply system allows the supply of the area endangered by low water quality, where a number of inadequate local systems existed. The concept of the system, with all specific properties (lowland system, large area, current development…) allows water supply of up to 300 l/s already in the present state of development, and potential expansion and modular additional construction allow development of the system in the entire area in all phases of development.

The basic precondition of good functioning of this regional system is organization of the municipal utility sector and ensuring of necessary staff ready to cope with the challenges of such a system (GIS, SCS, modelling…)

It is necessary to continue the preparation and construction of key facilities in the system (ground level water reservoirs and pumping stations) and, during the "zero" phase, carry out proper monitoring of the system in order to resolve the last doubts as regards e.g. well field yield, water quality in the system, pressure conditions, etc.

8. Literature

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Critical Analysis of Investment Efficiency in Construction of Water Supply and Sewerage Systems

Summary

The recent decade has been the period of intensive investing in construction of water supply and sewerage systems. Major cities and strong industrial centers are relying on loans and their own funds, while minor communities are dependent on funds from various sources: international loans, funds of Hrvatske vode, grants.

On the basis of a large number of reviews of designs made for the Ministry of Regional Development, Forestry and Water Management (former Ministry of the Sea, Tourism, Transport and Development), Hrvatske vode and other commissioners, the authors have gained considerable insight into the efficiency of investing of large funds, analyzing all relevant factors. Subject to analysis were various influences essentially affecting the efficiency of the investment, such as: decision-making on construction, ordering and preparing of design documentation, minimum technical criteria, strategic approach, integrity of material and labor market, misuse, psychological and sociological problems, etc. Analyzing the advantages and disadvantages of the existing practice, problems are indicated, and suggestions are given how to overcome the adverse situation.

Key words: water supply and sewerage in small communities, investment efficiency, designing, local communities

1. Introduction

During the past three years, the authors of this paper have carried out, for the Ministry of Regional Development, Forestry and water Management, and earlier the Ministry of the Sea, Tourism, Transpor and Development, a number of reviews of project documentation for water supply and sewerage, financed or co-financed by the said institutions. The projects were mostly related to minor communities, maily for water supply and to a smaller extent for sewerage. This paper is based on the experience gained through project reviewing, contacts with investors, co-investors, designers, local authorities and municipal utilities.

2. Status of water supply and sewerage

Croatian towns are mainly well covered by water supply, and considerably less by sewerage, and there are also numerous smaller communities without water supply and sewerage, their number usually being proportional to the economic potential of their respective counties.

During recent years, considerable funds have been invested in development of infrastructure, in particular water supply and sewerage. The sources of funds are the National Budget, various funds and credit lines of EU, World Bank and European Bank, grants and, in a minor part, from local communities' own funds. In practice, the rule is that local communities finance preparing of design documentation which is then used as the basic data in applying for financial assistance from the above institutions. There are few towns and communities capable to finance autonomously development of costly infrastructure and they, as a rule, apply for assistance.

3. Initiative and decision-making

It is quite natural that local communities want modern water supply and sewerage, because this kind of infrastructure is the basic precondition for economic development and providing of healthy and safe service. Local authorities find on the market designing firms and employ them to prepare design documentation, financing this activity from the local funds which are generally very small and limited.

Most commissioners "know" what they need, and suggest to the designer beforehand the solutions which are normally in the domain of the engineers' competence. They select the sewer system, pipe material, equipment, size and appearance of plant buildings and operating premises. Knowing in advance that most of the funds will come from external sources, they act irresponsibly and unreasonably.

One of most frequent interventions is the chice of sewerage system. Because of previously built negligible part of sewerage in the center of the community, which is of combined type, all other parts of the community "must" be provided with combined sewerage, although this brings great problems to the user, regarding construction of waste water treatment plants, pumping stations, relieving and considerably higher costs of construction, operation and maintenance. Designers who suggest optimum solutions based on multicriteria analysis often have to face the authority of municipal leaders who make the final decision on their own. We have to confess that it is often the designers who suggest bad solutions, motivated by interest relations with their business partners in the field of assistance in designing of complex works, such as waste water treatment plants. It is indicative that commissioners, and often also the designers, have their favorites among manufacturers of pipe material and electromechanical equipment. This favorizing starts from concept solutions, and usually lacks professional founding.

To avoid possible confrontations and loss of time, the designers frequently agree beforehand with local authorities about design solutions, and in accordance with the agreement formulate the Terms of Reference themselves.

Implementation of the project is essentially dependent on the initiative and political activity of the representatives of local authorities. Some municipalities and towns are very active, well informed and persistent in implementation of their plans, while others look puzzled, uninformed and lack the basic knowledge on the way of financing and procedures of preparing of project documentation. In this disproportion of activities and absence of technical supervision, parts of regional projects are implemented in an illogical sequence, so that it happens that parts of the water supply network have nothing to connect to, because a part of the network in neighboring communities has not been implemented.

4. Planning and legislation

Water supply and sewerage in each community is specific to some extent, and these specific properties must be particularly respected during design preparation. However, there are rules and laws applying on the macro-level, and small local subjects are unable to apply them autonomously.

General guidelines and strategies of development of water supply and sewerage must exist in every County and in the country as a whole. On the basis of economic laws, geographic, climate, demographic and other properties of separate regions on one hand, and accepted and proved European and global technological solutions on the other; technical guidelines should be worked out which will help the professionals and the decision-makers to suggest and implement solutions sustainable according to all relevant criteria. One of constant poor practices in sewerage is the application of conventional systems of public sewerage regardless of the community size, the tendency to include a larger number of communities into the network, and oversizing of the waste water treatment plants.

Although almost all Counties have ready water pollution control plans, the fact remains that these studies incorporate designs commissioned and partly paid by local communities, which means that many bad solutions have been built into physical plans, serving as starting points for terms of reference. The major disturbing fact is that the relevant criteria have not been defined at the level of institutions in charge of the national strategy.

In water supply, the situation is better, because major regional water supply systems have been studied and designed for a number of years. One may object that frequently the desire to incorporate all communities into regional water supply systems results in solutions that are economically inadequate and accompanied by abandoning of local water sources that are carelessly declared as insufficient and substandard.

In addition to a number of problems requiring solution, we must also mention the problem of legislation regarding fire protection. The regulations on the network of fire-fighting hydrants (NN 8/06) does not recognize the category of village water supply are the reason why some water supply works in villages and hamlets are unjustifiedly oversized and too costly due to the required high outlet pressure and capacity of the hydrants. Everybody employed in water supply is aware of the problem, but nothing has been done so far.

Connecting of users to the municipal infrastructure is the problem in the country. Although there are legal standards prescribing that every user should have adequate access to water supply and sewerage, many low income users delay connecting and satisfy themselves with the present solutions, frequently sanitarily inadequate and hazardous to the environment. Poor and unorganized local communities simply lack the power to take any action, being aware of the poor economic potential of their population. There are cases that inhabitants of small communities use water from so-called village waterworks, illegally built by theit own funds. Due to considerably lower unit prices of water supply, local inhabitants do not get connected to the expensive public water supply system, although water they use is unhealthy (Hrvatsko Zagorje).

The projects submitted for review according to the requirements of potential co-investors are very hard to challenge, because in addition to passing the entire formal procedure they also meet the solutions from physical plans. As regards sanctioning all failures, except hydraulic and construction parameters, the project reviewer has no formal foothold.

5. Psychological and social aspects

In SFR Yugoslavia, the prevailing practice in allocation of investments for construction of municipal infrastructure was “take now what they give you, who knows when your turn will come next”. This practice is still present, and the projections of demands and development are being overestimated. Also, there is the attitude that the present generation of active population should tackle the problem to reach the “final solution”.

The phenomenon of “fascination” by the European Union and its high criteria is frequently the reason of misunderstanding the problem and unreasonable behavior. This is also the reason of unrealistic expectations of the population, mostly transferred from the political environment. At the same time, in a large part of the country the level of social awareness and general education is very low.

The greatest incentive to such behaviour is too large participation of “someone else’s” money, as well as the absence of the criterion that each community and each user should himself pay his costs.

6. Designers

The participants in designing are all firms meeting the basic legal requirements, from renowned firms with numerous staff, many years of practice and references, to authorized bureaus that are often unable to prepare the design without the assistance of external associates. With a few honorable exceptions, small firms often produce documentation that does not meet the minimum professional standards.

There were several cases that reviews following obtaining of the Construction Permit or Certificate of Consistence revealed fatal errors rendering the entire project impossible to implement or causing considerable functional flaws.

It may be said that the most frequent flaws in project documentation are the following:

- overestimated number of population – users for the planning period;
- overestimating of water supply standards and using of old planning data, which are in obvious discrepancy with measured data on consumption;
- inadequate knowledge on sewerage and waste water treatment technology;
- inadequate knowledge of hydraulics;
- poor designs of waste water treatment plants;
- uncritical relying on foreign owners of technology and manufacturers of waste water treatment equipment;
- evading of rules of profession under demands of the commissioner.

In the Republic of Croatia there are no general regulations and standards in the field of water supply and sewerage installations. Each designing firm follows its own “school” of design, reflected by the choice of material, shape of structures, construction technology and the method of preparing of project documentation. It is impossible to standardize and prescribe everything, but obviously the most important technical criteria should be concerted at the national level.

The Ministries have tried, by various directives, to bring order into the field of construction criteria and equipping of water supply and sewerage projects. The directives prescribe the kind of pipe material, required project basic data, maximum permissible percentages of contingency works, standards for preparing of tender schedules of prices.

Due to frequent cases of manipulation with costs of earthmoving works, where attempts to change the category of excavated material are made on a regular basis in order to increase the unit price, universal price of excavation is required, regardless of the type of soil and conditions of excavation, following field reconnaissance. The Ministry was forced to establish its own consulting and supervision, and manage the construction, because frequent abuse of funds was noticed when project implementation was managed by local communities.

6.1 Designing.

Planning of capacities is a demanding task which is hard to carry out without reliable input data. In planning of water supply capacities and sizes of water supply mains and sewerage systems it is logical to use longer planning periods, while for construction of waste water treatment plants this is not necessary. With available knowledge and technique in designing and construction, it is possible to adjust treatment capacities and technologies in five year steps. This means that in the first phase 2nd and 3rd stage of treatment may be designed according to the present status, in particular in communities that do not "promise" rapid development. Likewise, it is equally unreasonable to dimension pumping stations to capacities for 20-year planning period, when the operating life of a pump is 10 or 15 years.

According to three past censuses, the number of population in the majority of small communities has been continuously decreasing. This decrease is eveidently not the result of war events only, but also of inavoidable migration of population towards larger urban centers, with economic centers and potential employment and progress. In spite of that, no designer would project, for the planning period, the number of population lower than the data of the latest census. Another unacceptable fact is that phase planning of construction always assumes 100 percent connection to public installations, although it is evedent that this figure is considerably smaller, in particular as regards sewerage.

Even the smallest municipalities in their physical plans foresee industrial zones. Except the fact that such zones consist of reserved and often purchased cheap agricultural areas, there are practically no industrial or service facilities. Large reserved areas must be integrated into the water supply and sewerage system. Even at minimum demands, water requirements and waste water quantities are often several times higher than the requirements of the community itself. Therefore the projects are burdened by large capacities wihich will be very difficult to implement in future.

7. Recommendations

Free market economies do not tolerate government intervention and do not allow favorizing of equipment and material manufacturers or contractors. Still, there must be some instruments allowing a major investor to invest his funds in the optimum way into projects with expressed social component. There is some positive experience in reconstruction projects where the relevant Ministry has developed a number of technical standards and price lists by which the contracts were awarded on the free market. Large procurements of construction material and furniture were organized, at exceptionally favorable prices. Hrvatske vode have typical schedules of prices resulting from their own bulletin Average Standards for Hydrotechnical Works.

Priorities in project financing should be based primarily on real needs, and not on political influence. The existing list of criteria should be extended, both in the field of planning, designing and in the field of implementation. It is particularly important to set the guidelines for organization of water supply and sewerage in rural areas. Unfortunately, it must be stated that in the field of water supply and sewerage there is no competent professional institution or association to take care of formulation and acceptance of technical criteria. The government institutions of water management, expected to deal with all water-related problems, should not occupy themselves with trade, but care about the use of water resources and the water regime.

Cost estimates for material and works for typical water supply or sewerage networks differ a great deal from one part of the country to another. Excluding errors and very careless estimates, the fact remains that unit prices (checked on several implemented projects) in the same climatic and terrain conditions may differ by more than 30 percent. This is the result of the general economic status of the region where the works are carried out, organization of the firm, but also of informal distribution of the market between potential contractors. This also affects the efficiency of the investment and represents a certain drawback in project implementation, which should be reduced or eliminated.

The authors believe that the opportunity has been missed to define in detail the technical standards for designing and implementation of water supply and sewerage in projects financed or co-financed by government institutions.

Large savings might be achieved by financially more favorable contracts with suppliers of material and equipment (pipes, fittings, armatures, pumps, etc.) and, with a good control over the investment, contracts according to unit prices or turnkey contracts are possible.

The authors do not have sufficient relevant information regarding the quality of implemented works to be able to make qualified assessment. It may be said that, due to large demand on the market, a large number of firms have been established which are not able to carry out the works up to the required standards, and the effects of using of low quality material and inadequate construction techniques remain to be seen during operation.

8. Conclusion

It is bad when expensive funds are unrationally invested in projects. Enthusiasm, not founded on professional and economic knowledge, and encouraged by ficticious easiness of providing of the required funds, will prove very hard to pay through all kinds of negative aspects. On one side, poor technical solutions have been implemented, and on the other hand the communities which are economically completely unautonomous are given the assets for which they are not able to ensure operation, to say nothing about maintenance and loan repayment. Oversized investments reduce the funds for other projects, just like poorly managed investments. According to the authors, there are too many such solutions.

The authors see the reason of such situation in unpreparedness of relevant government bodies and institutions, high degree of populism and ignorance of economic laws in the municipal sector.

The right time for preparation has passed, but still there remains a lot that could be done to rationalize and improve the efficiency of investments in infrastructure projects. The complexity of the problem requires engagement of the profession, but first of all, political willingness.

9. Literature

85 reviews of project documentation of water supply and sewerage by investors and designers from Croatia. EIB I (Program of reconstruction of municipal infrastructure, 2004-2007) and EIB II (Integrated development of local community, 2005-2008). Both programs finance municipal and social infrastructure, and in addition, EIB II supports environmental infrastructure.

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Protection of Groundwater for Public Water Supply In Croatia

Key words: public water supply, groundwater protection, sanitary protection zones, strategic groundwater reserves

Introduction

Water is a unique, irreplaceable natural resource of limited quantities and uneven spatial and temporal distribution. Economic development and urbanization lead, on one hand, to a great increase in water demand and, on the other, to the endangerment of water resources and aquatic environment. Water can thus become a limiting factor to development and a threat to human health and sustainability of natural ecosystems.

Croatia belongs to a group of countries relatively abundant in water. Groundwater makes approximately 12% of total water quantities in Croatia, but participates in public water supply with about 90% of abstracted quantities.

In Croatia, there are 134 utility companies with concessions for public water supply. They use 479 abstraction sites of different types. The total capacity of all abstraction sites, in the periods of maximum utilization, is approximately 25,000 l/s.

According to the Water Act, abstraction sites used or reserved for water supply must be protected from pollution and intentional or accidental contamination and other impacts which can adversely influence health safety of waters or their yield. The main condition for implementation of abstraction site protection is the establishment and maintenance of water protection areas (sanitary protection zones). Protection is implemented in line with the Decision on the protection of water abstraction site, which is enacted on the basis of earlier performed water investigation works, and which defines the size and boundaries of the water protection area as well as protection measures and water monitoring within the protection zone.

The main legislation which governs groundwater management and protection in the Republic of Croatia is the Water Act, although it is not the only document which regulates groundwater protection. Other legislation (Environmental Protection Act, Waste Act, Physical Planning Act, Construction Act, Mining Act, etc.) also contains relevant provisions related to the areas covered by these laws which protect groundwater from negative impacts and activities.

The efficiency of regulations in terms of groundwater protection is based on prevention from future pollution and improvement of water quality through obligation to develop and implement restoration measures.

Main hydrogeological characteristics of aquifers

In Croatia, there are two main hydrogeological systems:

1. Aquifers formed in deposits of intergranular porosity within which there is laminar groundwater flow;
2. Karst aquifers of fracture – cavernous porosity within which, through fissures and canals of irregular shapes, dimensions and positions, laminar and turbulent groundwater flows take place.

The main hydrogeological characteristic of aquifers of intergranular porosity is a relatively long retention of water in the underground, which facilitates different physico-chemical reactions and microbiological processes which, in turn, influence the reduction of potential polluter concentrations in groundwater. This characteristic is known as self-purification or autopurification. Most autopurification occurs when water passes through fine-grained clayey-silty deposits through which, due to low porosity, water flows very slowly, with the resulting significant intensity of reaction processes. Simultaneously, due to small velocities of groundwater flow, a polluter which enters such aquifer remains within it for a long time, thus making restoration processes time-consuming, very expensive and of uncertain efficiency.

The main hydrogeological characteristic of aquifers of fracture – cavernous porosity are significantly higher velocities of groundwater flow and a lack of a thin aquitard, which facilitates a relatively easy, direct entrance of polluters into the underground and their transport to great distances in short periods, due to which natural filtration is almost non-existent and other purification processes almost negligible, so the reduction of polluter concentrations occurs only during mixing with clean water.

For the above stated reasons, groundwater quality cannot be equally protected in all areas.

Legal basis of groundwater protection

Protection of groundwater used in public water supply has a long tradition and has been legally regulated since mid-1980s.

The main condition for protection of abstraction sites is the establishment of a water protection area for each abstraction site and implementation of proscribed protection measures. The present legislation governing groundwater management and protection in the Republic of Croatia is the Water Act. It is the principal, although not the only document which regulates groundwater protection. Other legislation also contains provisions related to groundwater protection from negative impacts and activities that may be caused by actions proscribed by certain laws.

The document which is the basis of existing groundwater protection at the majority of water abstraction sites is the Regulation on protection measures and conditions for determination of sanitary protection zones for abstraction sites for drinking water from 1986. Although it established the basic principles of water protection in Croatia and in many respects improved groundwater protection in particular, this Regulation also had numerous shortcomings.

A major inadequacy of this Regulation is that it does not consider differences in hydrogeological characteristics of aquifers, which is particularly evident in case of determination of protection zones for abstraction sites in the karst. The specific nature of the karst is taken into account only in Art. 4, which reads: "In karst areas, due to specific characteristics of the karst terrain, the recharge area, size and boundaries of protection zones and regimes are determined on the basis of special hydrogeological and hydrological investigations." This means that there were no legal criteria for determination of sanitary protection zones, number of protection zones or protection measures within a zone. As a result, in practice it was quite frequent for some abstraction sites to be protected by three, even four or five protection zones, depending on the proposals put forth by investigators.

For abstraction sites in the Istrian county, protection zones were determined mostly by comparing hydrological analyses with interpreted hydrogeological structures. Compact catchment areas were assumed, within which three or four zones with different protection regimes were isolated.

For abstraction sites in the Primorje-Gorski kotar and the Zadar counties, within a catchment area four protection zones were determined on the basis of apparent velocities of groundwater flow and the time it takes water to flow to the abstraction facility. Along with the four basic degrees of protection, the so called "water protection reserves" were also determined, which also included mountainous areas as recharge and groundwater retention areas in the deep karst underground.

For abstraction sites in the Lika-Senj county, water protection areas were divided into three or four protection zones on the basis of apparent velocities of groundwater flow in the underground and hydrogeological characteristics of the terrain, with special emphasis on tectonics.

For abstraction sites in the Šibenik-Knin, Split-Dalmatia and Dubrovnik-Neretva counties, five protection zones were determined, mostly on the basis of velocities of groundwater flow in the period of high water levels. Along with dividing protection areas into five zones, the term "microzoning" was also introduced and enabled mitigation of the strictest prohibitions in the majority of protection areas.

Numerous difficulties also occurred during determination of sanitary protection zones for alluvial aquifers of intergranular porosity due to a series of deficiencies in the mentioned Regulation, which assumed ideal protection and did not consider differences in the natural conditions and actual economic developments in the area where an aquifer was located. Solutions for this aquifer type were also regularly looked for in the transitional provisions (Art. 24), which allowed definition of protection zones by means of additional investigations (in nearly 85% abstraction sites in the river basins of the Sava, Drava and Danube rivers).

An additional problem in the determination of protection zones for abstraction sites in alluvial aquifers occurred when determining protection zone III, which, according to the Regulation, should include the area from the boundary of the recharge area to the external boundary of zone II. In case of large recharge areas of abstraction sites, protection zones III. A and III. B were determined, where zone III. A was frequently limited, according to the Regulation, to 2 km from the location of the abstraction site, with the exception of some abstraction sites where zone III. A was limited to one-year or three-year water retention in the horizontal flow. The boundary of protection zone III. B was determined either by depression cone at maximum yield of the abstraction site or by water retention time in the horizontal flow to the wells, which is most frequently a 30-year period of water retention in the aquifer. At some abstraction sites, zone III. B included the entire stretch of the river by which the abstraction site was located. An example of this is zone III. B of the abstraction sites in Požega, located in the alluvium of the Orljava river, where protection zones of two abstraction sites with the total yield of about 95 l/s cover 25 % of the entire area of the Požega-Slavonia county.

Through long-term implementation of abstraction site protection, shortcomings of the mentioned Regulation were identified and in 2002 the new Regulation on determination of sanitary protection zones was enacted (OG 55/02). The new Regulation and the associated guidelines attempted to define more clearly thw criteria for determination of protection zones and also take into account the specific nature of karst areas and areas with aquifers of intergranular porosity.

Among the novelties introduced in this Regulation is the provision which stipulates that individual protection zones should be defined on the basis of hydrogeological and hydrological characteristics of the aquifer, which means taking into account aquifer type with regards to thickness and porosity of the aquitard, manner and size of aquifer recharge, velocity of groundwater flow towards the abstraction site and purification characteristics of the aquitard and the aquifer. Integral part of the determination of protection zones is also development of the polluter register, analysis of water quality in terms of natural quality and anthropogenic impact, technical description of water abstraction facility and proposal of pumping rate for the abstraction site. Especially important is the presentation of data in the GIS format, which enables optimal land management.

The largest improvement in relation to the old Regulation, along with passive protection, is implementation of active protection of the abstraction site within the determined boundaries of the zone. Passive protection of the abstraction site is comprised of the measure of prohibition of construction and positioning of certain structures as well as performance of certain activities within a determined zone. Active protection of the abstraction site is comprised of regular monitoring of water quantity and water quality in the recharge area and implementation of measures for its improvement.

The new Regulation takes particularly into consideration protection, i.e. protection zones and protection measures for intergranular aquifers and karst aquifers. In case of aquifers of intergranular porosity, up to three protection zones are determined. In case of karst aquifers, four protection zones are determined and, due to specific characteristics of the karst, several criteria are applied – time, velocity and recharge quantity of the abstraction site. Due to high velocities of groundwater flows and short time of water retention in the underground, it is impossible to provide a criterion which would cover overall protection from pollution, thus the stated criteria have the purpose of grading space into zones with the aim to assess the time necessary for intervention at the abstraction site in case of accidental pollution in the recharge area; in other words, recharge quantity of the abstraction site becomes a relevant factor in terms of pollution consequences.

Protection measures according to the allowed limits are determined within the protection zones. Protection measures also contain the programme and the priority list for restoration in certain zones. Restoration is particularly significant for protection and even improvement of water quality at abstraction sites.

In the karst areas, a possibility of microzoning is introduced for potential implementation of projects which are not allowed within a certain zone. Smaller locations are researched through detailed, targeted water investigation works. Based on obtained results, the suitability of terrain for implementation of the proposed project is determined as well as protection measures.

Water protection areas determined in such manner enable a much higher level of flexibility in terms of land use, while active approach ensures higher efficiency of protection measures.

The new Regulation stipulates a five-year deadline for novation of the existing zones according to the new proscribed criteria.

Present state of groundwater protection

Of the total 479 water abstraction sites used in water supply according to the provisions of the Regulation on protection measures and conditions for determination of sanitary protection zones for abstraction sites for drinking water from 1986, protection zones are determined and enacted for 301 abstraction sites, which means that groundwater used in 62.8% abstraction sites is protected in some manner. For 20 abstraction sites proposals of protection zones were made, but decisions were not reached for various reasons (4.2%). The remaining 158 abstraction sites (31.5%) are not protected as proscribed by the law (Table 1).

Table 1 – Overview of protection of abstraction sites per river basins

RIVER BASIN		ABSTRACTION SITE		OLD REGULATION			NEW REGULATION		
		Number	MAXIMAL YIELD	DECISION	PROSAL	NO	DECISION	INITIATED PROCEDURE	NO
BLACK SEA BASIN	PANONIAN BASIN	250	21.258,30	151	6	93	72	40	138
		52,2%	43,6%	60,4%	2,4%	37,2%	28,8%	16,0%	55,2%
	KARST AREA	67	2.429,60	58	2	7	46	2	19
		14,0%	5,0%	86,6%	3,0%	10,4%	68,7%	3,0%	28,4%
ADRIATIC BASIN	INLAND	124	24.794,00	73	11	40	51	2	71
		25,9%	50,8%	58,9%	8,9%	32,3%	41,1%	1,6%	57,3%
	ISLANDS	38	280,00	19	1	18	12	5	21
		7,9%	0,6%	50,0%	2,6%	47,4%	31,6%	13,2%	55,3%
TOTAL		479	48.761,90	301	20	158	181	49	249
		100,0%	100,0%	62,8%	4,2%	33,0%	37,8%	10,2%	52,0%

If protection priorities are analyzed, and having in mind that abstraction sites have different yields, it is evident that during determination of protection zones the priorities were not defined, which primarily means that abstraction sites with the highest yield were not protected (Table 2).

Table 2 – Overview of protection of abstraction sites per yield

					OLD REGULATION			NEW REGULATION		
YIELD (l/s)	Number	%	Q_{max} (l/s)	%	YES	PROPOSED ZONES	NO	YES	INITIATED PROCEDURE	NO
0,0 - 5,0	125	26,10	387,00	0,79	70	2	53	47	7	71
					56%	2%	42%	38%	6%	57%
5,1 - 10,0	87	18,16	718,40	1,47	52	2	33	35	3	49
					60%	2%	38%	40%	3%	56%
10,1 - 25,0	103	21,50	1.816,50	3,73	69	5	29	47	12	44
					67%	5%	28%	46%	12%	43%
25,1 - 50,0	51	10,65	1.947,00	3,99	29	5	17	15	7	29
					57%	10%	33%	29%	14%	57%
50,1 - 100,0	42	8,77	3.274,00	6,71	34	1	7	16	7	19
					81%	2%	17%	38%	17%	45%
100,1 - 200,0	20	4,18	2.986,00	6,12	13	1	6	6	3	11
					65%	5%	30%	30%	15%	55%
200,1 - 500,0	29	6,05	10.043,00	20,60	18	4	7	7	7	15
					62%	14%	24%	24%	24%	52%
500,1 - 1.000,0	13	2,71	9.840,00	20,18	10	0	3	5	2	6
					77%	0%	23%	38%	15%	46%
1.000,10 -	9	1,88	17.750,00	36,40	6	0	3	3	1	5
					67%	0%	33%	33%	11%	56%
TOTAL	479	100,00	48.761,90	100,00	301	20	158	181	49	249
					63%	4%	33%	38%	10%	52%

Priority was also not given to abstraction sites whose recharge areas are located in naturally vulnerable areas.

Direct protection of groundwater is implemented through the Decisions on the protection of the abstraction site, which are enacted by local self-government units. According to the Regulation on determination of sanitary protection zones from 2002, local self-government units are responsible for implementing novations of the "old" decisions on protection within a five-year period.

Looking at the present state per counties, it is evident that there are very different approaches to implementation of the provisions from the said Regulation. While some counties have completely fulfilled their obligations, others have done nothing (Table 3).

Table 3 – Overview of protection of abstraction sites per counties

COUNTY	ABSTRACTION SITE				OLD REGULATION			NEW REGULATION		
	Number	%	Q_{max} (l/s)	%	YES	ZONE	NO	YES	PROCEDURE	NO
BJELOVARSKO-BILOGORSKA	14	2,92	178,50	0,37	8	0	6	1	3	10
					57,14%	0,00%	42,86%	7,14%	21,43%	71,43%
BRODSKO-POSAVSKA	16	3,34	1.902,50	3,90	11	0	5	3	1	12
					68,75%	0,00%	31,25%	18,75%	6,25%	75,00%
DUBROVAČKO-NERETVANSKA	24	5,01	9.398,00	19,27	1	3	20	0	5	19
					4,17%	12,50%	83,33%	0,00%	20,83%	79,17%
ISTARSKA	27	5,64	2.069,00	4,24	27	0	0	27	0	0
					100,00%	0,00%	0,00%	100,00%	0,00%	0,00%
KARLOVAČKA	28	5,85	1.977,50	4,06	19	2	7	1	2	25
					67,86%	7,14%	25,00%	3,57%	7,14%	89,29%
KOPRIVNIČKO-KRIŽEVAČKA	6	1,25	1.135,00	2,33	4	2	0	4	2	0
					66,67%	33,33%	0,00%	66,67%	33,33%	0,00%
KRAPINSKO-ZAGORSKA	18	3,76	419,70	0,86	9	0	9	3	3	12
					50,00%	0,00%	50,00%	16,67%	16,67%	66,67%
LIČKO-SENJSKA	26	5,43	1.313,00	2,69	17	0	9	13	0	13
					65,38%	0,00%	34,62%	50,00%	0,00%	50,00%
MEĐIMURSKA	3	0,63	822,00	1,69	3	0	0	3	0	0
					100,00%	0,00%	0,00%	100,00%	0,00%	0,00%
OSJEČKO-BARANJSKA	25	5,22	1.437,50	2,95	16	0	9	9	10	6
					64,00%	0,00%	36,00%	36,00%	40,00%	24,00%
POŽEŠKO-SLAVONSKA	27	5,64	360,50	0,74	20	0	7	0	0	27
					74,07%	0,00%	25,93%	0,00%	0,00%	100,00%
PRIMORSKO-GORANSKA	82	17,12	6.439,60	13,21	82	0	0	68	0	14
					100,00%	0,00%	0,00%	82,93%	0,00%	17,07%
SISAČKO-MOSLAVAČKA	13	2,71	781,00	1,60	6	1	6	1	3	9
					46,15%	7,69%	46,15%	7,69%	23,08%	69,23%
SPLITSKO-DALMATINSKA	23	4,80	5.599,50	11,48	6	4	13	0	0	23
					26,09%	17,39%	56,52%	0,00%	0,00%	100,00%
ŠIBENSKO-KNINSKA	12	2,51	2.038,00	4,18	4	2	6	1	0	11
					33,33%	16,67%	50,00%	8,33%	0,00%	91,67%
VARAŽDINSKA	10	2,09	987,00	2,02	9	1	0	0	4	6
					90,00%	10,00%	0,00%	0,00%	40,00%	60,00%
VIROVITIČKO-PODRAVSKA	10	2,09	446,00	0,91	4	2	4	3	4	3
					40,00%	20,00%	40,00%	30,00%	40,00%	30,00%
VUKOVARSKO-SRIJEMSKA	57	11,90	1.517,50	3,11	31	1	25	22	6	29
					54,39%	1,75%	43,86%	38,60%	10,53%	50,88%
ZADARSKA	20	4,18	2.299,00	4,71	2	5	13	0	2	18
					10,00%	25,00%	65,00%	0,00%	10,00%	90,00%
ZAGREBAČKA	31	6,47	3.416,10	7,01	18	1	12	15	3	13
					58%	3%	39%	48%	10%	42%
ZAGREB	7	1,46	4.225,00	8,66	4	3	0	7	0	0
					57%	43%	0%	100%	0%	0%
TOTAL	479	100,00	48.761,90	100,00	301	27	151	181	48	**250**
					63%	6%	32%	38%	10%	**52%**

Water protection areas (declared and proposed) now cover about 19% of Croatian territory (Table 4). A particularly large surface included in the protection zones is located in the karst, where it covers about 40% of the territory (Fig. 1). It should be noted that for a large number of water abstraction sites the boundaries of the protection zones have not yet been determined. Considering the size of protection areas for public water supply, there are already conflicts regarding land use, and they are expected to increase in the future.

Therefore, it is now the right time to start thinking about a new approach to groundwater protection, particularly in the karst. It will be necessary to elaborate, legally regulate and gradually implement a methodology for definition of vulnerability of karst aquifers, especially in areas with already existing problems.

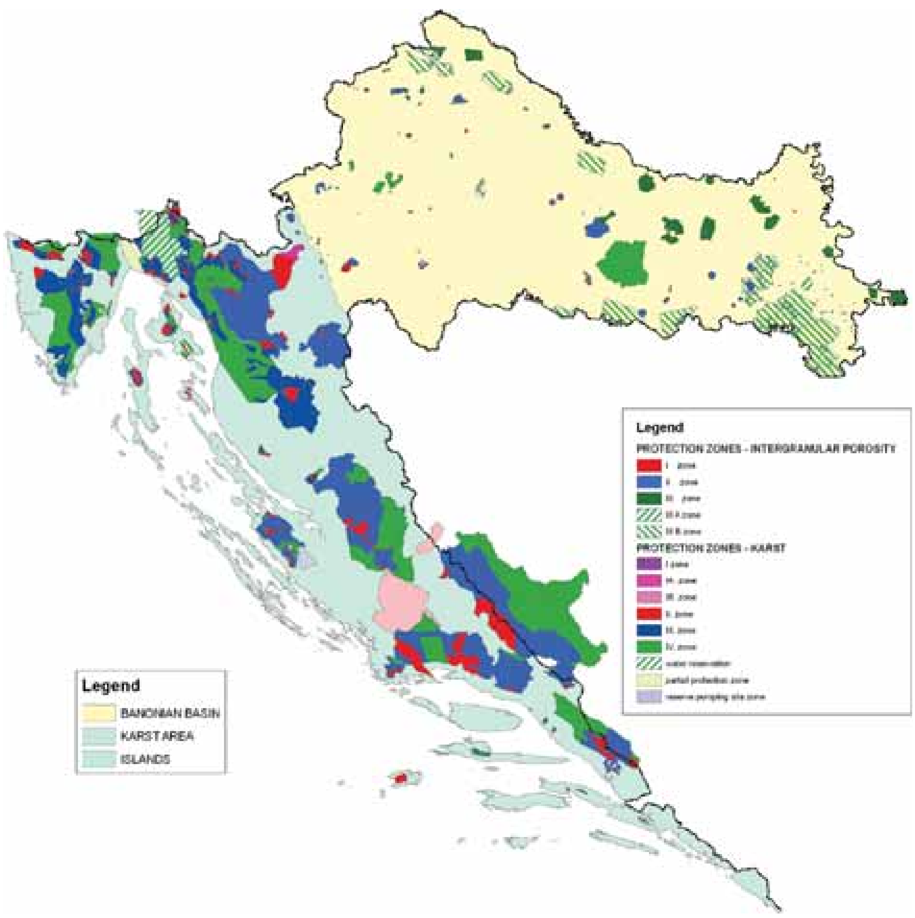

Fig. 1 – Spatial distribution of protection zones

Table 4 – Surfaces of sanitary protection zones for public water supply

Area	Declared	Proposed	Total	% of area surface
		km^2		
Save river basin	1.490	108	1.598	6
Drava and Danube river basin	409	50	459	5
Black Sea basin	**1.899**	**158**	**2.057**	**6**
Littoral-Istrian basins	3.342	206	3.548	40
Dalmatian basins	1.854	3.143	4.997	40
Adriatic Sea basin	**5.196**	**3.349**	**8.545**	**40**
Croatia	**7.095**	**3.507**	**10.602**	**19**
Outside Croatia			3.176	
Total			13.778	

Based on all that has been said earlier, it can be concluded that protection of groundwater as one of the most valuable natural resources in our country, for which the establishment of protection zones for abstraction sites is the main condition, must be given a much higher importance than it has today.

Groundwater quality

Groundwater quality in alluvial aquifers of the Pannonian basin is determined by the manner of sedimentation of deposits, thickness of poorly permeable aquitards and, in some areas, anthropogenic influences (Fig. 2).

In the westernmost part of the Drava alluvium, the aquifer is covered by relatively thin silty-clayey deposits, which is the reason why vulnerability of this shallower aquifer to pollution from the surface is exceptionally great. Consequently, in some areas there are increased nitrate concentrations in water. Groundwater from another aquifer in the area is of relatively good quality.

In the central and eastern part of the Drava river basin, due to a significant thickness of the aquitard, vulnerability to aquifer pollution is much lower and groundwater quality from the aquifer is mostly satisfactory. However, reductive conditions generally dominate in these areas, which

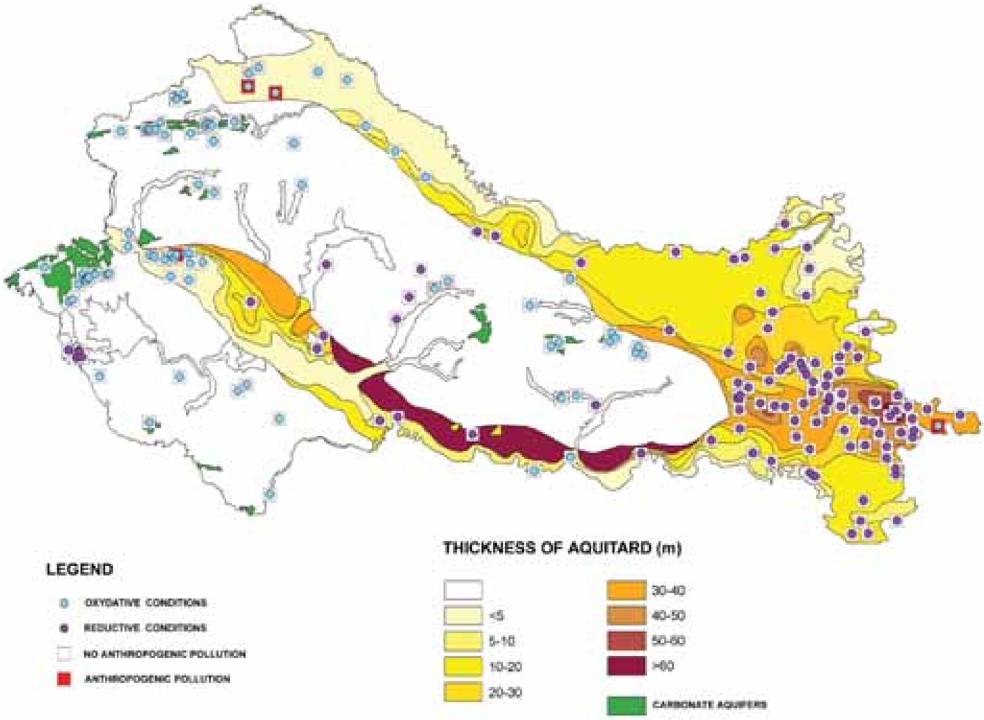

Fig. 2 – Groundwater quality in the Pannonian basin

is the reason why groundwater naturally contains high concentrations of iron and associated elements (manganese, ammonium, arsenic, etc.).

Groundwater from the Upper Triassic carbonate aquifers of the Pannonian basin is characterized by exceptionally good quality. Since their recharge areas are located in mostly unpopulated, forest-covered mountains, aquifer exposure to pollution is virtually non-existent.

Groundwater in the alluvial aquifer in the western part of the Sava river basin, including the City of Zagreb area, contains high concentrations of parameters indicative of anthropogenic pollution of groundwater, with consequential high aquifer vulnerability to pollution due to an exceptionally thin aquitard and numerous polluters in the area.

Groundwater quality downstream generally reflects changes in oxidative and reductive conditions in the underground, causing water in some places to contain increased concentrations of iron, manganese and associated parameters.

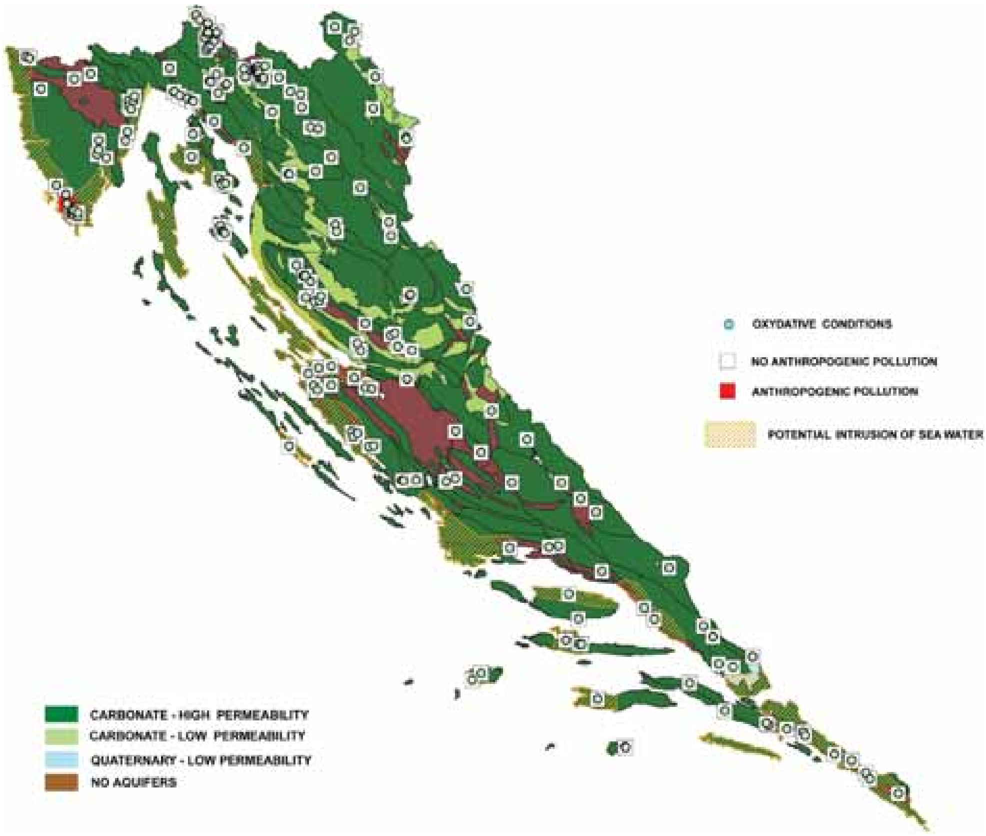

Fig. 3 – Groundwater quality in the karst area

The natural composition of karst groundwater (Fig. 3) is of exceptionally good quality, particularly in the spacious systems of Gorski kotar, Lika and Dalmatian hinterland where entire recharge areas are located in Croatia. There is generally a problem of water salinization in some coastal springs and the appearance of short-term water turbidity and bacteriological pollution in the periods of high water levels, particularly after long dry periods.

In cases where natural water quality does not satisfy the parameters proscribed by the Regulation on health safety of drinking water, water conditioning / purification is carried out. In the Black Sea basin, conditioning is mostly applied for reduction of the contents of iron, manganese, ammonium and arsenic. In the Adriatic Sea basin, water from the karst underground is mostly used for public water supply without purification, although with obligatory disinfection.

A generally good groundwater quality, which in all public water supply systems fulfils health safety requirements for drinking water, is to the largest degree due to the protection system which was established several decades ago in Croatia.

Future activites in groundwater protection

The analysis of positive and negative experiences in groundwater protection, which already has a tradition of several decades, in relation to the recent land use demand caused by accelerated development, the expected increase in water demand for various uses and Croatia's obligations in the EU accession process, shows that novation of legislation is necessary for facilitation of efficient groundwater protection under the new circumstances.

Generally speaking, the reasons why it is necessary to novate the Regulation on determination of sanitary protection zones for abstraction sites (OG 55/02) can be divided into several groups:
- inaccuracies and deficiencies of the Regulation;
- necessary harmonization with the requirements of the EU Water Framework Directive; and
- requirements derived from the Water Management Strategy.

Inaccuracies and deficiencies of the present Regulation

The experience in implementing the Regulation on determination of sanitary protection zones for the abstraction sites proved inaccuracies and deficiencies in terms of insufficiently clear definition of the procedures and obligations in implementation of the novation procedure for protection zones. The guidelines do not offer clear criteria for the definition of boundaries of certain zones as well.

In terms of the novation procedure, the obligations related to implementation of some planned phases of the procedure, financing in particular, are not clearly proscribed, which, as a consequence, leads to different interpretations of the implementation procedure and to the situation where in some counties virtually no obligations have been fulfilled to date. With regards to the penalty clauses, the procedure is also not accurately defined, which may be a partial reason for failure to fulfil the obligations.

In the Regulation, the procedure is also not clearly proscribed for cases where water abstraction sites did not have defined boundaries of protection zones even according to the Regulation from 1986, which is probably the reason why very little has been done for protection of these abstraction sites.

In professional terms, the Regulation and the guidelines for its implementation do not give a clear definition of the criteria for determination of boundaries of individual zones, which primarily relates to the following:

- inaccurate criteria for definition of boundaries for zone III of aquifers of intergranular porosity;
- multiple criteria for determination of boundaries of karst aquifers;
- insufficiently accurate definition of the term "microzoning" and the possibilities of its implementation,

as well as a series of minor inaccuracies which cause numerous problems in the practice.

The Regulation introduces the obligation to develop the polluter register within the recharge area of the abstraction site. However, what is meant by the terms "polluter" or "potential polluter" is nowhere accurately defined. There is a similar lack of definition of how their attributes are described, although the obligation exists for their registering and processing in the GIS technology.

One of the major deficiencies of the Regulation is undefined minimum investigation scope for determination of sanitary protection zones, particularly with regards to water quality status of the abstraction site, which very often results in too extensive requirements for additional investigations.

Harmonization of Croatian legislation with requirements of the EU Water Framework Directive

The enactment of the EU Water Framework Directive in 2000 and a series of associated directives requires amendments of Croatian legislation in the field of groundwater protection as well.

This primarily applies to the obligation of determination of areas at risk of failure to preserve good groundwater status, both in terms of water quantity and quality. This requires different planning and establishment of groundwater monitoring in recharge areas of the abstraction sites for public water supply as well as a new method of planning and initiation of restoration measures as a direct consequence of monitoring results.

The European legislation puts special emphasis on utilization and protection of transboundary aquifers. Since this protection takes place in the framework of bilateral cooperation with the neighbouring countries which may have different criteria for determination of protection zones, it is necessary to legally provide for determination of the protection zones on the basis of mutually agreed criteria for protection of transboundary aquifers, even if they are in some ways different from the proscribed national criteria.

Requirements derived from the Water Management Strategy

The enactment of the Water Management Strategy by the Parliament of the Republic of Croatia introduces numerous novelties in terms of groundwater use and protection.

This primarily relates to the introduction of the term “strategic groundwater reserves”.

Based on information about numerous areas in Croatia with no significant water resources, uneven spatial distribution of aquifers with large yields and their vulnerability to different kinds of pollution as well as assessment of future water demands lead to the need for definition of strategic groundwater reserves for purposes of long-term provision of water supply on the entire Croatian territory. These areas are the basis of already existing, but particularly of future water supply in Croatia, and there is no alternative to their preservation for future generations.

Strategic reserves are defined on the basis of existing level of investigation into groundwater, knowledge about reserves and quality of water in certain areas, level of their present use and their significance for present and future water supply, primarily according to potentials of their protection on the territory of the Republic of Croatia.

Due to differences in natural water quality in certain areas, present level of use, natural vulnerability of areas in which they are located and pressures on such areas as well as priorities and possibilities of protection in

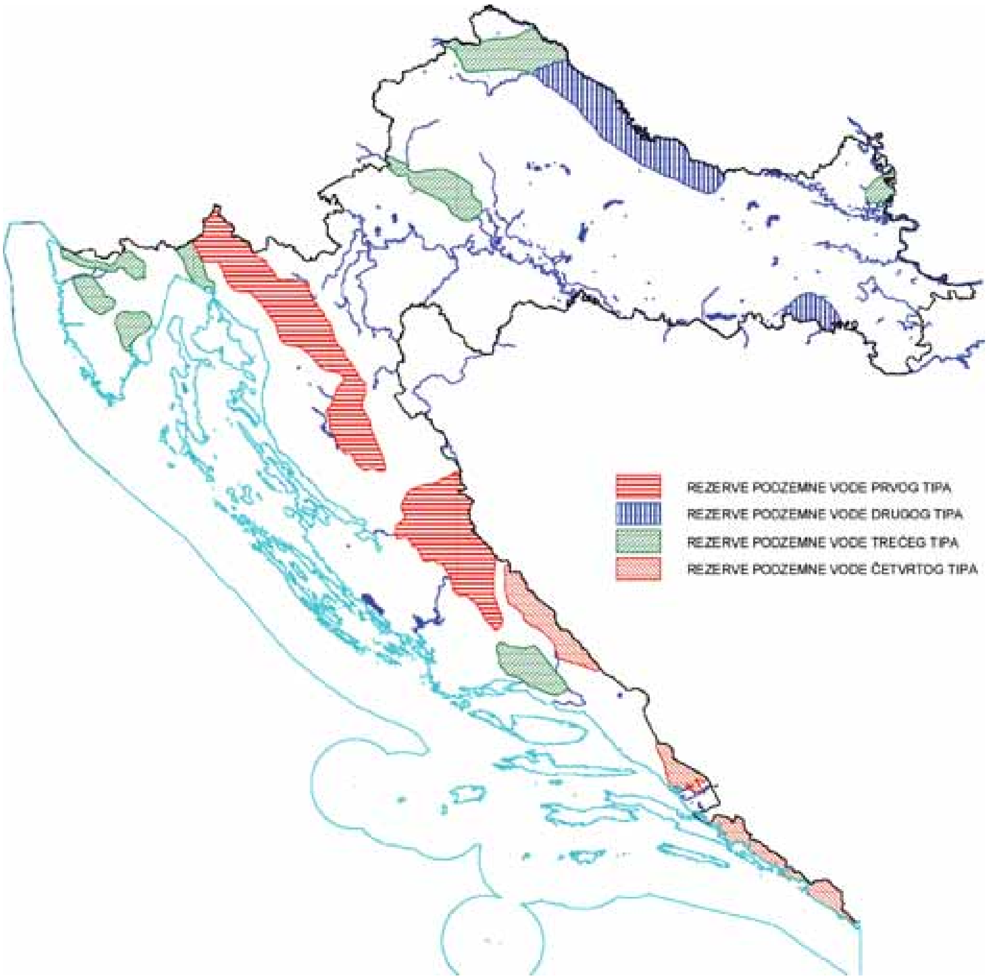

Fig. 4 – Strategic groundwater reserves in Croatia

some areas, strategic groundwater reserves are divided into four types (Fig. 4):

- The first type is comprised of waters from the karst area (Gorski kotar, Lika and Dalmatian hinterland), whose entire recharge areas are located in Croatia. They are characterized by very high quality of groundwater and very low level of use.
- The reserves of the second type are comprised of waters from alluvial aquifers in the valleys of the Sava and Drava rivers, whose natural

quality is slightly lower and the level of use relatively low. Due to intensive land use in areas in which they are located, they are significantly more difficult to protect.

- The third type of groundwater reserves are waters from areas where water is intensively, somewhere even maximally used, due to which its quality is gradually deteriorating. There is a danger that a part of these waters will be excluded from future water supply due to deteriorated quality, so special attention has to be paid to protection and restoration of these areas.
- The fourth type of reserves are water-abundant areas in southern Croatia, where water quality is good, but where recharge areas are mostly outside Croatian borders, which makes it difficult or impossible to actively protect its quality in the future.

The level of investigation in areas where strategic reserves are located is not the same everywhere, so the boundaries of individual areas are not equally accurately defined. The new legislation should find optimal solution for their protection in order to ensure that the quality of groundwater is preserved for future generations.

In Croatia, there are hundreds of so called “local water supply systems” whose water is used without quality control. The Water Management Strategy anticipates the inclusion of these small systems into existing water supply systems or, in the future, into grouped water supply systems. Since these generally small systems have their own abstraction sites which will be physically impossible to connect with larger systems, it means that these abstraction sites will continue to be used. The inclusion of these new abstraction sites into existing system of water supply also means the obligation of their protection, i.e. determination of their protection zones.

A large increase in the number of abstraction sites without decisions on the protection zones will deteriorate the already not great situation with regards to the percentage of protected abstraction sites for public water supply. Since the present Regulation requires time-consuming determination of sanitary protection zones for each abstraction site, which also means large human capacities and expenses, the task of the new legislation would be to define optimal methodology for protection of such abstraction sites as well as the method for definition of priorities in order to protect groundwater quality at these abstraction sites before it is too late.

Conclusion

Protection of groundwater as one of the most valuable natural resources in our country, for which the establishment of protection zones for the abstraction sites is the main condition, must be given a much higher importance than it has today.

Indications of climate changes, the ever increasing use of groundwater for different purposes, and particularly the expected increase in water demands in the near future on one hand and much higher pressures from different land users on the other require integrated approach to groundwater management in order to enable sustainable development. Water supply, and thus also protection of groundwater used in it, should remain an absolute priority.

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New Approach to Groundwater Protection in Croatia According to the Requirements of EU Directives and Guidelines

Introduction

By adopting the Water Framework Directive, WFD, (2000/60/EC) in December 2000, the concept of managing the water resources in Europe has significantly been changed. The Directive stipulates that water resources should be managed in an integral way, at the level of river basins. Until 2015, all the Member States of the European Union must take maximal possible measures concerning their water resources in order to satisfy the standards prescribed by the Directive. However, within the discussions carried out while adjusting the final text of the WFD, it turned out that in the EU Member States there were very different conceptual approaches to groundwater protection. For that particular reason in the final text of the Directive, in Article 17, the European Commission is requested to propose the special measures for the protection and control of groundwater pollution in the frame of the new Groundwater Directive (GWD).

The new Directive of the European Parliament and of the Council (2006/118/EC) on the protection of groundwater against pollution and deterioration has been adopted on 12th December 2006.

This paper will give details on the groundwater policy framework and environmental objectives of the new GWD. Furthermore, issues tackled jointly by the WFD and new GWD and the concept of homogeneity applied to groundwater bodies will be elaborated. Also, the significance of the natural background values and threshold values related to the definition of chemical state of groundwater will be explained. Finally, the provisions of the Water Framework Directive in relation to the drinking water protected areas will be highlighted.

Groundwater policy framework

Groundwater is an important natural resource, which is mainly used for drinking water, industry and agriculture. It has also a high environmental value as it interacts with surface waters and wetlands, and thus represents a key part of the water cycle, which should be protected.

Different hydrogeological conditions exist in different regions of Europe, and also diversity of uses and multiple pressures and impacts pose a threat to groundwater quality and quantity. Groundwater is the most sensitive and the largest body of freshwater in the European Union and, in particular, also a main source of public drinking water supplies in many regions.

To reduce the uncertainty in predictions of groundwater quality status determination and to enhance the conceptual understanding of the groundwater bodies and its interactions with receptors, it is important to quantify the risk to groundwater bodies that may influence its status. The risk depends on the pollutants of concern, the nature of the groundwater bodies or the groundwater vulnerability and the nature and susceptibility of the receptors.

In the above context, a groundwater policy framework has been deemed necessary and developed at the end of the 1970's as Directive 80/68/EEC [1] on the protection of groundwater against pollution caused by certain dangerous substances. This Directive provides a protection framework by preventing the direct discharge of high priority pollutants (List I) and subjecting the discharge of other pollutants (List II) to an authorisation procedure preceded by a thorough investigation on a case-by-case basis. Monitoring is required only for those specific cases of authorisation and is not generally required for all groundwater bodies.

At first sight, it appears that the Directive 80/68/EEC ensures a stringent groundwater protection regime against pollution for all activities that present a risk of groundwater deterioration through direct or indirect discharges of a wide range of pollutants. The implementation of this Directive is, however, sometimes faced with the difficulties of a lack of groundwater quality data and objectives. In other words, infringement cases may be difficult to judge in some instances in the absence of clear information on background groundwater quality levels in the zone affected by discharges, and of quality objectives on the basis of which deterioration may unambiguously be identified [2].

Directive 80/68/EEC will be repealed in 2013 under the Water Framework Directive (2000/60/EC) [3], after which the protection regime should be continued through the WFD and the new GWD. While the WFD provides a general framework for groundwater protection, clear criteria regarding the definition of groundwater environmental quality objectives, and in particular good chemical status, were lacking.

In addition, specific measures to prevent and control groundwater pollution were needed. This was recognised when the WFD was agreed to the extent that Article 17 of that Directive requested the European Commission to come forward with a new groundwater directive proposal to address these needs.

Environmental objectives of the new groundwater directive

Directive of the European Parliament and of the Council on the protection of groundwater against pollution and deterioration (2006/118/EC) [4], has been adopted by European Commission in December 2006, hence an obligation in Article 17 of the Water Framework Directive (WFD) was fulfilled. This Directive requires the European Commission to propose specific measures to prevent and control groundwater pollution and to achieve good groundwater chemical status.

This Directive is designed to prevent and combat groundwater pollution. Its provisions are (figure 1):

- to establish common criteria and procedure for the assessment of good groundwater chemical status for groundwater bodies based on:
  - a groundwater quality standards for pollutants listed in Annex 1 of this Directive, where Community standards exist: these pollutants are nitrates and active substances in pesticides, including their relevant metabolites, degradation and reaction products;
  - threshold values of pollutants and indicators which contribute to the characterisation of GW bodies being at risk, to be established by Member States at the appropriate level (national, river basin or groundwater body), depending on the variations of natural groundwater conditions, identified pressures and related chemical substances; at the very least, this must include ammonium, arsenic, cadmium, chloride, lead, mercury, sulphate, trichloroethylene and tetrachloroethylene;

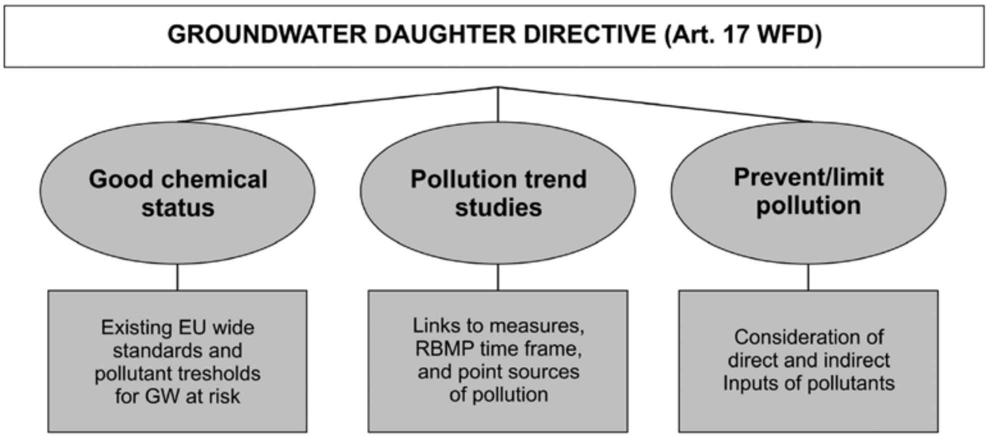

Fig. 1 – The main provisions of Groundwater Directive (2006/118/EC)

- to establish criteria for identifying significant upward trends in pollutant concentrations in groundwater and defining starting points for reversing these trends; Member States must establish a monitoring programme in conformity with Annex IV to this Directive;
- to establish measures for preventing or limiting direct – and particularly indirect – inputs of pollutants into groundwater; the programme of measures drawn up for each river basin district under the WFD must include preventing indirect discharges of all pollutants, in particular those hazardous substances mentioned in Points 1 to 6 of Annex VIII to the WFD (List I of Directive 80/68/EEC), as well as the substances mentioned in Points 7 to 9 of the Annex (List II of Directive 80/68/EEC), when deemed to be hazardous. Furthermore, pollutants not listed as hazardous must also be limited if they pose a real or potential risk of pollution.

Issues tackled jointly by the water framework directive and new groundwater directive

The Water Framework Directive and new Groundwater Directive (2006/118/EC) adopt specific measures to prevent and control groundwater pollution as shown on figure 2.

Assessment of the chemical status for the groundwater bodies being at risk of failing the environmental quality objectives for groundwater is

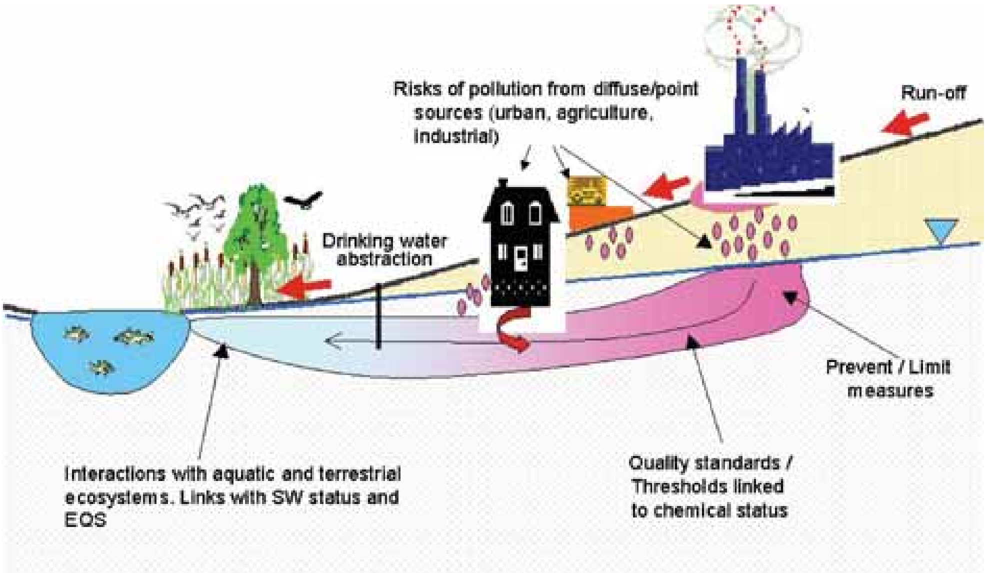

Fig. 2 – Measures to prevent and control groundwater pollution according to the WFD and the new GWD

based on groundwater (environmental) quality standards and threshold values of pollutants and indicators of pollution.

To define threshold values it is necessary to take into account:

- extent of interactions between groundwater and associated aquatic/terrestrial ecosystems;
- interference with actual or potential legitimate use or functions of groundwater;
- all pollutants characterising GW bodies as being at risk;
- hydrogeological characteristics including on background levels and water balance.

It is important to emphasize that threshold values need to be established for all pollutants and indicators of pollution, which characterise bodies of groundwater as being at risk.

Identification of significant and sustained upward trends is needed for every pollutant, group of pollutants or indicators of pollution found in bodies or groups of bodies of groundwater identified as being at risk. Starting point for implementing the reversal measures is required when pollutant concentrations reach 75% of the values of GW quality standards and threshold values.

Measures to prevent or limit inputs of pollutants into groundwater should be established in accordance with the article 4 of the WFD, which requires use of all measures necessary to prevent inputs into groundwater of any hazardous substances, or to limit inputs into groundwater of non-hazardous substances, which present an existing or potential risk of pollution.

Groundwater is considered to have a good chemical status when:

- measured or predicted nitrate levels do not exceed 50 mg/l, while those of active pesticide ingredients, their metabolites and reaction products do not exceed 0.1 μg/l (a total of 0.5 μg/l for all pesticides measured);
- the levels of certain high-risk substances are below the threshold values set by Member States; at the very least, this must include ammonium, arsenic, cadmium, chloride, lead, mercury, sulphate, trichloroethylene and tetrachloroethylene;
- the concentration of any other pollutants conforms to the definition of good chemical status as set out in Annex V to the Water Framework Directive
- if a value set as a quality standard or a threshold value is exceeded, an investigation confirms, among other things, that this does not pose a significant environmental risk.

If measured concentrations of substances exceed groundwater standards or threshold values, an appropriate investigations are needed to confirm that plume of pollution in subsurface:

- present no significant environmental risk to associated terrestrial or aquatic ecosystems;
- do not significantly impair the ability of groundwater body to support human uses and
- do not significantly change the chemical composition of groundwater, which would be regarded as intrusions.

Then, the use of groundwater modeling may be necessary to quantify the principal transport processes and attenuation mechanisms in contaminant migration like advection, longitudinal and transverse dispersion, molecular diffusion, decay, sorption etc.

Concept of homogeneity applied to groundwater bodies

As a result of non-regulated EU and national legislation on indirect discharges of pollutants into groundwater, it might be expected that many historical point pollution sources could have a deteriorating influence on groundwater quality. This seems to be a very serious problem, particularly in the urban areas where the multiple pressure impacts and pollution indicators of groundwater quality are frequently observed.

Generally, delineation of the clouds of groundwater pollution depends on a rather accurate description of the geology and hydrogeology of the aquifer system under study. Conceptual understanding of the flow system, chemical variations and the interaction between groundwater and surface ecosystem is essential for characterisation of groundwater bodies. Conceptual model/understanding will identify the specific requirements for establishing a monitoring network and the degree of monitoring, in terms of number of sites, site density and frequency of monitoring [5]. This model/understanding will be consistent with that developed and used as part of the characterisation and risk assessment process.

The concept of homogeneity applied to groundwater bodies may be a valuable tool to assist the characterization process according to the WFD. Homogenous areas point to identical aquifer recharging conditions and hydrogeochemical conditions in parts of the aquifer system. Using information on groundwater table changes in time and groundwater chemical composition it is possible to identify the areas, which are expected to react similarly or identically to the natural or man-caused events. Accordingly, this information could be used in groundwater monitoring network design.

The use of multivariate statistical analyses, e.g. the *principal component analysis* (PCA), can be very powerful tool to define aquifer recharging conditions and quantitative monitoring according to the WFD requirements. This type of analysis allows for incorporation of all existing groundwater table measurement results for the individual observation well locations.

Traditionally, the groundwater level data are mostly used for the preparation of water-table contour line maps for a particular moment in time. These maps are generated on the basis of single measurements of continuous variable of the groundwater changes in observation wells and are not representative for describing of the groundwater dynamics. The monitoring data are also used in engineering activities performed on particular sites for creation of hydrographs that depict groundwater table change rates in exactly determined spot sites in space. However, the observation well locations are commonly set far from the engineering activity sites, so they are not representative for determination of the groundwater changes in individual sites.

The modern approach consists of using all groundwater level data from the monitoring sites. In so doing it would be possible to estimate the significance of geological and hydrogeological characteristics in fluctuating patterns of the groundwater table change, and to enable making conclusions on prevalent groundwater flow conditions in parts of the aquifer system.

This approach was followed in Zagreb area [6, 7]. The results of the multivariate statistical analysis revealed several groundwater table fluctuation patterns, which can be described with representative hydrographs (figure 3). The areas with the identical fluctuation pattern may be considered as the hydrodynamic homogeneous zones.

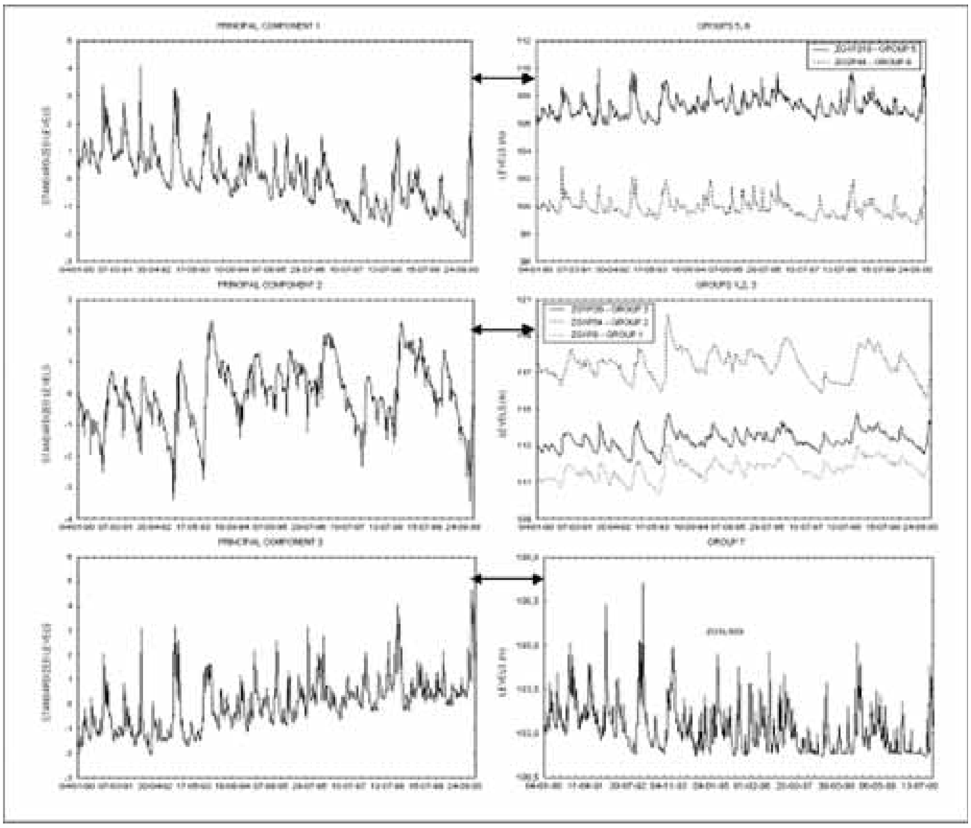

Fig. 3 – Water level fluctuation patterns in observation wells in Zagreb area (after [6])

The advantage of this approach is that monitoring of groundwater table changes in time within the particular hydrodynamic zone in Zagreb area may be significantly reduced. Only a few observation well fluctuation pattern in each zone can be taken into account in order to accurately describe the groundwater dynamics within the aquifer system.

Applying multivariate statistical analyses and geochemical modeling tools, it is possible to examine the lateral and vertical distribution of chemical composition of groundwater in parts of aquifer system, in order to develop a conceptual model that would reveal hydrogeochemical homogenous areas, expected to react similarly or identically to natural or man-caused events.

To examine the lateral and vertical distribution of chemical composition of groundwater in Zagreb area, several multivariate statistical analyses, e.g. MANOVA and Cluster analysis were applied [8]. Using geochemical modelling tools, the distribution of the saturation indices (SI) of the mineral phases can be revealed, e.g. the partial CO_2 pressure (P_{CO2}) distribution, which may indicate a local anomaly zones with increased P_{CO2} values in the area occupied by landfills and/or illegal dumpsites (figure 4).

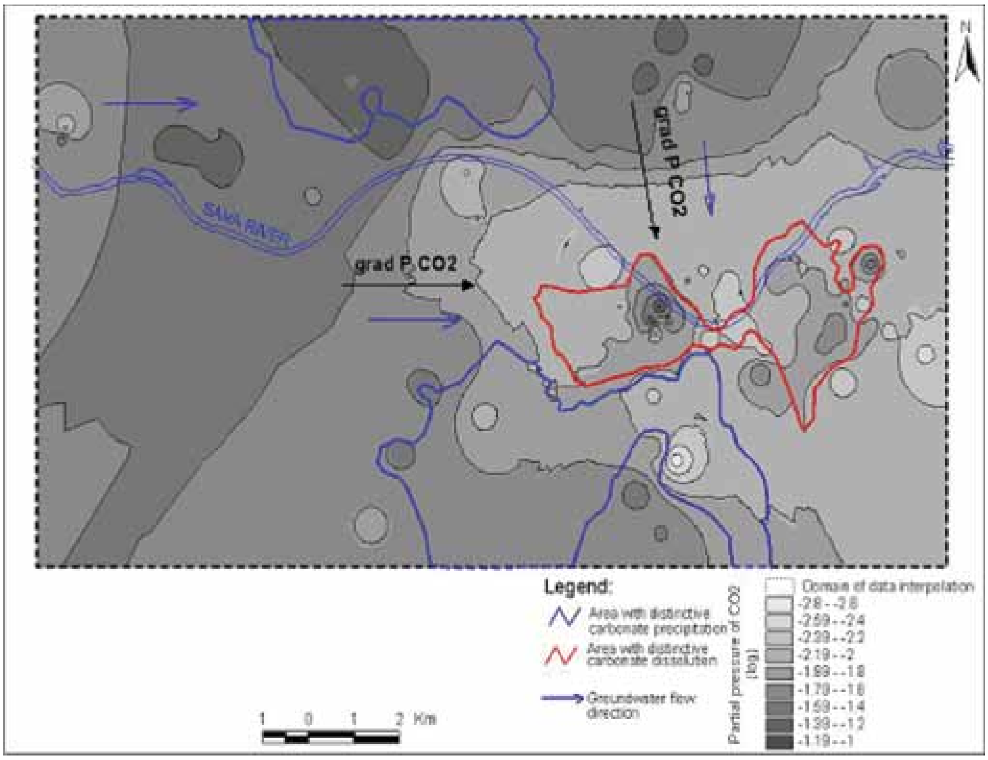

Fig. 4 – Result of geochemical modelling: distribution of the saturation indices of important mineral phases (after [8])

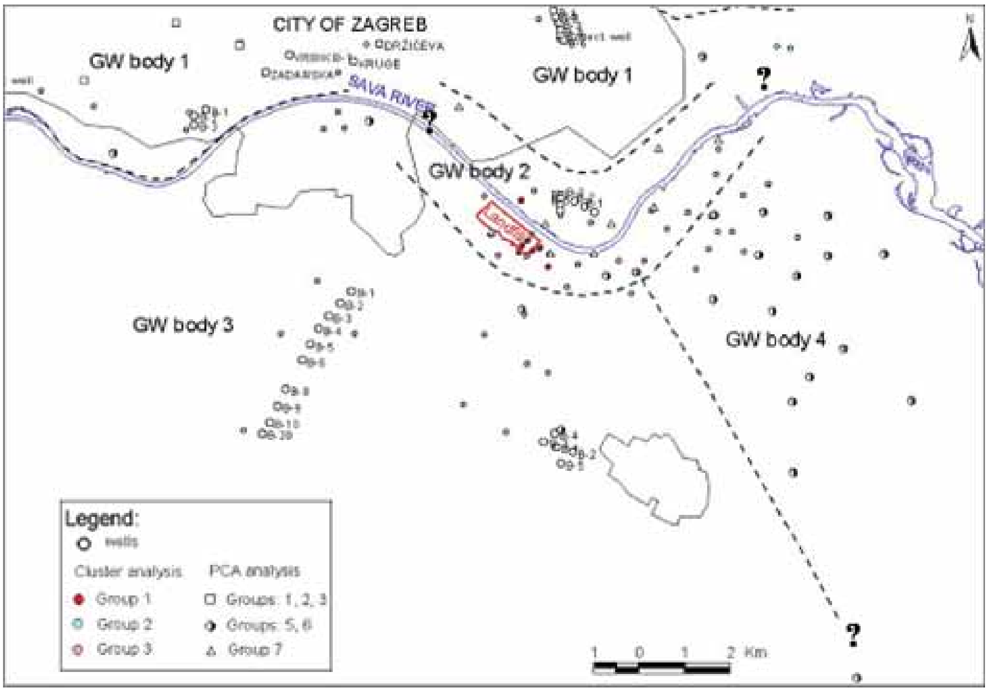

Fig. 5 – The possible solutions for the delineation of groundwater bodies in Zagreb area, according to the results of conceptual understanding of groundwater flow and hydrogeochemical variations in different parts of the aquifer system (after [9])

These hydrodynamic and hydrogeochemical models may be combined to reveal the homogeneous areas within the aquifer system. According to the WFD CIS Guidance document on groundwater monitoring [5], these combined models may be used as regional conceptual model of the aquifer system, which enable the understanding of the factors at groundwater body scale that identifies the need to establish a monitoring network/point and how the data will be used. These models may also be used to delineate the groundwater bodies [9] (figure 5).

Methodology to set up groundwater threshold values

Threshold values can be established at the national level, at the level of the river basin district or the part of the international river basin district falling within the territory of a Member State, or at the level of a body or a group of bodies of groundwater.

Within the BRIDGE project [10] (the Background Criteria for the Identification of Groundwater Thresholds) co-funded by the European Commission within the Sixth Framework Programme, a methodology to set up groundwater thresholds in Europe was proposed.

This methodology is based on a good conceptual understanding of the groundwater bodies and particularly on:

- characterization of potential pollutants and any parameters indicative of pollution, including description of the properties which influence their fate and transport, the behavior of hydrogeochemical environments, ecotoxicology and toxicology.
- description of the hydrogeochemical setting of aquifers, the background values of naturally occurring substances in aquifers and any dependencies of water quality on changes in hydrodynamic conditions in aquifers;
- characterization of receptors, including aquatic ecosystems, dependent terrestrial ecosystems and groundwater itself.

The methodology to derive threshold values must refer to the definitions of good status provided by the WFD and new GWD. The GWD demands that characteristics of receptors, or the extent of interactions between groundwater and associated aquatic or terrestrial ecosystems, as well as interference with the legitimate use of groundwater, are taken into account when establishing threshold values. Consequently, in some cases threshold values would need to be established at the level of groundwater bodies, at the same level as the receptors were defined.

The reason why threshold values have to be derived by a risk-based approach, that is oriented towards receptors, is showed on the figure 6.

Some substances, although considered as pollutants, may be present in naturally elevated concentrations. Due to the elevated concentrations and high natural variability of substances designated as pollutants in groundwater body characterization, the groundwater body or group of groundwater bodies may be in good chemical status but with poor groundwater quality.

The importance of the natural background level of a substance is recognized by the new GWD.

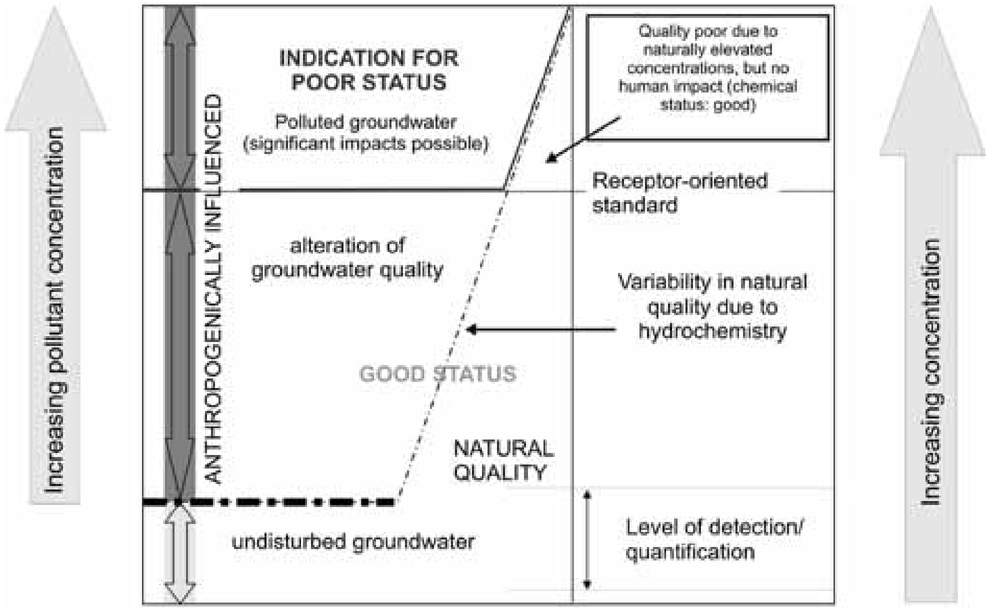

Fig. 6 – Relationship of groundwater quality and status

Approach to assess Natural Background levels

To derive threshold values and to assess chemical status of the groundwater bodies, according to the GWD it is necessary to define geochemical background values of naturally occurring substances in groundwater.

Natural geochemical background levels reflect natural processes unaffected by human activities and are needed to distinguish between natural and man-made concentrations in groundwater. This is particularly important due to the growing human impact on groundwater quality, e.g. from industry, air pollution, agriculture etc. However, it can be argued that natural background concentrations of chemical parameters no longer exist due to the human influences on whole planet. An option is to define an ambient background values under slightly altered conditions, when elevated levels of element concentrations in soil or water result from long term human impact, such as agriculture, industry and urbanization and are no longer natural [11].

Geochemical background is very often incorrectly regarded as a fixed value (mean or median) that represents a hypothetical background concentration without taking into account natural variability. However, it changes both regionally as well as locally. It is more realistic to view it as a range of values rather than as an absolute value. Maybe the best way to calculate geochemical background would be using the probability graph methods, which split the overall data distribution into distinct components and, in so doing, identify threshold values.

This approach was following in developing computer-based methods for calculating geochemical background values [12] (figure 7). These methods were used to evaluate and separate anomalies or outliers from the background concentrations of naturally occurring inorganic parameters in groundwater of Zagreb aquifer system [13].

In this particular case, the ambient geochemical background calculations have been conducted for: nitrates, dissolved oxygen, sulphate, chloride, iron and manganese, because they are indicators of human impacts from agriculture and industry.

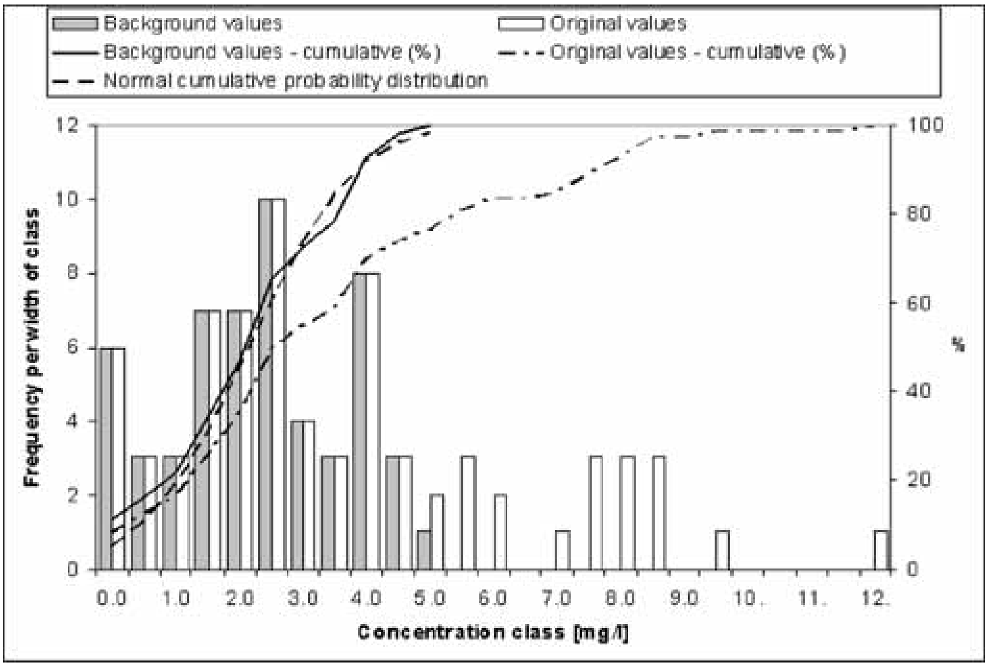

Fig. 7 – Example of background calculations: ambient background concentrations of nitrate in groundwater of Zagreb aquifer system (from [12])

The Water Framework Directive in relation to the drinking water protected areas

Under Article 4, the environmental objectives of the Water Framework Directive (WFD) are divided into those for surface waters, groundwater and protected areas [14]. Annex IV of the WFD defines protected areas for the abstraction of water intended for human consumption under Article 7 of the WFD – Drinking Water Protected Areas (DWPAs).

According to the *WFD CIS Guidance on Groundwater in Drinking Water Protected Areas* [14], DPWAs should be whole groundwater bodies. The necessary protection measures may be focused (but not necessarily restricted) to zones around actual of planned abstractions, i.e. safeguard zones. According to this interpretation, it implies that:

- DWPAs cover actual safeguard zones (zones of sanitary protection) and other zones of potential abstraction;
- Protection measures are focused on safeguard zones normally linked to existing drinking water abstractions that are at risk of deterioration. This does not rule out wider measures over the entire DPWA, if it is needed to provide protection to an area that is identified for future abstractions.

If DWPA is designated as an area, which is part of a groundwater body, or extend over parts of two or more bodies, then safeguard zones, defined under Article 7.3 of the WFD, may not be needed in addition to the DWPA. Effectively, the DWPAs become safeguard zones where measures are focused [14].

The groundwater body will be designated as Drinking Water Protected Areas when:

- the body is used for the abstraction of groundwater intended for human consumption and provide more than 10 m^3/day as an average;
- serve more than 50 persons or
- is intended for such future use.

In such cases the most stringent protection regime should prevail within the boundaries of groundwater body.

On figure 8 an example was shown that illustrate aforementioned statement of the guidance.

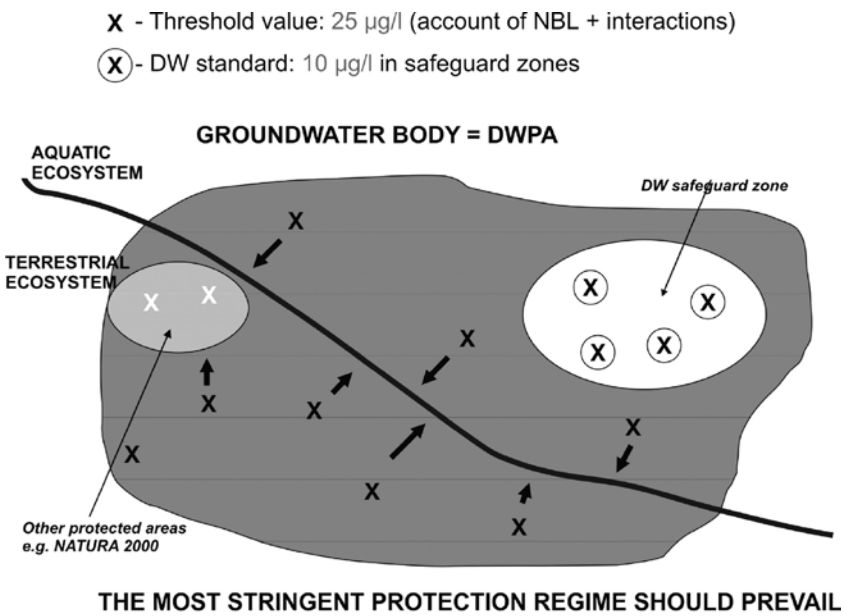

Fig. 8 – Protection regime in Drinking Water Protected Areas

If e.g. the threshold value for some chemical substance is 25 μg/l and this value is derived taking into account the natural background level and interactions with ecosystems, and quality standard for this substance, from Drinking Water Directive (98/83/EC), is 10 μg/l, than it is necessary to establish measures within Drinking Water Protected Areas which will assure than concentration of that particular chemical substance, within the boudaries of DWPA, is lower than 10 μg/l.

As noted in the new Groundwater Directive (2006/118/EC), safeguard zones may be part of a groundwater body (i.e. DWPA), may cover parts of two or more bodies, or cover the whole territory of a Member State. In many cases safeguard zones will be significantly smaller than groundwater bodies and there could be a number of such zones within a groundwater body.

However, in some circumstances, such as karstic aquifers, safeguard zones may need to be quite large, reflecting rapid flow and extreme groundwater vulnerability. Safeguard zones may even need to be extended beyond the boundaries of the groundwater body and also include associated “upstream” surface water bodies, reflecting the capture zones of the drinking water abstractions.

Conclusions

By adapting the new Groundwater Directive (2006/118/EC), the specific measures for fulfilling the objectives of environment protection and control of groundwater pollution were determined. These measures are related to:

- definition of the common criteria and procedures for determining the chemical status of groundwater bodies based on the quality standards from other EU directives and concentration threshold values;
- definition of the common criteria for identification and change of the upward trends of the substances specified as pollutants;
- protecting or limiting the direct and indirect input of a pollutant in groundwater.

Groundwater body is in good chemical status if measured concentrations of chemical substances are lower than groundwater quality standards or a threshold values. In cases when the value for a groundwater quality standard or threshold value is exceeded at one or more monitoring points, an appropriate investigation is needed to quantify the principal transport processes and attenuation mechanisms in contaminant migration.

The concept of homogeneity applied to groundwater bodies may be a valuable tool to assist the characterization process according to the WFD. Homogenous areas point to identical aquifer recharging conditions and hydrogeochemical conditions in the aquifer system. The development of the conceptual models of the groundwater flow and contaminant transport may be used as the basis for understanding and documenting the groundwater body delineation and characterization, and to aid decision-making.

Proposed methodology to set up groundwater thresholds in EU Member States includes calculation of the background level of a naturally occurring substances designated as pollutants in groundwater body characterization. Very often, the best way to calculate geochemical background would be using the probability graph methods. In Croatia, computer-based methods for calculating geochemical background values were developed and applied to evaluate and separate anomalies or outliers from the background concentrations of naturally occurring inorganic parameters in groundwater of Zagreb aquifer system.

Drinking Water Protected Areas should be whole groundwater bodies, as recommended in *Guidance on Groundwater in Drinking Water Protected Areas,* but the protection measures may be focused to safeguard zones (zones of sanitary protection). Safeguard zones may be part of a groundwater body, may cover parts of two or more bodies, or cover the whole territory of a Member State. In many cases safeguard zones will be significantly smaller than groundwater bodies and there could be a number of such zones. However, in some circumstances, such as karstic aquifers, safeguard zones may need to be quite large.

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Changes in Water Quality in the Sava River as a Result of Construction of the Central Wastewater Treatment Plant of the City of Zagreb

1. Introduction

Water protection is one of basic activities of water management and, considering water's vital importance to people and the exponential development of human society, it has a perspective of assuming the leading role. It is based on the provisions of the Water Act, river basin management plans and regulations in the field of water protection from pollution as well as compliance with other documents regulating, among other issues, water protection, as follows: the Nature Protection Act, Physical Planning and Construction Act, National Physical Planning Strategy, Environmental Protection Act, National Environmental Protection Strategy, National Environmental Action Plan and Public Utilities Act.

The starting point for planning water protection measures is information on ecological and chemical status of surface waters, chemical and quantity status of groundwater and water quality with regards to intended uses as well as the assessment of impact of pollution on water from point sources of pollution (industrial facilities, sewerage discharges and/or wastewater treatment plants) and diffuse sources of pollution (agricultural land, stormwater from traffic areas, etc.). The quoted information is collected through systematic monitoring of water quality.

Water quality monitoring over a longer period indicates the presence of changes in water quality, which in a certain number of cases result from anthropogenic influence, be it that watercourses are influenced by pressures or that measures are taken to prevent or limit actions which have impact on water pollution. Pressures on surface waters and groundwater include pollution caused by population, waste disposals, industries, agriculture, traffic, hydromorphological changes (hydroelectric power plants, flood protection structures, etc.) and other pressures which include abstraction sites for water supply, navigation, watercourse regulation, aquaculture, tourism and accidental pollution. Measures which ensure the achievement of environmental protection goals are defined for each river basin district in river basin management plans, and include, among others, control of discharges by means of emissions control, which should be based on best existing technologies and through the application of best ecological practice, construction measures for drainage and wastewater treatment structures, measures for promotion of efficient and sustainable water use, etc.

This paper presents the impact of implementing the measure of wastewater collection and treatment structure construction in the City of Zagreb on water quality in the Sava River in the period from 2002 to 2007.

2. Central Wastewater Treatment Plant of the City of Zagreb

The Central Wastewater Treatment Plant of the City of Zagreb is comprised of structures for mechanical and biological treatment of wastewater and of structures for sludge treatment. The plant was built for the capacity of 1.2 million PE and completed in autumn 2007, and can be extended to the capacity of 1.5 million PE.

The construction and putting into operation of the entire plant was conducted in several stages. The part of the plant for mechanical treatment of wastewaterihas been operational since April 2004, while the part of the plant for biological treatment and for treatment of generated sludge, which was constructed in four stages from December 2004 until September 2007, was also put into operation in stages. Apart from the application of activated sludge technology, the procedure of anaerobic sludge digestion is applied in biological wastewater treatment, which produces biogas. The energy generated from biogas is used for operating a small electrical power plant within digester heating devices, where sludge digestion takes place.

After putting the plant into operation, the concessionnaire Zagrebačka otpadne vode d.o.o. has the obligation to operate and maintain the plant during the full duration of the concession, after which the plant is taken over by the City for further operation.

3. Test Area and Method of Processing Test Results

The assessment of changes in water quality in the period from 2002 to 2007 in the Sava River is based on test results from the gauging station upstream of the City of Zagreb's wastewater discharge (Petruševac) and from the gauging station downstream of the discharge (Oborovo). Data from the group of indicators of oxygen regime and nutrients and the saprobity index, which indicate organic pollution of watercourses, were processed. The dynamics of measurements was 26 times per year for indicators oxygen regime and nutrients and twice per year for the saprobity index.

Oxygen regime is comprised of indicators of dissolved oxygen, oxygen saturation, chemical oxygen demand and 5-day biological oxygen demand. Anthropogenic input of organic substances into watercourses has a negative impact in two ways – on one hand, it causes a decrease in the contents of dissolved oxygen due to decomposition of organic matter, and on the other, oxygen contents increase as a consequence of eutrophication processes in water. In summer months, due to higher temperatures and lower water discharge, problems with the contents of dissolved oxygen are even more pronounced. A 5-day biochemical oxygen demand is used as an indicator of biodegradable organic pollution, whereas chemical oxygen demand is characterized by the presence of components which use oxygen.

Nitrogen and phospohorus are nutrients which are the most frequent limiting factors in aquatic ecosystems and count among the major causes of water quality deterioration. Increase in nutrient quantities leads to significant problems in terms of water quality, including algae growth, hypoxia, impoverishment of aquatic communities and their habitats, etc. The most frequent sources of nitrates, ammonium and other nutrients in water are wastewater and sludge from public sewerage systems and manure from agricultural areas.

Indicator species of organisms are aquatic organisms which exibit optimum growth under certain conditions of organic pollution, and includes animals, autotrophic and mixotrophic plants. In order to be considered an indicator, a species must fulifil several criteria: it must have a narrow ecological valence, it must be widespread and it must be easy to determine. The system of indicator species is used for expressing the Pantle-Buck saprobity index. The system used is the system according to Wegel, which includes Central European species and is more suitable for the continental part of Croatia, i.e. the Black Sea basin. To calculate the saprobity index, indicator value of a species is used, which is determined for each species according to the zone for which it is an indicator and population density. Dynamics of sampling and measurement for determination of the Pantle-Buck saprobity index was twice a year, in summer and winter periods at low water levels.

For assessment of changes in water quality, statistical values of the 90th (i.e. 10th) percentiles were used as well as the arithmetic mean of the concentrations. The annual values of the 90th and 10th percentiles were shifted towards higher/lower values of the series, thus indicating less favourable concentration ranges, whereas the arithmetic mean showed significantly less sensitivity to extreme values.

4. Presentation and Assessment of Test Results

OXYGEN REGIME

Indicators of oxygen regime at the two observed stations on the Sava River (Fig. 4.1 and F.2) indicate the trend of water quality improvement, which was more pronounced at the station Oborovo, downstream of the City of Zagreb's wastewater discharge as well as in the statistical values of concentrations of dissolved oxygen and oxygen saturation. By comparing these statistical values with the limit values from the Regulation on Water Classification (OG No. 77/98), it can be stated that the values at the beginning of the observed period were within the ranges for water classes III and IV, decreased over the years and in 2007 moved into water class II, based on which it can be concluded that the input of organic load into the Sava River is lower than in the previous years and that this can be related to the construction and gradual putting into operation of secondary treatment of the urban wastewater treatment plant in Zagreb. The analysis of the values of dissolved oxygen saturation which relate to chemical and biological oxygen demand in wastewater at the inlet and outlet of the plant in 2007 (Table 4.1) register a decrease in load percentage by 90 %.

Table 4.1 – Mean annual concentration values of BOD_5, COD, total nitrogen and total phosphorus in wastewater at the inlet and outlet of the Central Wastewater Treatment Plant of the City of Zagreb and the percentages of load decrease in 2007

BOD_5			COD			Total N			Total P			Mean annual discharge
[mgO_2/l]		% load reduction	[mgO_2/l]		% load reduction	[mg/l]		% load reduction	[mg/l]		% load reduction	
inlet	outlet		inlet	outlet		inlet	outlet		inlet	outlet		l/sec
163	17.6	89	420	38.3	91	37.26	22.26	40	6.25	3.03	48	2928

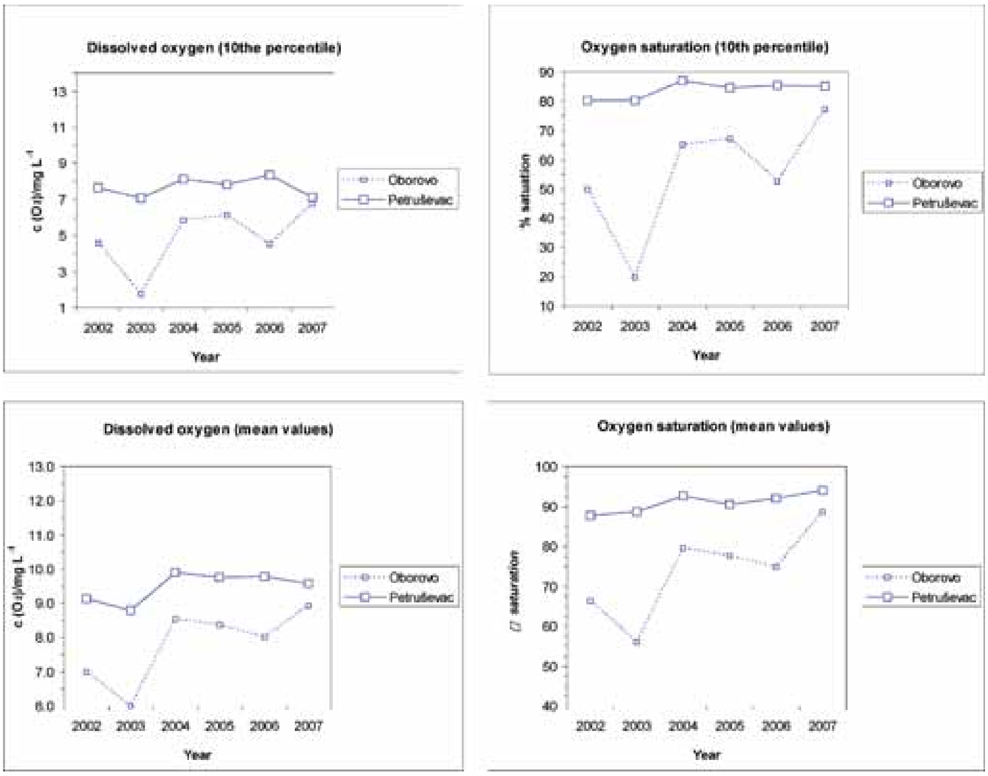

Fig. 4.1 – Changes in annual statistical values (10the percentile and mean value) of indicators dissolved oxygen and oxygen saturation at gauging stations Sava Petruševac and Sava Oborovo in the period from 2002 to 2007

The above reflects on the water quality in the Sava River in a manner that the annual 90th percentiles of dissolved oxygene concentrations used for biological oygen demand (BOD5) in the Sava River at the Oborovo station register a significant decrease to the value of 3.2 mgO_2/L in relation to 2002, when registered concentrations equaled 7.7 mgO_2/L. A similar decrease is determined for the COD indicator. 10th percentiles of dissolved oxygen increased from 4.6 mgO_2/L in 2002 to 6.8 mgO_2/L in 2007, indicating decrease in the load of nutrients which use oxygen in the process of their decomposition. The lowering of concentrations was also present at the Petruševac station, although the extent was smaller than at Oborovo.

In 2003, the statistical values showed a more significant degradation, with individual measurement results worse than during summer months when unfavourable hydrological and temporal conditions were recorded

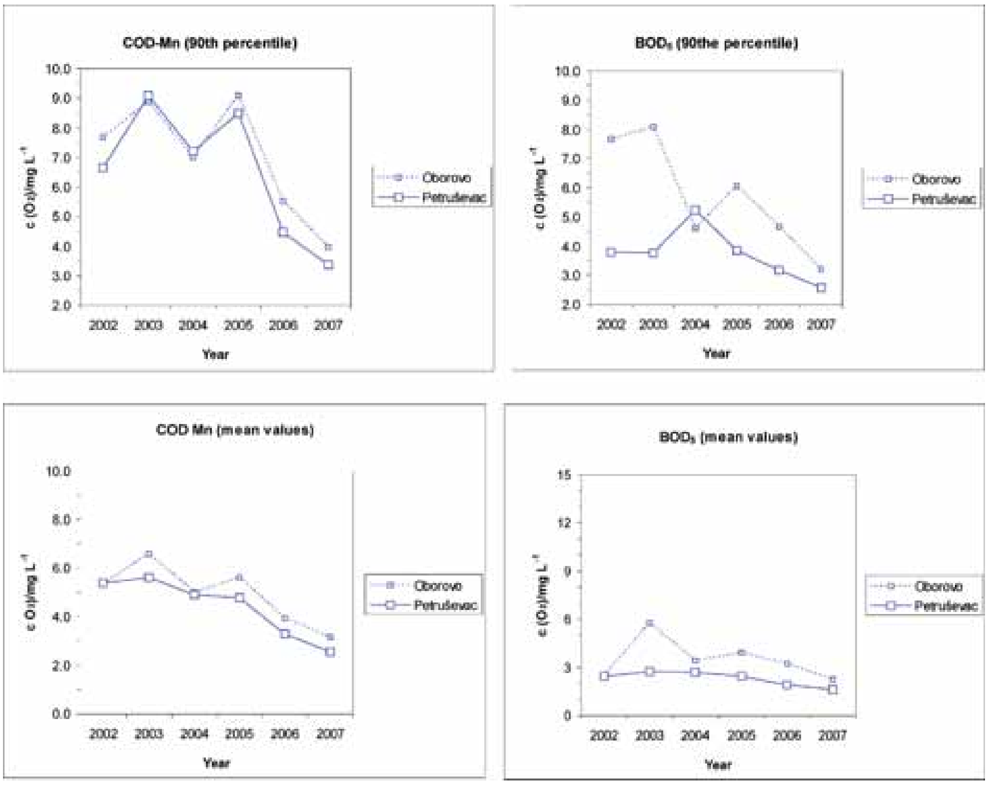

Fig. 4.2 – Changes in annual statistical values (90th percentile and mean value) of indicators COD and BOD5 at gauging stations Sava Petruševac and Sava Oborovo in the period from 2002 to 2007

and lead to a degradation of the watercourse due to oxygen deficit. That summer, high temperatures and low water levels also caused sudden algae growth, which lead to hypersaturation of water with oxygen.

NUTRIENTS

The trend of water quality improvement determined in relation to the indicators of oxygen regime in the observed period was also present with regards to nutrients, although less pronounced than in the indicator group of oxygen regime (Fig. 4.3 and 4.4). At Oborovo, continuously higher values were present than at the Petruševac station, with 90^{th} percentiles showing greater oscillations. However, at both observed stations statistical values of mass concentrations showed a decrease. More signifi-

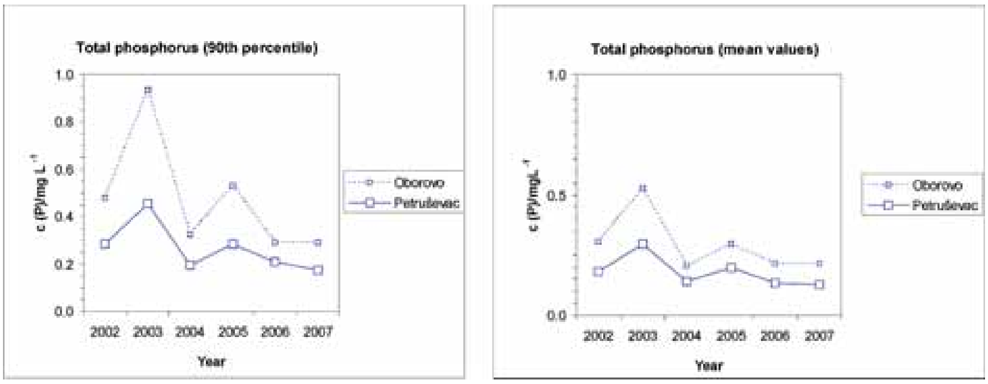

Fig. 4.3 – Changes in annual statistical values (mean value and 90th percentile) of total phosphorus at gauging stations Sava Petruševac and Sava Oborovo in the period from 2002 to 2007

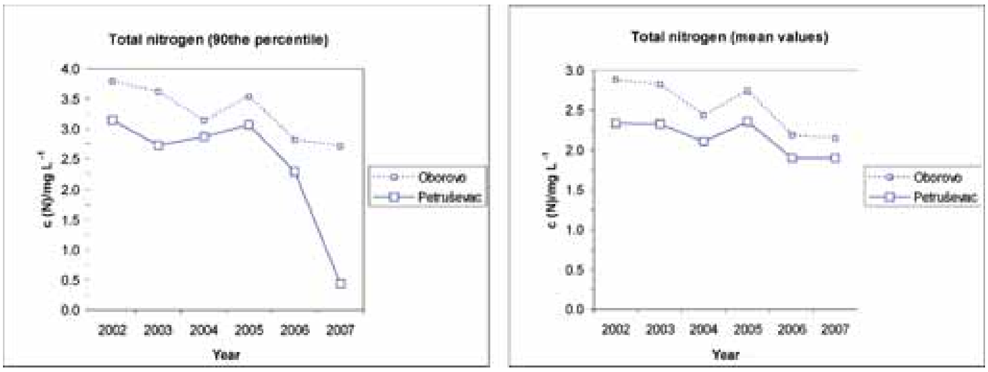

Fig 4.4 – Changes in annual statistical values (mean value and 90th percentile) of total nitrogen at gauging stations Sava Petruševac and Sava Oborovo in the period from 2002 to 2007

cant differences in water quality changes were not registered at the two stations, which could be related to the wastewater treatment of the City of Zagreb in the period from 2004 to 2007. When the values of concentrations in wastewater at the inlet and at the outlet of the plant in 2007 (Table 4.1) were analyzed, a decrease in the percentage of total nitrogen and total phosphorus of 40 – 50 % was evident. However, this decrese did not have a more significant impact on the water quality trend at the Oborovo station in relation to the Petruševac station.

In 2002, at the Oborovo station the concentrations of total phosphorus and total nitrogen ranged within the limit values for water class III.

However, in 2006 and 2007 the statistical values decreased, so that there was a determined improvement of water quality for total nitrogen to water class II.

In relation to nutrients, in 2003 statistical values were significantly higher than in other observed years, which was again a consequence of unfavourable hydrological conditions, i.e. markedly lowered water levels due to a dry period, particularly during summer months.

SAPROBITY INDEX

The values of the Pantle-Buck saprobity index are shown in Fig. 4.5. They indicated a declining trend at both stations, although this was more pronounced at the Oborovo station in 2007, when the mean value of this biological indicator at Oborovo was significantly lower in comparison to the previous period. Based on this, it can be concluded that the input of organic load into the Sava River was lower than in the preceding years, which is again related to the construction and putting into operation of secondary treatment of the urban wastewater treatment plant in Zagreb. A more significant decrease in the index values followed in 2007, although the biological part of the plant has been in partial operation since

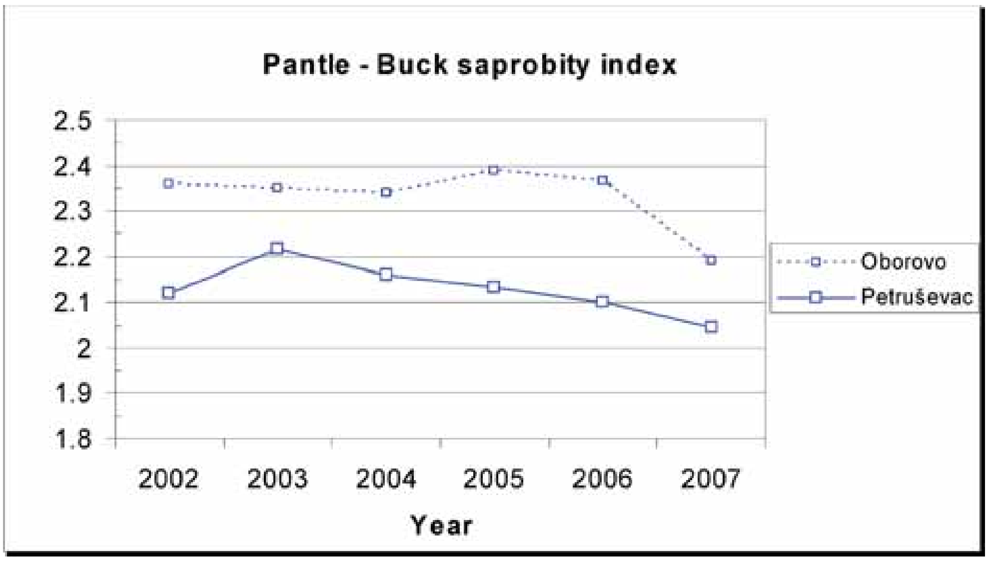

Fig. 4.5 – Changes in annual mean values of the Pantle-Buck saprobity index at gauging stations Sava Petruševac and Sava Oborovo in the period from 2002 to

2004. The reason for this is the fact that the process of adaptation of organisms to the changed conditions takes a longer time period and that the changes in the composition of communities do not register simultaneously with the changes in physico – chemical indicators.

5. Conclusion

The assessment of changes of water quality in the Sava River in the period from 2002 to 2007, which is based on the analysis of indicators from the group of oxygen regime, nutrients and saprobity index, showed that there was a trend of water quality improvement at the gauging stations Sava Petruševac (upstream of the wastewater discharge of the City of Zagreb) and Sava Oborovo (downstream of the discharge), which was more pronounced at the Oborovo station. The positive trend was the most pronounced for indicators dissolved oxygen and oxygen saturation. With regards to indicators of organic pollution, the improvement od water quality was a consequence of a decrease in the load of organic matter which uses oxygen during decomposition. The analyses of concentration values of dissolved oxygen relating to chemical and biological oxygen demand, also record a decrease in statistical values, which was more pronounced at the Obrovo station.

A positive trend in the change of water quality was also determined for nutrients, although it was less pronounced here than in the group of indicators of oxygen regime. At both observed stations, the statistical values of mass concentrations registered a decrease, although the values determined at the Obrovo station were higher than those at the Petruševac station.

The values of the Pantle-Buck saprobity index, which indicate organic polution, registered a positive trend both upstream and downstream of the City of Zagreb's wastewater discharge. The mean values of the saprobity index at the Obrovo station in the period from 2004 to 2006 did not show any trend, since adaptation of organisms to changed conditions takes a longer time, thus a positive trend was registered only in 2007.

The input of organic matter into the Sava River due to the construction and putting into operation of the Central Wastewater Treatment Plant of the City of Zagreb in the period from 2004 to 2007 has been signicantly reduced, thus the registered trend is partly a consequence of this decrease.

Key words: Sava River, water protection, water quality, nutrients, oxygen regime, saprobity index, Central Wastewater Treatment Plant of the City of Zagreb

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Development of the Ecological Models of the Adriatic Sea

Abstract

Numerical ecological modelling is relatively new approach in Croatia for determination of ecological state of the Adriatic Sea. In this article a description of numerical ecological modelling implemented in scientific–professional Project *The Adriatic Sea Monitoring Program* has been presented. The main goal of the Project is to make an expert assessment of the currently sea monitoring system and its compliance with the provisions of the EU Water Framework Directive (2000/60/EC). This article gives short insight in scope of works of *The Adriatic Sea Monitoring Program* related with in-situ physical, chemical and biological oceanographic measurements, numerical modelling implementation and its results.

Oceanographic measurements for the first six months of the Project were performed in the eastern part of the Adriatic Sea at 20 current meter and CTD sites, 46 sites occupied with all measured parameters, 16 CTD sites and 2 waverider sites. For the numerical modelling, four renowned numeric systems (ROMS, POM MIKE 3 and MIKE 3 FM) were utilized. ROMS and POM were used for the hydrodynamic analysis on the whole area of Adriatic Sea. The results of that analysis are used for the boundary conditions for MIKE 3 and MIKE 3 FM at 8 (MIKE 3) and 5 (MIKE 3 FM) unfolded spatial domains. For numerical analysis of the spatial and temporal dynamics of the dissolved oxygen (DO), faecal streptokokus (FS) and faecal coliform (FK) concentrations MIKE 3 FM and MIKE 3 EcoLab module were used.

Finally, results of measurements and modelling were presented as well as their comparison. It has been concluded that very good agreement between measured and modelled values were obtained.

Key words: numerical ecological modelling, oceanography, Adriatic Sea.

1. Introduction

Scientific – professional Project *The Adriatic Sea Monitoring Program* as a part of Coastal Cities Water Pollution Control Project is finance through fund of The Republic of Croatia and the loan of The World Bank. For the purpose of planed two years long activities and services the consortium of the following companies were established:

- Faculty of Civil Engineering, University of Zagreb (FCE – leading partner)
- Hydrographic Institute of the Republic of Croatia, Split (HI)
- Institute of Oceanography and Fisheries, Split (IOF)
- Ruđer Bošković Institute, Centre for Marine Research, Rovinj (CMR)

This article gives short insight in scope of works related with in-situ measurement and numerical modelling implementation in this monitoring program.

The primer objective of the Program is to make an expert assessment of the current sea monitoring system and its compliance with the provisions of the EU Water Framework Directive (2000/60/EC), and to identify necessary improvements and modifications. Plans are made within the Program about the necessary research work which shall be used as the basis for the establishment of the basic models for the analysis of the Adriatic Sea quality state. Results of measurements on specific network of stations, together with results of basic models of the Adriatic Sea quality state will support the Adriatic Waters Management Plan, which Hrvatske vode is legally bound to prepare by 2010.

The most important parameters are defined with the help of which it is possible to monitor the changes in the marine ecosystem brought about by the discharge of effluents, basically treated municipal faecal and industrial wastewater, but also by other planned human activities in the internal sea waters of the Republic of Croatia. These parameters will have to be sufficient to establish models of ecology state of the Adriatic Sea on the first approach level, which will enable insight into the present ecology state and potential future changes.

In accordance with the Environmental Protection Act of the Republic of Croatia (Narodne novine 82/94, 128/99), the bye-law was adopted – Ordinance on Sea Quality Standards on Sea Beaches (Narodne novine 33/96), which defines the criteria for sampling, testing methods and assessing of sea quality on Beaches. The Ordinance is based on the Council Directive EEC concerning the Quality of Bathing Waters, 76/160/EEC, Official journal of EEC No L281/47-52, Guidelines of Sea Quality for Bathing of the Mediterranean Action Plan of the United Nations Environmental Program (UNEP/MAP) and the criteria of the World Health Organization (WHO). Microbiological parameters are considered the most important indicators of sea pollution by faecal waste water, and the evaluation is conducted according to limit values for microbiological indicators from the Ordinance, and expressed as "meeting – not meeting". Water of sea beaches meets the standard if the values of bacteriological indices do not overstep the limit values prescribed by the Ordinance (Article 9 of the Ordinance):

Faecal coliforms FC	100 FC/100ml	(in 80 % samples)
	200 FC/100ml	(in 20 % samples)
Faecal streptococci FS	100 FS/100ml	(in 80 % samples)
	200 FS/100ml	(in 20 % samples)

In order to assess the benefits of construction of public sewerage systems under Phase 1 of the Adriatic Project, the analyses included the concentrations of faecal coliforms in front of the beaches near the locations of planned submarine outfalls at the present level of development, compared to model values at the same locations for the planned level of development.

2. Measurements

Oceanographic parameters have been measured within territorial water of the Republic of Croatia. Oceanographic sites are divided into 4 groups in accordance with measured parameters as follows:

1) Current meter and CTD sites where sea currents are continuously measured over 2x6 months interval (using ADCP current meters) along with measurement of sea temperature, salinity and density (5 times in the middle and south Adriatic Sea and 7 times yearly in the north Adriatic Sea) using a Seabird CTD probe;

2) All parameters defined by the Project objective, except sea current and waves (5 times in the middle and south Adriatic Sea and 7 times yearly in the north Adriatic Sea);

   All parameters means: Physical oceanography parameters include (sea temperature, salinity and density, sea water transparency and color, surface waves), parameters of chemical (dissolved oxygen, pH, nutrients, ammonia, nitrite, nitrate, orthophosphate, orthosilicate, total phosphorus, total nitrogen, trophic index-TRIX) and biological parameters (chlorophyll-a concentrations, determination of composition and abundance of phytoplankton community, faecal pollution indicators, heterotrophic bacteria).

3) Termohaline sites (CTD sites) where sea temperature, salinity and density are measured when research vessel sails (5 times in the middle and south Adriatic Sea and 7 times yearly in the north Adriatic Sea) using a Seabird CTD probe;

4) Waverider sites where wind generated waves are continuously measured in the time interval of 2x6 months using waveriders Datawell.

Locations of oceanographic stations are shown in Figure 1 for the first six months of the project (phase I, 22.10.2007. to 22.5.2008), 20 current meters and CTD sites, 46 sites occupied with all measured parameters defined by the Project objective, 16 CTD sites and 2 waverider sites.

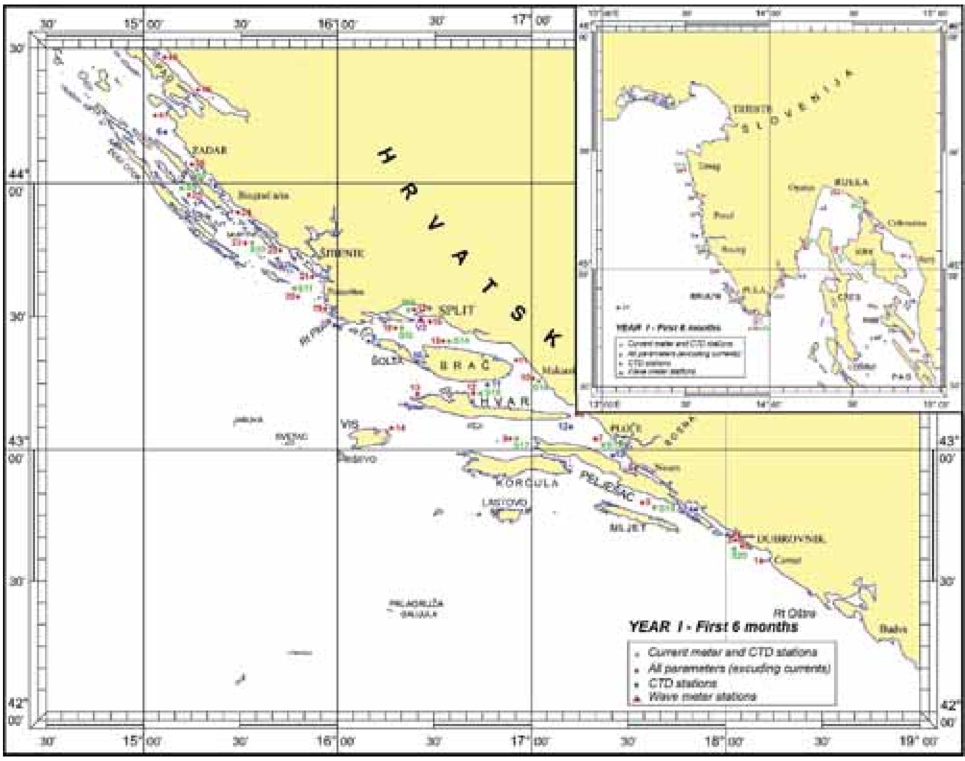


Fig. 1 – schematic presentation of oceanographic stations for the first phase of the field measurements (first six months)

3. Numerical modelling

Modelling approach

In this part of report an overview of numerical modelling implementation in analysis of the parameters of salinity, temperature, velocity fields and concentrations fields of faecal coliforms (FC) and faecal streptococci (FS) concentration in the coastal part of the eastern Adriatic is given. FS, FK and DO represent principal components for the assessment of the rate of the changes due to the planned implementation new 58 public sewage systems including submarine outfalls. For the determination of the spreading of the effluent plume created due to the operation of the existing and planned submarine outfalls, it is necessary to have the description of the high-frequency changes in the flow dynamics of the sea recipient, which can be obtained through the use of numerical models with the desired degree of spatial and time resolution.

For the numerical modelling, four renowned numeric systems (ROMS, POM MIKE 3 and MIKE 3 FM) were utilized. ROMS and POM were used for the hydrodynamic analysis on the whole area of Adriatic with the spatial resolution 2 km and 2,5 km. The results of that analysis are used for the boundary conditions for MIKE 3 and MIKE 3 FM at 8 (MIKE 3) and 5 (MIKE 3 FM) unfolded spatial domains with spatial discretisation up to 200 m in the vicinity of the eastern Adriatic coast. For numerical analysis of the spatial and temporal dynamics of the DO,FS and FK concentration MIKE 3 FM and MIKE 3 EcoLab module was used (table 1).

Spatial domain of whole Adriatic sea extensively utilized by numerical models ROMS and POM is given on figure 2. Regional spatial domains used within MIKE 3 FM model platform are indicated with blue rectangular. Example of northernmost regional spatial domain named Istra (MIKE 3 FM) is shown in figure 3. Example of local spatial domain named Kvarner (MIKE 3) is shown in figure 4.

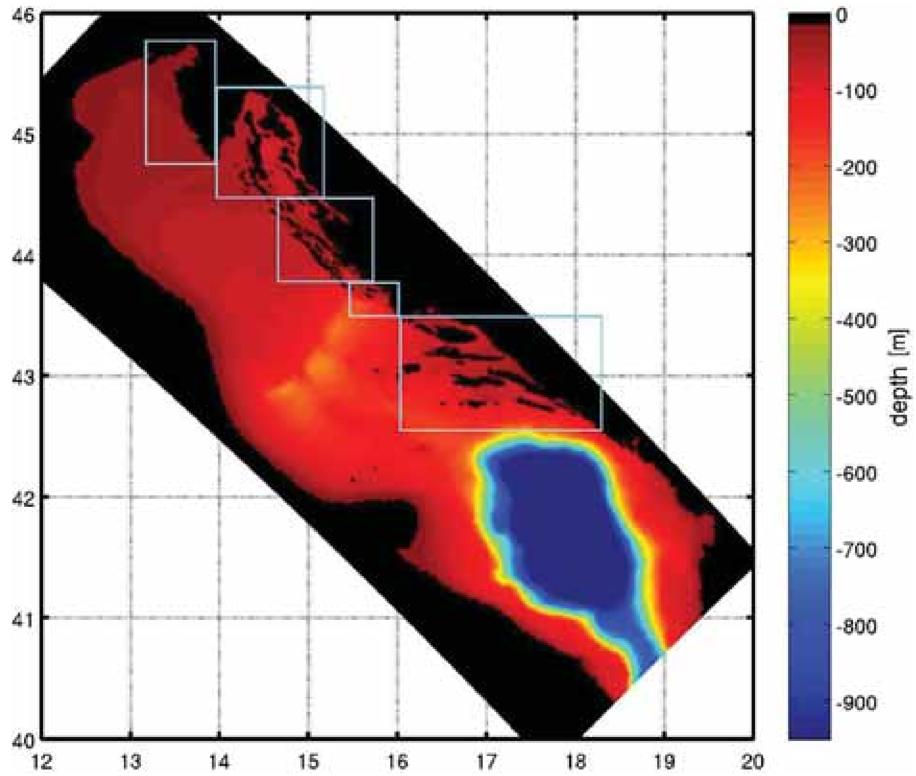
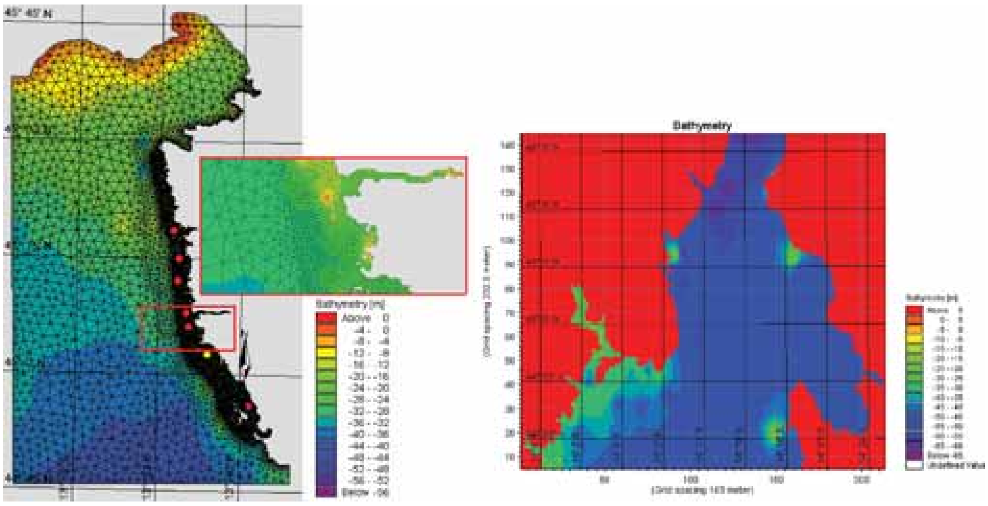


Fig. 2 – Spatial domain of the model of the whole Adriatic for numerical models ROMS and POM (regional spatial domains for MIKE 3 FM are indicated with blue rectangular)

Table 1 – Model executions

Model	Period	Horizontal resolution	Vertical resolution	Primer function	Output data
POM	15.8.07.-15.5.08.	2,5km	22sigma	Boundary conditions for MIKE, MIKE FM	S, T, u, v, levels
ROMS	15.8.07.-15.5.08.	2km	20sigma	Boundary conditions for MIKE, MIKE FM	S, T, u, v, levels
MIKE 3 FM	13.2.08.-13.3.08.	2km→200m	20sigma	Analysis of the influence of submarine outfalls	FK, FS, S, T, u, v, levels
MIKE 3	13.2.08.-13.3.08.	cca 200m	$\Delta z = 2m$		FK, FS, S, T, u, v, levels



Figs 3,4 – variable mash with bathymetry basis for regional spatial domain Istra comprised with model MIKE 3 FM (left) ; finite differences mash with bathymetry basis for local spatial domain Kvarner 1 comprised with model MIKE 3 (right)

Numerical models

Framework of modelling whole Adriatic Sea is build around implementation of ROMS finite difference model which is a free-surface, terrain-following, primitive equations ocean model. The hydrostatic primitive equations for momentum are solved using a split-explicit time-stepping scheme which requires special treatment and coupling between barotropic (fast) and baroclinic (slow) modes. In order to avoid the errors associated with the aliasing of frequencies resolved by the barotropic steps but unresolved by the baroclinic step, the barotropic fields are time averaged before they replace those values obtained with a longer baroclinic step. A cosine-shape time filter, centered at the new time level, is used for the averaging of the barotropic fields (Shchepetkin and McWilliams, 2005 [1]). In addition, the separated time-stepping is constrained to maintain exactly both volume conservation and consistency preservation properties which are needed for the tracer equations (Shchepetkin and McWilliams, 2005 [1]). Currently, all 2D and 3D equations are time-discretized using a third-order accurate predictor (Leap-Frog) and corrector time-stepping algorithm which is very robust and stable. The enhanced stability of the scheme allows larger time steps, by a factor of about four, which more than offsets the increased cost of the predictor-corrector algorithm. In the vertical, the primitive equations are discretized over variable topography using stretched terrain-following coordinates (Song and Haidvogel, 1994 [2]). The stretched coordinates allow increased resolution in areas of interest, such as thermocline and bottom boundary layers. The default stencil uses centered, second-order finite differences on a staggered vertical grid. Options for higher order stencil are available via a conservative, parabolic spline reconstruction of vertical derivatives. In the horizontal, the primitive equations are evaluated using boundary-fitted, orthogonal curvilinear coordinates on a staggered Arakawa C-grid. As in the vertical, the horizontal stencil utilizes a centered, second-order finite differences. However, the code is designed to make the implementation of higher order stencils easily. The vertical mixing parameterization in ROMS is defined by local closure schemes. The local closure scheme is based on Generic Length Scale (GLS) parameterization. ROMS numerical domain, shown in Figure 2, encompasses the whole Adriatic basin.

POM is a primitive three-dimensional finite difference model with the complete nonlinear hydro- and thermodynamic. Its physical and numerical properties are described in detail by Blumberg and Mellor (1987[3]). POM numerical domain, shown in 1, encompasses the whole Adriatic basin. The equations which capture the model physics are the traditional equations for conservation of mass, momentum, heat and salt coupled with the equation of state (Mellor, 1991[4]). The equation of state is a modified UNESCO form. The model's prognostic variables are the three components of the velocity field, temperature, salinity and density. In the application to the Adriatic and its coastal areas three simplifying approximations are used: the hydrostatic, Boussinesq and 'f-plane' approximation. Vertical turbulent exchange coefficients are calculated in the model using the second-order turbulence closure submodel 'Level 2 1/2' described in the Mellor and Yamada (1982 [5]) review. The turbulence closure submodel solves two prognostic differential equations for the turbulence kinetic energy and turbulence macroscale. The processes having a spatial scale smaller than the grid mesh size are parameterized in terms of horizontal diffusion, as described by Mellor and Blumberg (1985 [6]).

The horizontal viscosity and diffusivity coefficients are obtained using the Smagorinsky (1993 [7]) horizontal diffusion formulation adapted to the sigma coordinate system (Mellor and Blumberg, 1985 [6]). Besides standard POM version, one of its alternative version was used in the numerical simulations as well. Instead of standard POM centered difference scheme for the advection of tracers, the Smolarkiewicz (1984 [8]) and Smolarkiewicz and Clark (1986 [9]) flux corrected upstream scheme (characterized by small implicit diffusion) was used (Sannino et al., 2002 [10]). The need for an alternative advection scheme arose from the inaccuracy obtained in the temperature and salinity fields in the areas of sharp horizontal and vertical density gradients (Zavatarelli and Pinardi, 2003 [11]). Numerous POM applications were already made for the Adriatic, namely for the whole basin (Zavatarelli and Pinardi, 2003 [11]), for the shelf area (Beg Paklar et al., 2001; 2005; 2008 [12,13]), for the limited domain in the east coastal waters (Orlić et al., 2006 [14]) and small basins along the eastern coast (e.g. Beg Paklar et al., 2002, Dadić et al., 2006 [15,16]). Adriatic applications range from the simplified process-oriented studies (Beg Paklar et al., 2005; Orlić et al., 2007 [17,18]) to the realistic simulations used in the Adriatic prognostic system within ADRICOSM project (Orlić et al., 2006 [14]).

Within the MIKE 3 FM and MIKE 3 system (DHIgroup Water, 2008) three modules have been used; 3D hydrodynamic module for the computation of levels, current velocities, S and T; convective-dispersive (AD) module for computation of transport and concentrations; and ecological module (WQ) for computation of the rate of concentration changes of DO, FC and FS.

MIKE 3 FM hydrodynamic module is based on the numerical solution of the three-dimensional incompressible Reynolds averaged Navier-Stokes equations invoking the assumptions of Boussinesq and of hydrostatic pressure. Thus, the model consists of continuity, momentum, temperature, salinity and density equations and is closed by a turbulent closure scheme. The free surface is taken into account using a sigma-coordinate transformation approach. The spatial discretization of the primitive equations is performed using a cell-centered finite volume method. The spatial domain is discretized by subdivision of the continuum into non-overlapping element/cells. In the horizontal plane an unstructured grid is used while in the vertical domain a structured discretization is used. The elements can be prisms or bricks whose horizontal faces are triangles and quadrilateral elements, respectively. An approximate Riemann solver is used for computation of the convective fluxes, which makes it possible to handle discontinues solutions. For the time integration a semi-implicit approach is used where the horizontal terms are treated explicitly and the vertical terms are implicitly. Turbulence module uses k-ε formulation (Rodi, 1980 [19]) in the vertical direction and the Smagorinsky [6] concept in the horizontal direction. The influence of rivers and submarine outfalls is included in the measured values of discharge, velocities, and temperatures, and the salinity is defined as 0 value.

The mathematical foundation in MIKE 3 is the mass conservation equation, the Reynolds-averaged Navier-Stokes equations dimensions, including the effect of turbulence and variable density, together with the conservation equations for salinity and temperature. The hydrodynamics module of MIKE 3 makes use of the so-called Alternating Direction Implicit (ADI) technique to integrate the equations for mass and momentum conservation in the space-time domain. The equation matrices, which result for each direction and each individual grid line, are resolved by a Double Sweep (DS) algorithm. Discretized on the Arakawa C-grid aiming at a second order accuracy on all terms, i.e. "second order" in terms of the discretization error in a Taylor series expansion. For analysis of transported fields 3D QUICKEST-SHARP scheme is used. This scheme belongs to a group of so-called CWC schemes (Consistency With Continuity), designed to be consistent with the continuity equation of the HD module. In most three-dimensional models the fluid is assumed incompressible. However using the divergence-free (incompressible) mass equation, the set of equations will inevitably form a mathematical ill-conditioned problems. In most models this is solved through the hydrostatic assumption whereby the pressure is replaced by information about the surface elevation. In order to retain the full vertical momentum agnation an alternative approach has been adopted in MIKE 3. This approach is known as the artificial compressibility method (Rasmussen, 1993 [20]) in which an artificial compressibility term is introduced whereby the set of equations mathematically speaking becomes hyperbolic dominated.

Initial conditions and atmospheric forcing

Numerical integration with POM model started on 15 August 2007 and it was initialized with mean summer seasonal fields of temperature and salinity on standard oceanographic levels from Dartmouth Adriatic Data Base (DADB). Initial temperature and salinity fields were obtained from the corresponding mean seasonal field by bilinear interpolation into the POM grid. DADB data base is constructed from two existing data sets (Galos, 2000[21]): Mediterranean Oceanographic Data base and Adriatic Sea Temperature, Oxygen and Salinity data set (ATOS2), and its summer season comprises the period from July to September (Cushman-Roisin et al., 2007 [22])..

For the interpolation and extrapolation of the values on the numerical nodes of the model domain MIKE 3 FM and MIKE 3 the objective analysis is used (Bretherton, 1976 ; Thiebaux, 1987 [23,24]). The initial conditions for FK and FS are defined as zero values on whole spatial domains.

For the atmospheric forcing of used oceanographic models (ROMS, POM, MIKE 3 and MIKE 3 FM) the results of the local atmospheric model ALADIN with the spatial resolution of 8 km and temporal resolution of 3 hours are used for all models. Bulk relation, including wind, pressure, temperature, humidity, cloudiness, shortwave radiation is used.

The ALADIN (Aire Limitee Adaptation dinamique et Development InterNational) model, used for the atmospheric forcing of oceanographic models, is a hydrostatic, primitive equation model developed in the framework of an international cooperation involving several National Meteorological Services. The model evolves from the global ARPEGE (Action de Recherche Petite Echelle Grande Echelle) model of Meteo-France (Courtier et al., 1991 [25]), with which it shares most of the physical parameterisations (Cordoneanu and Geleyn, 1998 [26]) and which provides it with the initial and boundary conditions. The main difference for the limited area is that Fourier transformation is used in both horizontal directions, with an extension zone to ensure periodicity (Bubnova et al., 1993 [27]). The model is running operationally on a daily basis on different domains over participating countries. In all cases initial states and time-dependent lateral boundary fields are obtained from the operational outputs of the ARPEGE model. The model has been used for operational purposes at the Meteorological and Hydrological Service of Croatia and, in particular, it has been applied for studying the mesoscale environment in which severe winds in the Adriatic region occur (Brzović, 1999; Brzović and Strelec-Mahović, 1999 [28,29]).

Rivers are introduced into oceanographic models via a continuity equation by means of a member which represents added volume of the water in the surface layer with zero salinity and measured temperature that are different from the sea ambient temperature. The real data on the discharges of the rivers that have confluence on the eastern side of the Adriatic as well as those concerning the river Po are used, while the remaining rivers that have confluence on the western side of the Adriatic are "scaled" according to the river Po .

Submarine outfalls

Numerical models MIKE 3 and MIKE 3 FM is also used to carry out numerical analysis of concentration field dynamics of faecal coliforms and streptococcus.

The transport of the mass of dissolved and suspended matter discharged into the sea from submarine outfalls is a complex hydrodynamic process, which is due to various dominant factors in the very process of mixing usually divided into the near-field and far-field zones (Fisher, 1979 [30]). In the near field zone immediately after the discharge of effluent from the diffuser nozzles of the submarine outfall prevails the mode with the dominant effect of the quantity of motion, and then follows a zone with dominant buoyant effect in the case when there is presence of initial difference in the density of sea water and discharged effluent. The buoyant jet that spreads through the non-stratified sea water column, when encountering a horizontal border, such as sea water surface or density discontinuity, experiences transition into the far-field zone (Jirka, Akar, 1994 [31]). Depending on the strength of the source of the initial flow of the buoyancy action and ambient currents in the transition region, the occurrence of the "upward" spreading of effluent plume is also possible up to the position at which stagnation occurs due to the action of in-coming currents. Generally speaking, jets with strong buoyant action and low velocities at the place of encounter with the horizontal border of the sea surface or the picnoclyne will have a tendency of spreading upwards (Jirka, Akar, 1994 [32]). Further spreading within the far-field zone is realized in the form of the plume that changes its dimensions, and thus also the concentrations of the transported effluent content in the horizontal and vertical directions. The intensity of these changes in all directions depends on the remaining difference in the density between the plume and the recipient, and on the recipient's currents velocities and turbulence. The near-field region is under the influence of the design solution for the submarine outfall's diffuser section and is still under the "control" of the man. With the transition into the far-field zone, the spreading of the effluent plume exclusively depends on the conditions of the environment that is outside the reach of the direct influence of the man. Due to these very reasons, the intention was to reproduce with the numerical models the field of currents in the far-field zone as realistically as possible.

Numerical analyses of the effluent spreading, primarily faecal coliforms and streptococci, have been conducted for 58 submarine outfalls that are planned to be constructed during the implementation of the Adriatic Project, as well as those already existing and covered by the EKO-Kaštela Bay Project (Figure 5). For the planned public sewage systems, the initial concentration of 10^7 FC/100ml and $2*10^6$ FS/100ml (UNEP, 1995), or if the biological treatment is planned, 10^6 FC/100ml and $2*10^5$ FS/100ml (UNEP, 1995) were used.

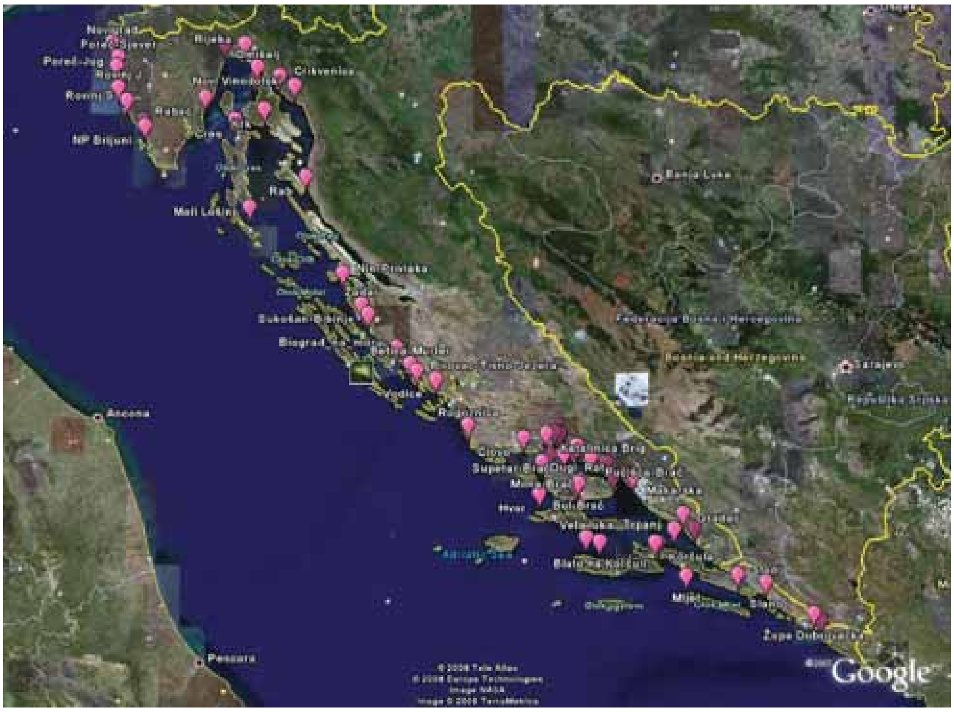


Fig. 5 – Location of submarine outfalls in the region of the local and regional spatial domains of the numerical models MIKE 3 FM and MIKE 3

4. Measurements and modelling data comparison

Comparison of the measured (March 2008) and model (ROMS) values of temperature on positions of oceanographic sites (see figure 1) is given in Figure 6. In Figures 7a,b presented are 2D fields of sea surface temperatures obtained by satellite recording and model ROMS for 18.2.2008.

Monthly averaged model current field for the whole Adriatic area (ROMS – March 2008.) is given in Figure 8. Calibration of models MIKE 3 FM and MIKE 3 is referenced to the results of the measurements with ADCP current meters at the sites defined within this monitoring program. Figures 9 and 10 give the comparison of the measured and modelled (MIKE 3 FM) hourly averaged current velocities at the ADCP current meter sites S2 and S9 (see figure 1).

Presentation of averaged model currents fields at the depth of –8m for time period 13.2.-13.3.2008. at some local models spatial domains (MIKE

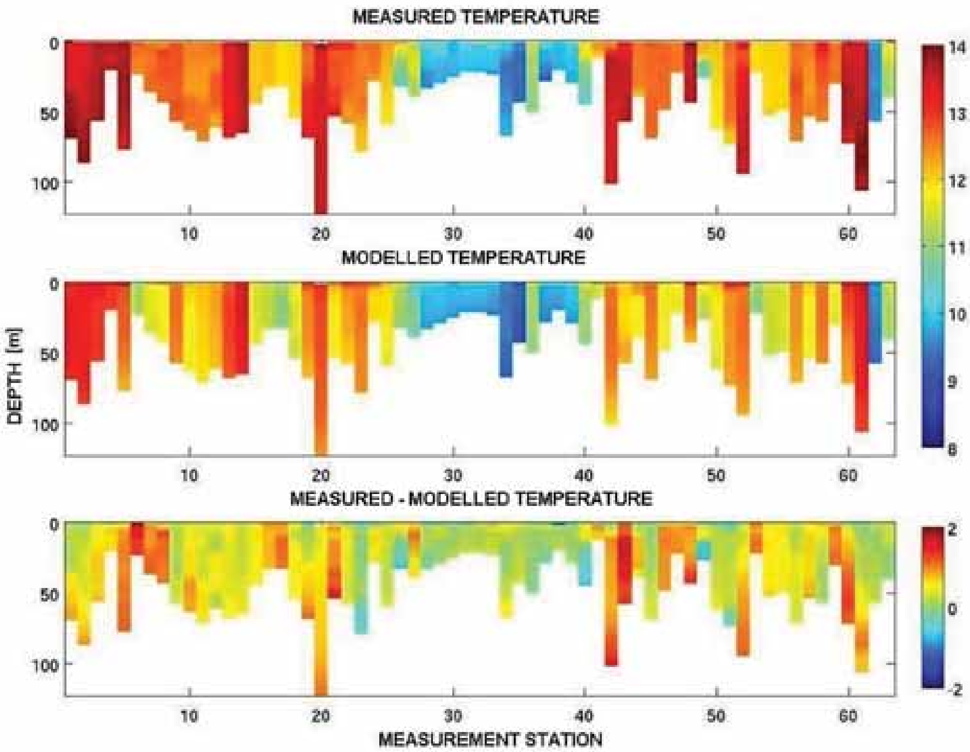


Fig. 6 – Comparison of model (ROMS) and measured verticals for T (13.3.08)

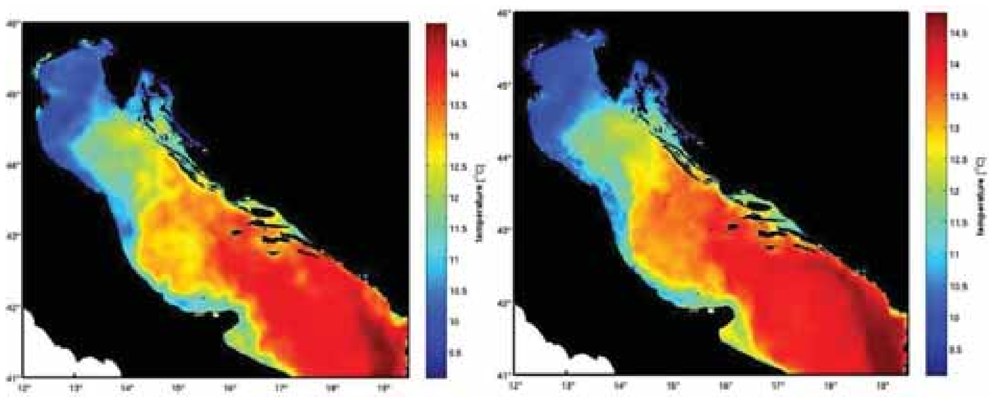


Fig. 7a,b – Presentation of 2D fields of sea surface temperatures obtained by satellite recording for 18/2/2008 (left) and those calculated using model ROMS (right)

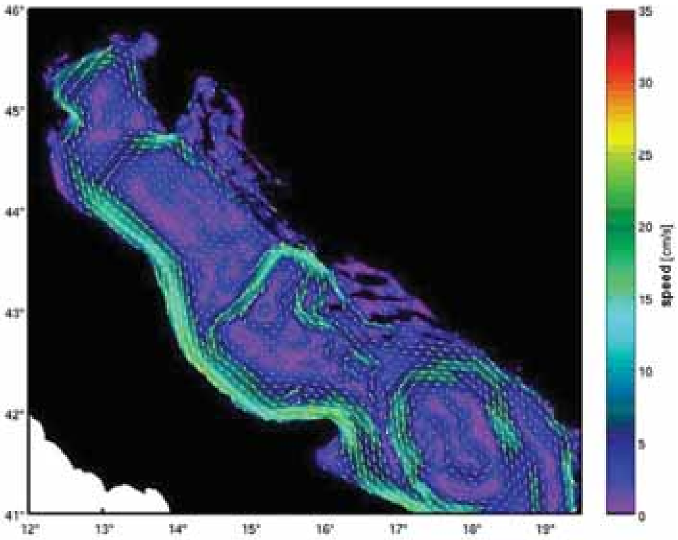


Fig. 8 – Monthly averaged model current field for the whole Adriatic area (ROMS – March 2008.)

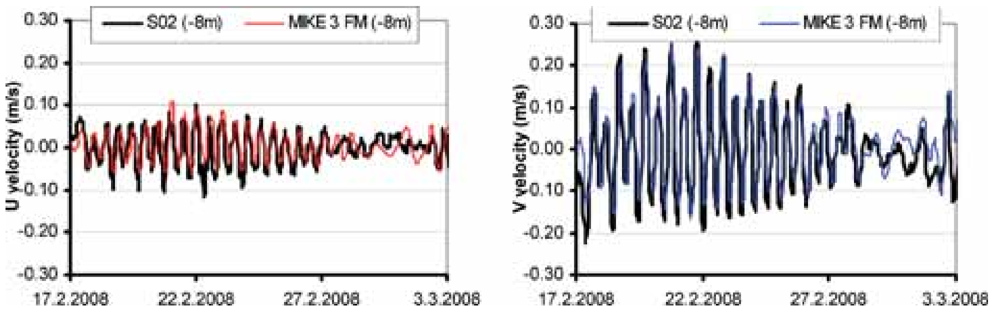


Fig. 9 – Comparison of the measured and modelled (MIKE 3 FM) hourly averaged current velocities at the ADCP current meter site S02 at a depth of –8m

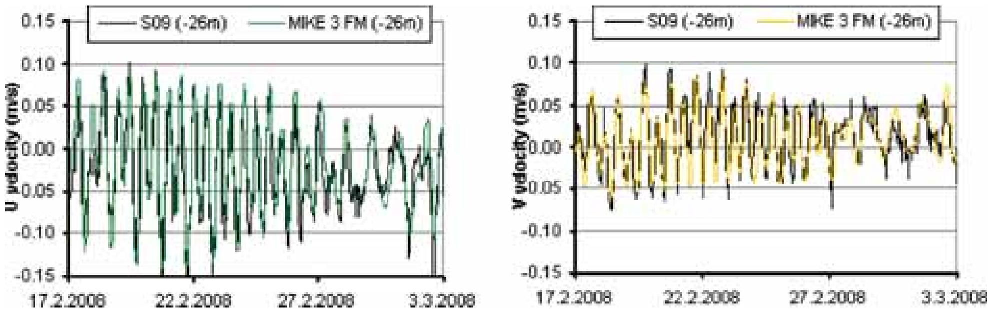


Fig. 10 – Comparison of the measured and modelled (MIKE 3 FM) hourly averaged current velocities at the ADCP current meter site S09 at a depth of –26m

3) is given in Figures 11 through 13. Dissolved oxygen concentration and maximum faecal coliform concentration fields for the same local models spatial domains at the depths of –2m (DO) and –26m (FC) is given below graphical presentations of current fields. Comparison of the measured and modelled (MIKE 3) dissolved oxygen concentration (DO) at the oceanographic sites 5 and 10 for standard oceanographic measurement depths is given on figure 14.

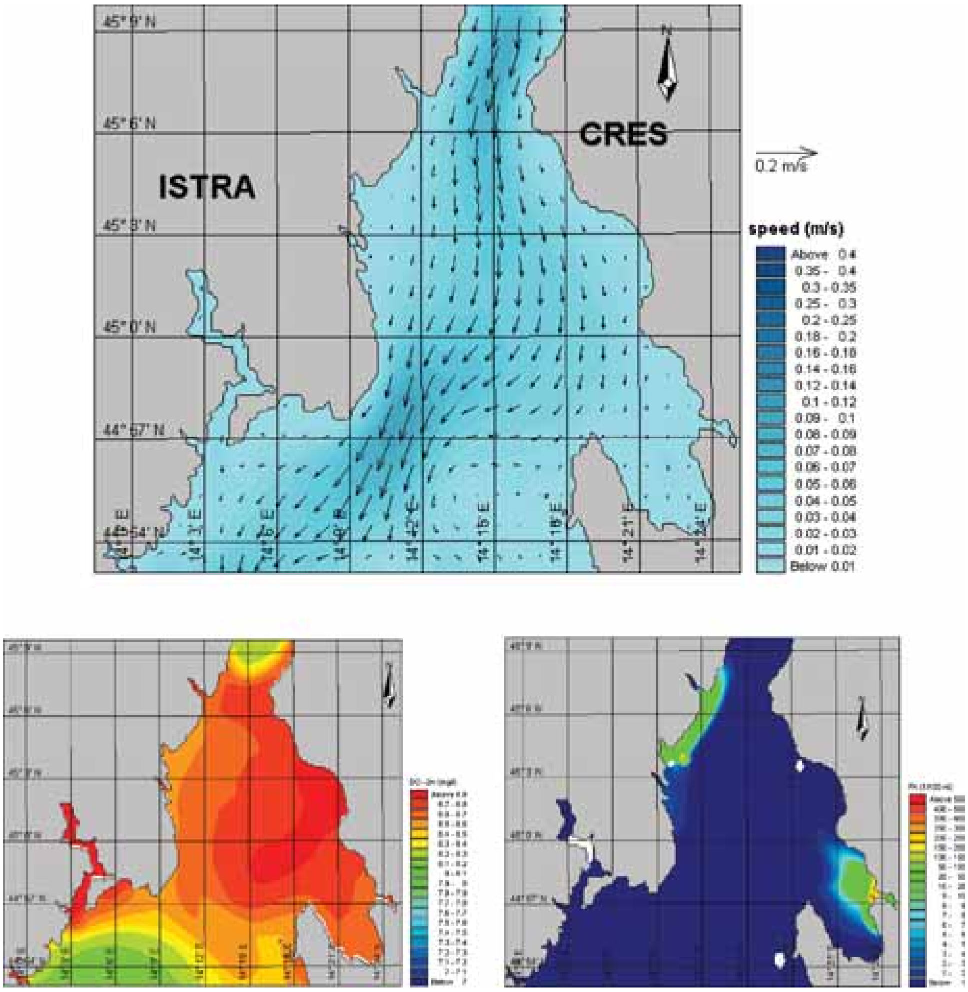


Fig. 11a,b,c – Averaged model currents fields at the depth of –8m for time period 13.2.-13.3.2008. at local domain Kvarner obtained with MIKE 3 (above) ; dissolved oxygen concentration field at the depth of –2m for 13.2.2008. (below left) ; maximum faecal coliform concentration field at the depth of –26m for time period 13.2.-13.3.2008. (below right)

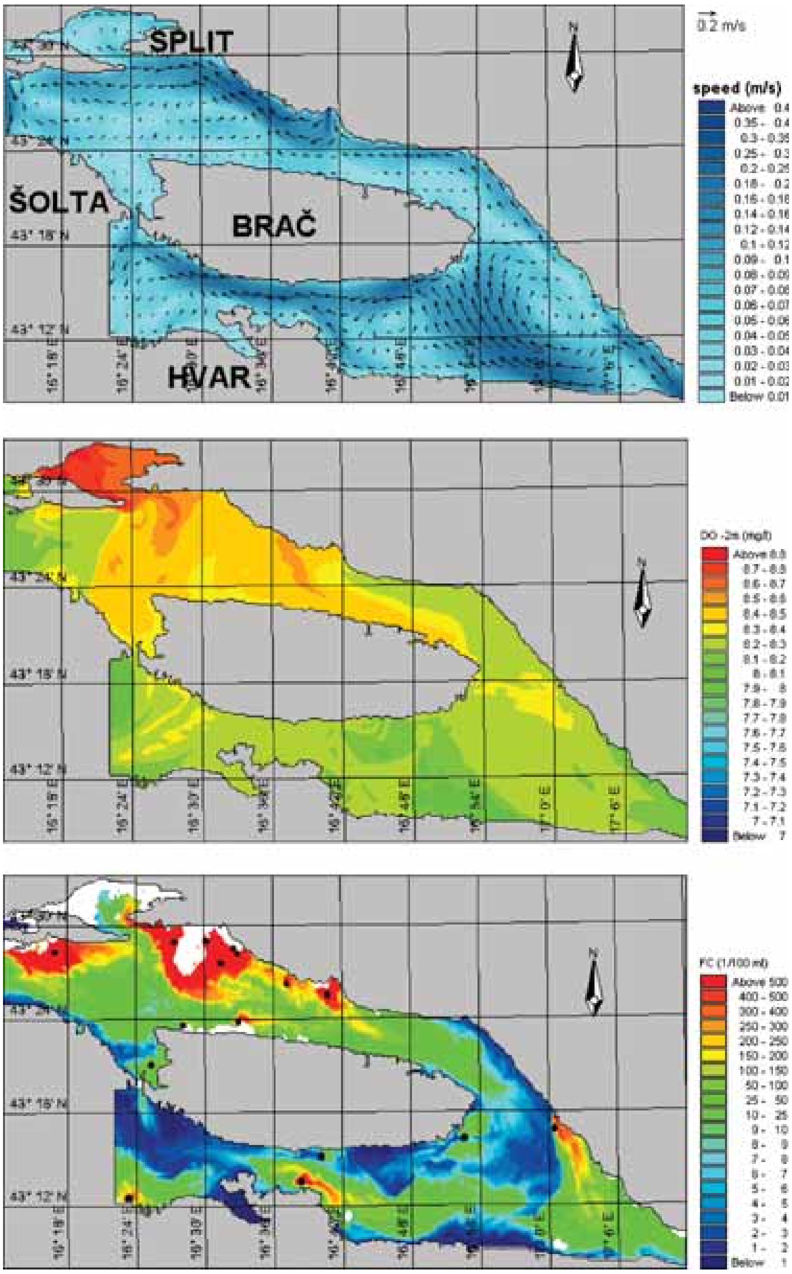


Fig. 12a,b,c – Averaged model currents fields at the depth of –8m for time period 13.2.-13.3.2008. at local domain Split obtained with MIKE 3 (above) ; dissolved oxygen concentration field at the depth of –2m for 13.2.2008. (middle) ; maximum faecal coliform concentration field at the depth of –26m for time period 13.2.-13.3.2008. (below; black circles → submarine outfalls)

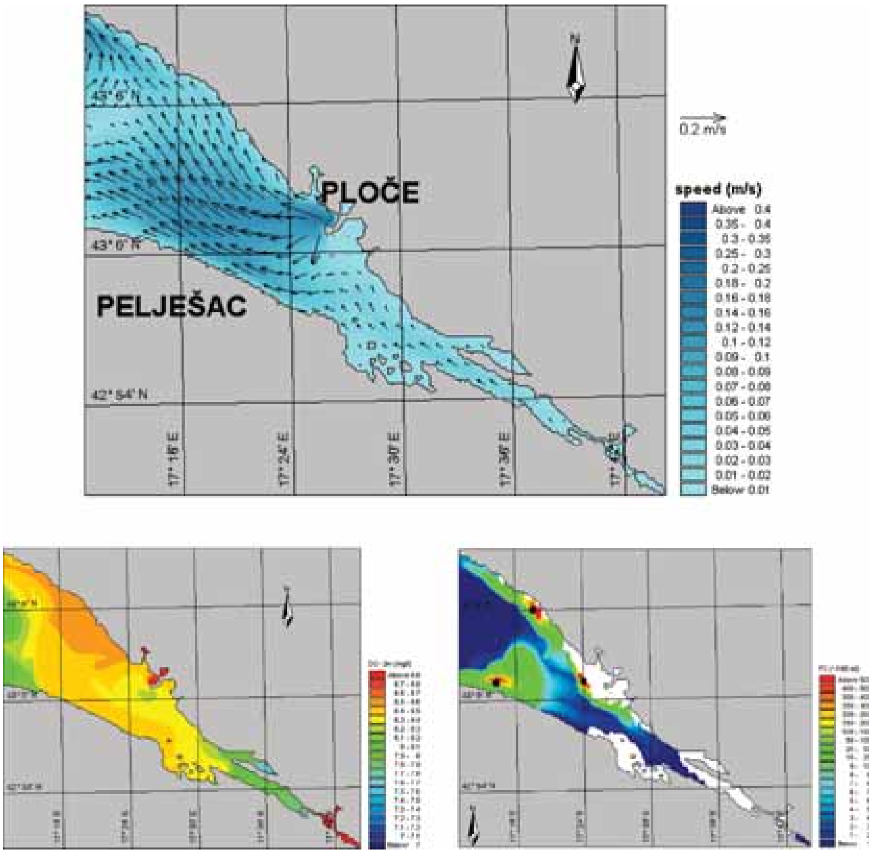


Fig. 13a,b,c – Averaged model currents fields at the depth of –8m for time period 13.2.-13.3.2008. at local domain Ploče obtained with MIKE 3 (above) ; dissolved oxygen concentration field at the depth of –2m for 13.2.2008. (below left); maximum faecal coliform concentration field at the depth of –26m for time period 13.2.-13.3.2008. (below right ; black circles → submarine outfalls)

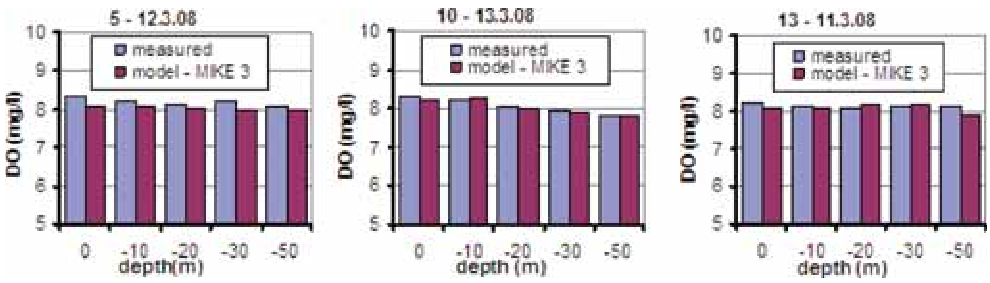


Fig. 14a,b,c – Comparison of the measured and modelled (MIKE 3) dissolved oxygen concentration (DO) at the oceanographic sites 5,10 and 13 for standard oceanographic measurement depths

5. Conclusion

The proper way of the realization of the Adriatic Sea monitoring program is set by the contract between Ministry of Environmental Protection, Physical Planning and Construction and Consortium (Faculty of Civil Engineering, University of Zagreb (Leading partner), Hydrographic Institute of the Republic of Croatia, Split, Institute of Oceanography and Fisheries, Split, Ruđer Bošković Institute, Centre for Marine Research, Rovinj). This article gives short insight in scope of works related with in-situ measurement and numerical modelling implementation in this monitoring program.

According to the presented results of the monthly averaged current field obtained by the numerical model ROMS main features of circulation pattern for March of 2008. is that stable circulation in the major parts of Adriatic Sea follows f/H (isobaths lines), the mostly pronounced in the southern Adriatic, where model is representing well southern Adriatic circulation pattern connected with the region of high bathymetry gradients. This feature is appearing as well in the region of Jabuka Pit, where again, cyclonic pattern is evident for the same reason as in the southern part of basin. That is a well-known characteristic of the Adriatic circulation during the whole year (Zore, 1956 [33]; Poulain, 2001 [34]). What makes the difference from the standard Adriatic circulation pattern is outflow from the Kvarner Bay into the middle Adria region along with east Istrian coast. This is probably because the strong wind forcing found during this winter, mainly from north-east direction which can be linked to the bura wind. The signal was strong enough to leave signature in the mean circulation field. Another supporting evidence for the argument is seen in the northern Adriatic where we can see cyclonic gyre usually as consequence of strong nonhomogenious rotation in the wind field (strong bura wind in Trieste region, weak at the middle of Istra and strong again in the Senj region).

In positions of current gauging stations, a satisfactory level of similarity was achieved between measured and modelled current velocities (MIKE 3 and MIKE 3 FM), both as regards the intensities and current directions.

Based on the comparison of measured and modelled (MIKE 3 and MIKE 3 FM) values of concentrations of dissolved oxygen (DO), it may be concluded that satisfactory matching of measuring and modelling results has been achieved. Model values generally give slightly reduced values of concentrations, probably due to assuming too high values for “natural” sedimentary oxiogen demand in modelled areas. With regard to the fact that for the respiration rate constant the value of 0 was used, further reduction of respiratory consumption of DO for the purpose of desired increase of DO concentration in bottom layers is not possible.

Although the Ministry of Environment Protection, Regional Development and Construction conducts measuring during the "summer" period (May 1, 2008 – October 1, 2008), which has not yet been included in numerical analyses, the obtained model results already clearly indicate improvement of the present state, which will occur after completed construction of adequate public sewerage systems.

Detailed review of results of measuring carried out so far and numeric analyses is available in References 31-35.

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Proposal of Conclusions

1. Water management strategy

The water management strategy (WMS) was introduced on 15 July 2008 on the 5th session of the Croatian Parliament as a long-term planning document determining vision, mission, objectives and tasks of the water management state policy. WMS is a framework for the preparation of the strategy and plans of physical planning, environment protection and development of the whole economy and infrastructure activities. *The WMS is coordinated with relevant directives of the European Union making the groundwork for the scheduling of negotiation approaches for front-end treaties. It has a special meaning in the process of prearrangement for front-end treaties with the goal of using the means form the non refundable funds of the European Union.*

WMS gives guidelines of water management development starting from the existing condition of water sectors, development requirements, economic realities of international obligations, needs for conservation and improvement of water conditions and water related ecosystems.

The basic goal of water management (WMS) is the implementation of complete and coordinated water regime on the territory of the Republic of Croatia. In the process of WMS the major water management partners will be: agriculture, power supply, tourism, water traffic, municipal management, physical planning, environmental protection, nature conservation – involving continuous cooperation with educational and research institutions and professional non state associations.

2. Water management in Slovakia

The overview of the hydro engineering aspects of international cooperation on the project of revitalization of cross border rivers resulted in presenting the basic indicators of achieved environmental objectives and water management, landscape conservation, as well as economic and social indicators. The overview pointed at the significance of solving the issues of water management control form both aspects of quality and quantity. The implementation of framework *directives on EU waters refers to the increasing importance of environmental aspects of water management and direction,* with emphasis on renewal of overused or changed international natural watercourses.

3. Water and food production

Due to deteriorated agricultural conditions between 1991 and 2005 the real catchment water fees were reduced. Their purpose was to maintain technical and economic works of hydro ameliorative systems of surface drainage. The result was the reduction of their functionality in relationship to the requirements of timely drainage of excess waters from agricultural and other catchment areas. Since *2006 the funds for the renewal of channel network and corresponding facilities were ensured in the state budget in order to bring them to their design and performance level.* In the years 2006, 2007 and 2008 from the total of 24 670 km of amelioration channels of the IIIrd and IVth order the renewal of 10 791 km was carried out – which is 43,7 percent from the total needs. *Unfortunately, the drain outlets were damaged or demolished on this part of the amelioration channels of the IIIrd and IVth order. It resulted in the deterioration of the ground drainage system. It is necessary to create legal and material basis for the implementation of the Regulation of technical, economic and other conditions of maintenance and organization of the irrigation and drainage systems.*

In November of 2005 the Government of the Republic of Croatia accepted the *National project of irrigation and agricultural soil and water management, which involved* 45 local professionals and researches from 10 institutions and consultants from Italy as well. The irrigation plans for 17 provinces were created and accepted by responsible institutions by the end of 2008.From 2005 until the end of 2008 68 preliminary and main designs of irrigation systems in 15 provinces were created. *A special meaning is contributed to the activities and scheduling of 4 national and several pilot projects for provinces.* The renovation and construction of facilities and irrigation systems on 14 locations in 11 provinces are underway – the completion of which and start up of operation is scheduled on 35000 ha of agricultural surfaces until the end of 1010.

4. Water and energy production

Over many decades of investigating Croatian hydro energy potentials a series of studies and solutions were created as a basis for evaluation and utilization of hydro energy perspectives. In compliance with it technical and financial conditions of constructing small hydro power stations for the use of remaining hydro potentials should be developed. The usable water potentials of the Republic of Croatia are estimated at 12,45 TWh/a year, and the current usability is 49 %. The small watercourses dispose of 10 % of the total hydro potentials. Basing on investigations on 20 small watercourses 60 micro locations for the construction of small hydro power stations are planned. Due to relatively low installed power and low annual production the construction of small hydro power stations is achievable according to the programme of stimulating electrical energy production in the conditions of the *European Union, and in compliance with existing condition of space and watercourses utilization,* and with the condition of protecting natural characteristics of locations and watercourses.

The requirements for achieving a satisfying water condition contained in the EU's Framework directive on waters (FDW) prescribe the standards that could, strictly applied, slowl lessen the possibility of further utilization and spreading of hydro energy. *The implementation of the EU's FDW in Europe differs currently a lot, but there is an endeavour to find a compromise between hydro energy and strict ecological requirements.*

5. Water – Croatian export product

The Republic of Croatia in the Adriatic belt includes significant water abundance in natural sources and hydro energy facilities whose machinery compartments are located in the coastal region. After being exploited for electrical energy production over 260 m3/s of water runs off after into the sea. Sufficient high quality water surpluses for export can be ensured through rational exploitation, and particularly through the sanation of losses in distribution networks. This is particularly significant for protection, as the hydro engineering systems do not have to meet preventive protection requirements unless the part of water volume is used in water supply. It refers specially to the springs of the *Ombla river and hydro power plant Plat*, where the whole catchment area is located in neighbouring country, and the protection of water resources depends on regulations which are not under control of Croatia. Among mentioned water sources the highest quality springs are Novljanska Žrnovnica, which could be responsible for the water supply of northern and middle Adriatic islands due to their free capacities, and in the combinations with Rijeka's water sources it could be even capable for transportation on remote destinations. The potential water market is certainly the Mediterranean, where the water transportation has been already in use, and solutions for water surplus transportation on the free market should be devised.

Water transportation is becoming increasingly modernized, efficient and more economical. The water supply of Adriatic distant islands where water is indispensable for development should be involved into the system. The conclusion can be drawn that the water surpluses in Croatia as renewable natural resources of high quality should be included into economic activities.

6. Inland navigable waterways and ports in Croatia

The high priority issue is to complete research and project documentation for the start-up of the Danube-*Sava multipurpose canal (DSMC), the significance of which means*:

– shortening of the navigable route for 417 km in direction of western Europe and for 85 km in direction of Eastern Europe.
– development of agriculture through creation of conditions for extension of surface and ground drainage systems, and irrigation of 36000 ha
– creation of conditions for water regime maintenance according to the needs of optimal forest vegetation development, on the catchments of Biđ,Bosut, Spačva and Studva.
– enrichment of small waters of the rivers Biđ, Bosut, Studva and Vuka – environmental impact,
– urbanism and municipal development

The inland waterway ports are the key elements of the total transportation system of inland navigation, on which the performance of the complete transport process becomes dependable. The European Union orientation is to set the balance of the traffic development for the long term period with the emphasis on the inland waterways and railway as transportation alternatives. The development of the Sava's port system is connected with its links with the Danubian part (short-term Sava or long-term DSMC).

An important shift in Croatian strategic traffic policy is the following:

The implementation of 580 km traffic corridor *Podunavlje-Jadran:* 61,4 km Danube-Sava canal classV b, 306 km of trained or canalized river of Sava from Šamac to Sisak class IV, class V a or class Vb, 210 km=160 km+50 km two track railway Sisak-Zagreb-Rijeka. The regulation of navigable waterways on the rivers (Sava, Drava and DSMC) is in compliance with declared classes of AGM agreement on international inland waterways.

7. Water supply of settlements in Croatia

The requirements of water supply for population and economy has to be met in the most adequate way. As in the other exploitation modes one part of water is getting lost, and the other is being polluted through waste materials, then returned into watercourses or the sea while polluting or degrading them, which leads to deterioration of water exploitation in all aspects. The water intake, its transportation, exploitation and pollution are a complex issue which should be adequately solved. Water exploitation development, taking into consideration the sustainability principle, should be directed to maintenance and promotion of today's systems efficiency, and toward construction of new systems, creation of a needed framework for society's development and economy avoiding disagreements between users' interests while creating strategic goals. Sufficient high quality waters form the existing or new sources should be ensured with strict conduction of protection measures in the zones of sanitary protection for the public water supply requirements. The conditions should be fulfilled to raise the average supply in the next investment cycle to 85-90% supply from the public water supply systems. The water supply systems should: upgrade management, increase the exploitation and supply safety level, ensure the needed water quality for all users, and depending on the raw water quality to conduct water processing, to rationally use water quantities in general, particularly in tourist areas and on the islands. Through larger investments water losses should be gradually reduced from the system of public water supply with better control and raising the consciousness of population about the significance of rational water usage, etc.

The construction of the regional water supply system of the Eastern Slavonia enables the water supply of the area with endangered water quality and featuring a series of inadequate local systems. The concept of the system with all specific features (lowland system, large area, existing constructability) enable water supply of up to 300 l/s already in current condition of constructability, with extension and modular enlargement on the whole area. The basic precondition of the quality functioning of such regional system is the establishment of the municipal sector and personnel capable of coping with challenges and requirements of such a system (GIS, NUS, modelling). Through further system supervision, which means following the development of consumption over time and operations modelling it will become possible to modularly extend the system on the locations of planned structures and to interpolate new facilities (pumping stations, water tanks) in the required places.

8. Water protection in the Republic of Croatia

Water protection is one of the basic activities in the water management. Due to its vital function for the man and exponential development of the human society it has the perspective of taking over the leading role. It bases on the regulations of Law on Waters, plans of governing the water areas and on the rules of protecting water from pollution, and considering other documents that, among other things, regulate the water protection such as: Law on Protection of Nature, Law on Physical Planning and Construction*, Strategy of Physical Planning of the Republic of Croatia, Law on the Protection of Environment, National Strategy of Environment Protection and National Plan of Environmental Impact, and Law on Municipal Management. Ground waters make around* 12% from the total water volume in Croatia, but in public water supply participate with only 90% of captured volume. Natural quality of ground water is generally good. There are specific problems in the Black Sea catchment with the water quality from some alluvial aquifers due to increased contents of iron, manganese, and accompanying elements, which are the consequence of reductive conditions in the aquifers. In the Adriatic catchment temporary muddying and microbiological water pollution following heavy precipitation present specific problems. Strategic reserves of ground water should be defined so as to ensure long-term water supply on the whole territory of Croatia. The basic precondition for protection of water source is ensuring water protected areas for each source and carrying out prescribed protection measures. The decision on proclaiming the zones of sanitary protection are reached by local self-government units, who do not implement them due to often unsettled financing and lack of professionals who should care about decision's implementation. Because of inconsequent implementation of prescribed protection measures, e.g. lack of sanation of existing polluters, even in cases when decisions on the sanitary protection zones are reached, ground waters are still inadequately protected.

Those documents are the starting point in upgrading of Croatian regulations related to ground water protection. One should also consider the fact that the regulations do not include the requirement of determining the zone of sanitary protection for well areas and spring water intakes. Therefore, the rational solutions should be found that would not limit the development of economy, transportation and power supply facilities and infrastructure, and which will adequately protect ground water and facilitate their practical implementation.

According to the proposal of papers' co-authors and discussion participants summarized by the Head of the Organization committee

Prof. **Josip Marušić**, Ph.D.
Zagreb, February 27, 2009

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Process Color Management for Producing Double Images

Abstract

Studying the way printing inks behave under the influence of light in the area from 100 to 1000 nm has given space for new proposals and document protection methods as well as controlling information produced in the form of graphics. Each color has its own savevalue of response and its own reflection and light absorption characteristics. Printing inks cyan, magenta, yellow and carbon black are the basics for today's color printing. Many studies have proven that the application of the listed colors is satisfactory for color reproduction visible in the human eye visibility range. Due to the fact that these colors respond differently in the IR area, algorithms have been set for controlling multiple RGB/CMYK separations with the goal being to create “infrared graphics”.The subject of our research and innovations is two images being reproduced simultaneously with the same colors and in the same place, of which one is visible in daylight and the other under IR light. This thesis has been put forward and then proven on basis of experiments. Finally it has been applied in many designs: first in printing securities and now in general graphics and industrial design. The idea of “double separation” has been introduced, the procedure of CMYKIR color separation. Algorithms have been developed

for integrating several original images that are either for pixel images, vector images or algorithm images. This report contains demonstrations with various types of merging, as well as individualized solutions in infrared graphics. No such research work has been carried out to date. Only IR graphics in the form of a single IR image is applied in banknotes, and as one spot color only that is in comparison of minor effect, without theoretical or software basis. This report shows that an unlimited number of color tones may be applied in one and the same print, and each tone can have multiple visibility characteristics in the planned wavelengths. Response, reflection and absorption, infrared effect is registered with instruments – a camera that has an IR source. This report contains presentations of relations in color arranging basics with double characteristics and the formalism for explaining the interdependency of color tones in the visible and the infrared areas.

1. Introduction

Human vision is defined in the range of 400 to 700 nm. Color printing is achieved with the process CMYK components. Good-quality color printing covers more narrower range of wave lengths as human eye can not see some of these printing inks neither above 600 nm. The properties of the printing CMYK inks with different preservation and the losing in electromagnetic radiation, has been base of the managing the visibility of information in printed works.

In printing securities and documents the specific characteristic of certain ink is used in the range from 100 to 1000 nm. Properties of these colors are not published. These are spot colors prepared for each special graphics. A graphic containing infrared color is registered instrumentally with IR cameras [1]. This paper is on the method of mixing colors with the goal to have each color tone appear in the near IR area from 700 to 1000 nm, having intensity from zero to "their maximum". The condition is that colors derived in such a way should not alter the color experience in the range of visibility [2]. The colors that carry image information instrumentally seen under IR light are named for the needs of this paper as – IR colors and the graphic work produced in such a way – IR graphics.

We are introducing the method of color separation named CMYKIR with which it is possible to achieve three characteristics in the produced print. The first is graphics recognized under IR light only. The second is graphics observed under IR light and daylight. And the third is graphics seen in daylight only. Only standard printing inks are used in CMYKIR separation [3]. Thus infrared security protection is introduced in printing all graphic products without enhancing production costs.

Algorithms called double separation have been created where two sources of information are used. The first source is the image whose reproduction we wish to see in daylight. The second source is the image incorporated into the first image with the goal to be recognized under infrared light. This *IR information* may be defined as: pixel graphics, textual graphics, vector drawing taken from an independent digital base, individualized data or generated with computer graphics algorithms.

2. Graphics invisible in daylight, visible under IR light

The color tone may be shown with printing techniques using only Cyan, Magenta and Yellow. A graphic produced in this manner does not respond under IR light amounting to over 750 nm. The same color tone may be obtained with diminished CMY ink values and adding *carbon process black ink* let us mark it as K. This component will provoke the printed graphic's appearance in the IR area [4]. Changes of color responses after scanning IR images are explored in the wavelength range from 570 to 830 nanometer.

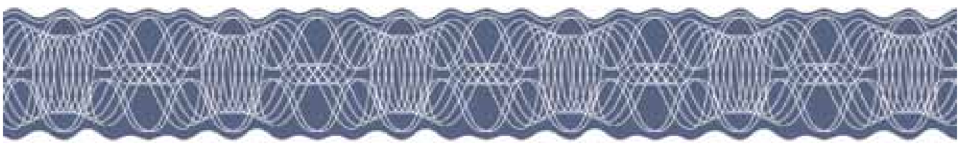


Fig. 1 – Security graphics with CMYKIR design

The frieze is a typical graphic on security documents. In Fig. 1 the frieze hides the text information. Surrounding the text is gradually lost as increasing near infrared wavelength. On wavelengths over 750 nm remains the only text that has been designed with the colors visible in the IR range (Fig. 2). Print of frieze in Fig. 1 is designed with two colors of equal hue, which would in conventional security printing meant as a two-spot colors.

Fig. 2 – Security graphics frieze in 570 nm, 645 nm, 715 nm and 830 nm

Words SECURITY GRAPHIC is colored with color $X_{\max}^{Xeikon4}$ and the backgrund area is colored with $X_0^{Xeikon4}$. Both colors have the same values in color systems that define color in the human eye's vision range: RGB, HSB and Lab. The visual area is determined with V matrix:

$$V = \begin{bmatrix} R & H^0 & L \\ G & S\% & a \\ B & B\% & b \end{bmatrix}.$$

The separation and transition in the CMYK system define the vectors X:

$$X_{\max}^{colorsetting} = \begin{bmatrix} C \\ M \\ Y \\ K\max \end{bmatrix}; \qquad X_0^{colorsetting} = \begin{bmatrix} C \\ M \\ Y \\ K=0 \end{bmatrix}.$$

Colors in Fig. 1 have value: $V_1 = \begin{bmatrix} 85 & 220 & 41 \\ 100 & 35 & -2 \\ 130 & 51 & -21 \end{bmatrix}$. In the CMYK , color is achieved with dual values:

$$X_0^{Xeikon\,4} = \begin{bmatrix} 70 \\ 51 \\ 22 \\ 0 \end{bmatrix} \text{ invisible under IR light (background), and}$$

$$X_{\max}^{Xeikon\,4} = \begin{bmatrix} 60 \\ 35 \\ 0 \\ 41 \end{bmatrix} \text{ visible under IR light (text).}$$

Words SECURITY GRAPHIC have karbon K component and remains visible under IR light. This separation begins with the 550 nm and the difference is increased to the moment of complete experience of losing information that is planned to be visible only in daylight. Loss of certain CMY colors are not the same. Farthest remains cyan that response and over 700 nm. Because the background and text are designed with the same tone color but with different mixed CMYK components, our eyes do not recognize the words in the daylight.

3. Discussion on color settings for V1 color

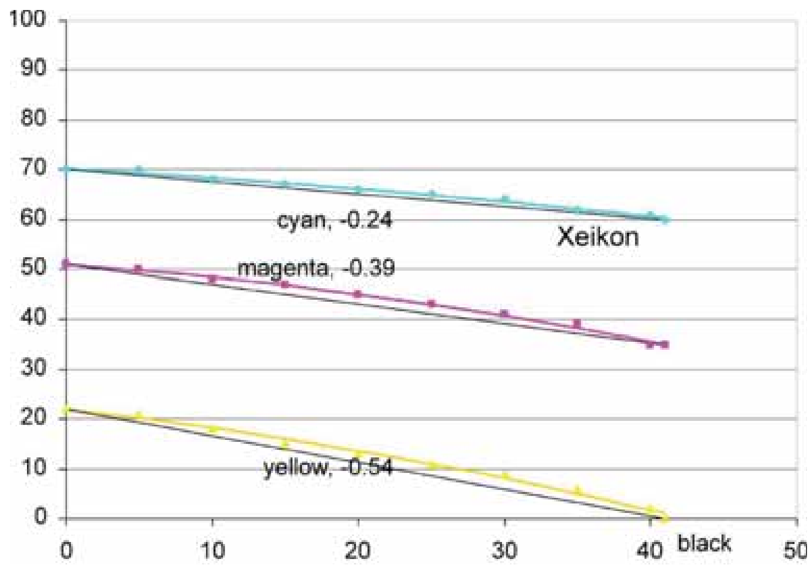
The conventional separation theory points to the fact that the maximum K component will be that value which equals to the lowest value between $C_0M_0Y_0$. Real-life printing varies in respect to this assertion and is described through color setting. However, this school assertion directs us towards the fact that IR effect is achieved with that color tone which contains all of the three CMY components for K=0 in order to open the space for replacing CMY components with K. CMYK values depend on the printing conditions. Different values $X_i^{colorsetting}$ of the same color V1 for color settings “Euroscale Uncoated v2” and “Japan Color 2002 Newspaper” are:

$$X_0^{Euro} = \begin{bmatrix} 97 \\ 64 \\ 33 \\ 0 \end{bmatrix}; \qquad X_{\max}^{Euro} = \begin{bmatrix} 63 \\ 29 \\ 0 \\ 46 \end{bmatrix};$$

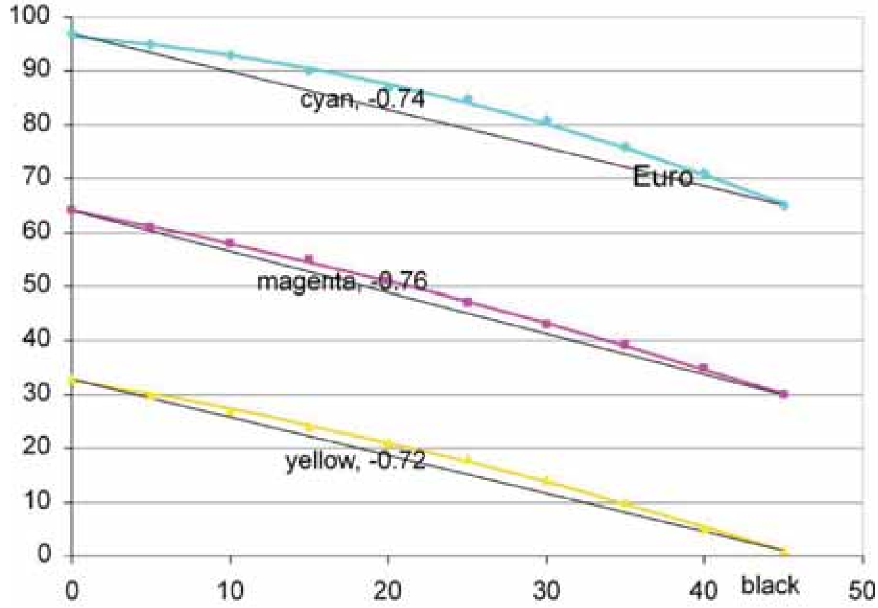
$$X_0^{JapanNP} = \begin{bmatrix} 95 \\ 80 \\ 39 \\ 0 \end{bmatrix}; \qquad X_{\max}^{JapanNP} = \begin{bmatrix} 51 \\ 25 \\ 0 \\ 38 \end{bmatrix}.$$

They are significant differences in printing these three conditions. On the position of color with zero value of the black component, the minimum need for yellow has Xeikon, only 22%. The other two color settings have value 33% and 39%. Deviations from the conventional theory are significant in achieving the maximum black. These are the values: 41%, 46% and 38%. In all three examples is expected this event for the yellow color because her presence was at least at the beginning of the separation of the K value is zero. Yellow descent has a coefficient: –0.54, –0.72 and –1.02 respectively for the observed color settings. Similarly, large differences are obtained for the remaining C and M components. The minimum coefficient of descent is in cyan with Xeikon technology, only –0.24. Maximum descent coefficient is in magenta for JapanColorNewspaper and is –1.45. These large differences warning that for each printing system must be accurately determined colorsetting if goal is to achieve high quality ofCMYKIR double separation.

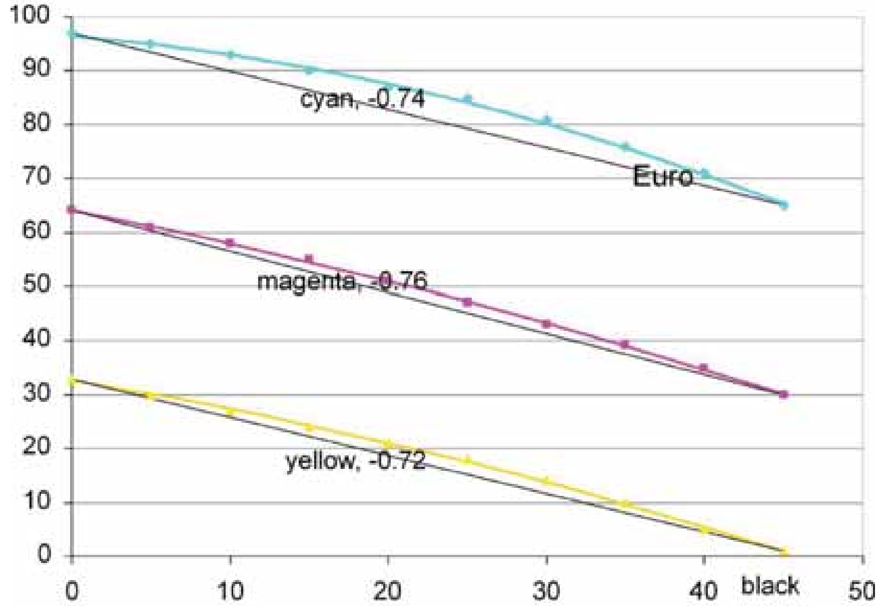
Graphs 1, 2 and 3 shows the dependence of the descent CMY process components with the increase of black component. In all three graphs is maintained the same color V from the frieze example in Fig.1.



Graph 1 – Xeikon color setting for color V_1



Graph 2 – Euroscale Uncoated v2 color setting for color V_1



Graph 3 – Japan Color 2002 Newspaper color setting for color V_1

For each printing technology, paper and inks, are setting up their own relations with the appropriate color setting. Many color hues have not extreme duality and can not be achieved. Conditions of some printing inks and papers does not allow the achievement of dark tones with only CMY components. Such colors were performed with K component and therefore the graphics may not became invisible under infrared light.

4. Multicolor graphic with IR information on constant IR intensity

With the K component is controlled response of the infrared effect. The subject of this report is the ability to control large number of colors with programmable IR information on the same print. One example is given in Fig. 3 that have been generated with the same congruent model with the same seed (initial random number). Each color has individual value of disappearing under IR light. Instrumental scanning of prints in daylight mode are visualy compared with physical prints.

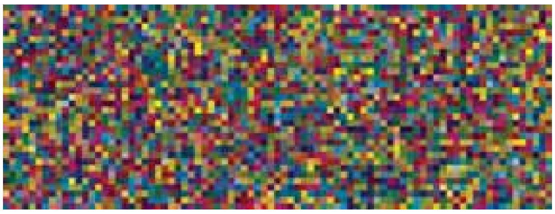


Fig. 3 – Random CMYKIR graphics

This graphic design is based on a randomly selected colors. Some colors have values for K that exceeds 40% and such small squares are seen under IR light. It was the very purposes to have the small text that we do not see in daylight. The text graphics is recognized if the image is placed under IR light. Fig. 4 shows the appearance IR hidden text with scanning of image in wavelenghts: 645 nm, 715 nm, 780 nm and 850 nm.

This example may be checked in the attached image with the infrared camera. We have developed different algorithms for generating graphics called 1000 IR colors. The final graphic is produced with the program taking into consideration information on spots where the black component is necessary, and on spots where this component should not appear.

Fig. 4 – IR scanning: 645 nm, 715 nm, 780 nm i 850 nm.

The model for mixing colors includes extreme situations in order to obtain the graphic's “liveliness” in the visual area. Extreme colors are those that have only two components. The areas invisible under IR light are colors produced from combinations: CM, CY, MY or only from one of the CMY components. On the contrary, colors that should be seen under IR light have been produced by mixing KC, KM and KY. By means of programming it is possible to realize many models for producing graphics with IR effect, so this method is also called “1000 IR colors”.

Since the selection of colors is random, it was necessary to create a program that has a general solution for color separation, which takes into account the two information. The first is the information randomly selected color itself and the second information is preset intensity from image that must be achieved IR effect. The third part is added to the algorithm, which corrects originally selected color if it does not have enough space to achieve IR effect on the preset element of the image B.

5. 1000 IR colors in their continuous intensity

The abstract background with an enormous number of colors can hide another image (Fig. 5, Fig. 6). A quantity of K ink is determined for each color that is the same as in the other image. This second picture is called “mask “. The pixel value in the boy portrait has determined the K compo-

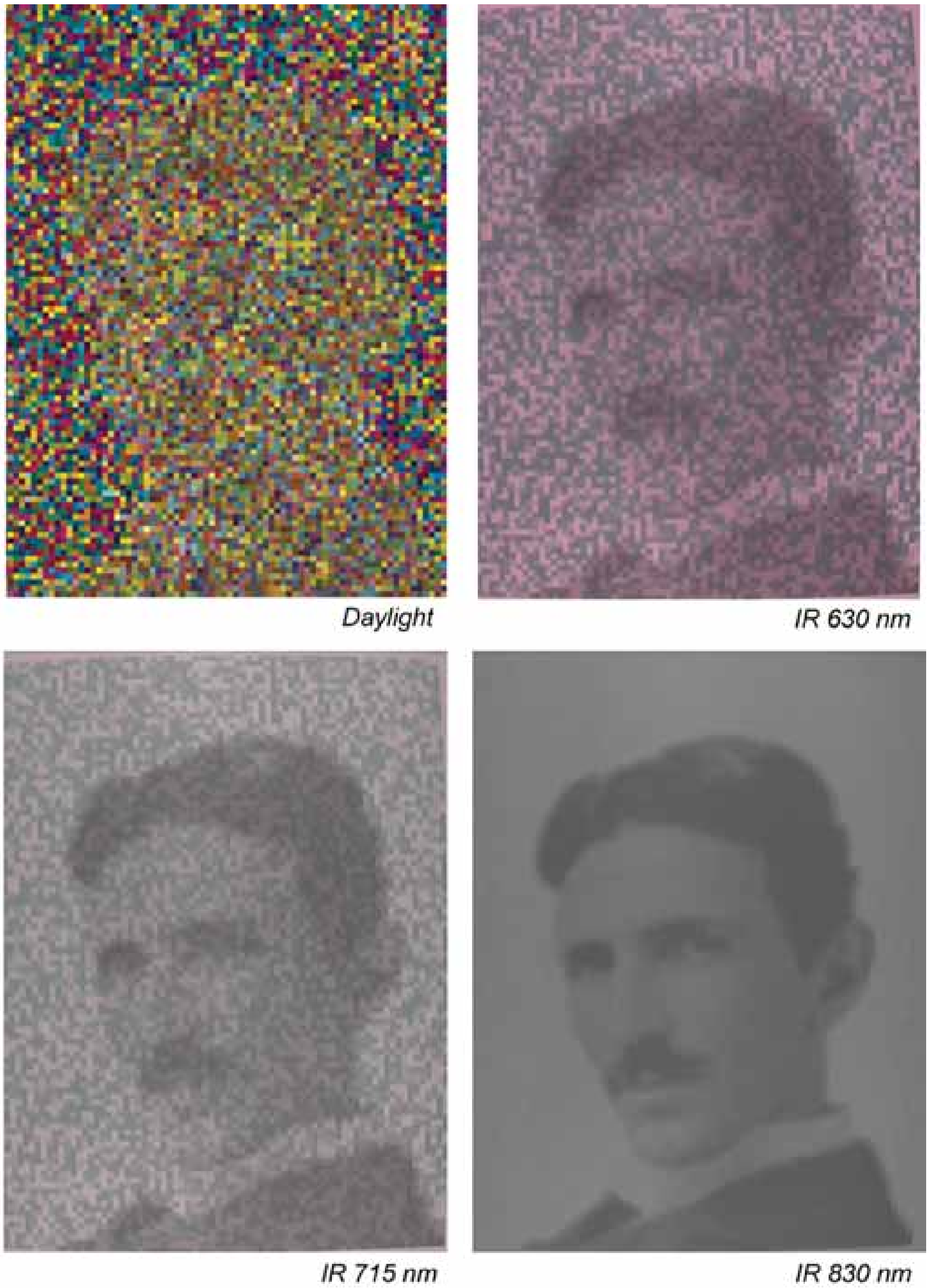


Fig. 5 – Graphics example of Nikola Tesla in “1000 colors” and scann: 630 nm, 715 nm and 830 nm

Fig. 6 – Graphics example of Rudjer Boskovic in "1000 colors" and scann: 630 nm, 715 nm and 830 nm

nent quantity in the multi-color image. Hiding the image, which has continued intensity here is demonstrated. For each color is determined representation of K component continuously from zero to the maximum value. As shown in Graph 1 for V1 color, so the algorithm is formed as a general solution for all tones. As in the example with the numbers, randomly selecting colors is subject to correction due to information about the intensity from B image. "Inverse separation" is introduced. First, the minimum of K components is determined which derives from the image B. At a minimum condition CMY components are randomly added. Sufficient multicolor quantity of prints is controlled statistically. This control is necessary because we do not have "empty" pixels in the image B, which would enable multicolor playfulness.

The multi-color background has been program-derived with the goal to be very colorful in security graphics so as to prevent our eyes tracking among the colors and recognizing hidden information. An IR graphic is designed and incorporated into an image, text, logotype. The procedure is convenient for applying on all graphic products, and it is easily detected whether the graphic is authentic or not. It is applied on packaging material, texts in books, original graphic sheets. Scanning of a CMYK print passes through a RGB color system. The structure of K component division into parts that are seen and those not seen under IR light is thus lost. Repeated separation of RGB into CMYK cannot repeat the color arrangement on basis of the IR effect's original design. The reproductions will lose the information protecting the graphic product through infrared design of the prepress graphic.

6. Double separations

Joining two realistic images of which the first one is the image we wish to see in daylight and the second one is the one we wish to be recognized under IR light is carried out through double separation procedures. The double separations program loading two images A and B (mask). It is conducted through two separations steps. The first procedure is to turn image A from the RGB system into CMYK=0. The next step is to carry out the separation from CMY into CMYK so that the black component quantity is determined by the information on the coverage of the identically positioned pixel in the second image B. The developed software tool is based on the multi-pole regression analysis of measuring a large number of colors after printing. An iterative procedure was developed for adjusting the color tone balancing continuously from the values for K=0 to K=K_{max}. The software tool includes testing of color tables that have been generated randomly in order to achieve as many as possible different situations. The goal was to have image A remain as smooth as possible and the incorporated image B appearing under IR light not to be detected with eyes.

Image B-IR under IR light is not the same as image B that is stored into the double separation program. Intensity of the image B-IR pixels depends on the intensity in image A. The possible replacement with the K component up to the maximum (K_{max}) is determined by the condition that one of the CMY components in image A drops down to zero. The general rule is that the light tones of image A will be recognized in image C. If the intensity in image B is less than K_{max}, then image B is fully transferred into the IR image. The C image in that pixel has a proportional share of replacement with K and an equal diminishing of CMY components. In the security sense, image C carries information of image A and image B.

Demonstration picture of Rudjer Boskovic as image A accepts the separation picture of Nikola Tesla like a mask, creating a picture C for printing (Fig. 7). Print is scanned in 630 nm, 715 nm and 830 nm. The face of Tesla appears and separates from the image A already at 570 nm. Fully separation is showed at 830 nm. Such application scanning in infrared area carries characteristics of many parameters. Besides original images A (Rudjer Boskovic) with the mask B (Nikola Tesla), the result of scanning in the wavelength range between 630 and 850 nm reveals adequacy of general double separation algorithm and quality of color setting.

Gradually appearing image B can be seen with scanning in eight steps at different wavelengths in near infrared range (Fig. 8 and 9). The image of the city Split has built-in silhouette of the city Dubrovnik. Separation of Split and Dubrovnik appears at 600 nm, which is visible range to human eye. Cyan remains visible up to 750 nm. The process yellow color is the first color that disappears from the visual field. Scanning in the daylight not shows presence of image of Dubrovnik.

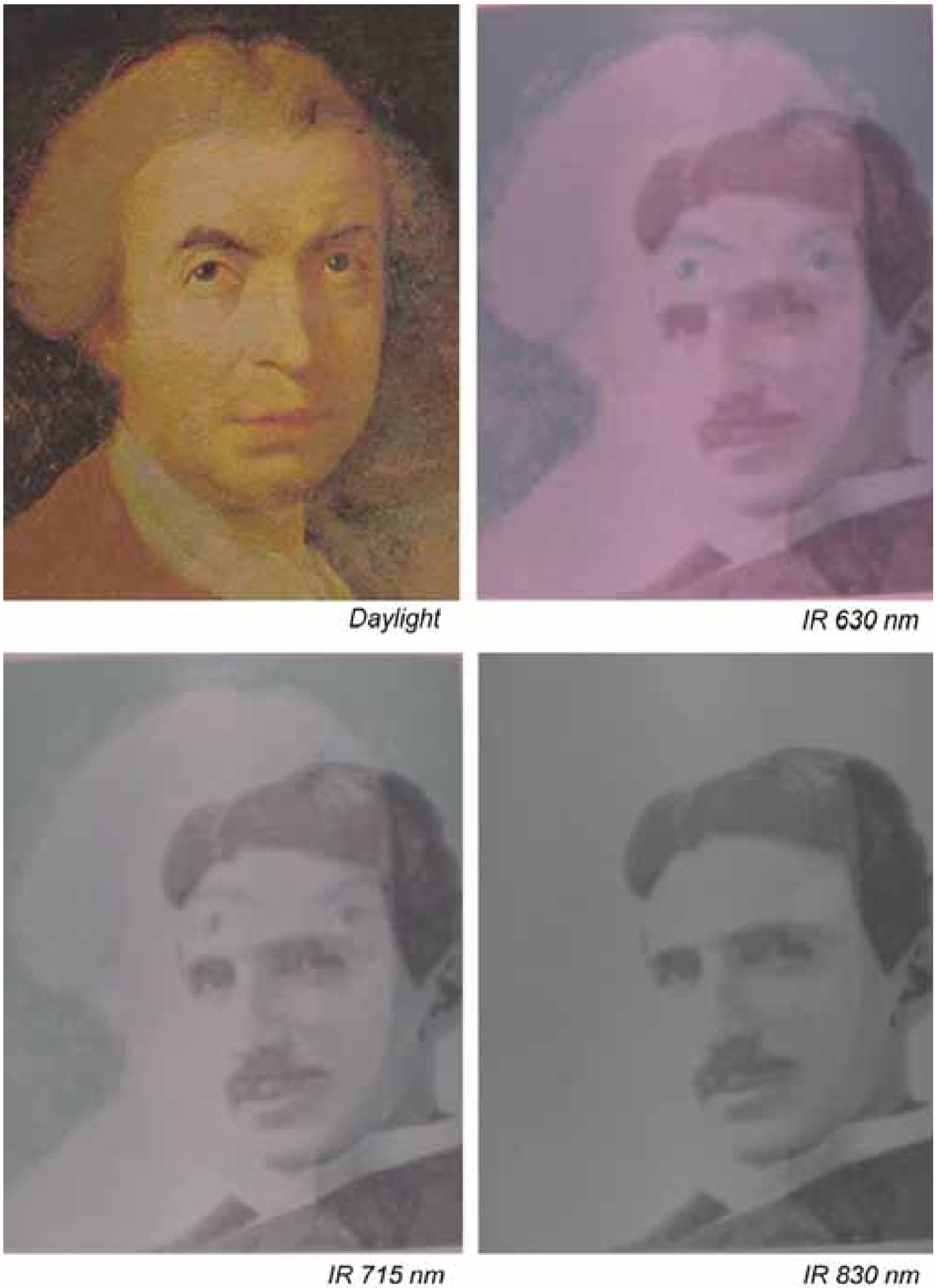


Fig. 7 – Result of double separation C-CMYKIR and scann:
630 nm, 715 nm and 830 nm

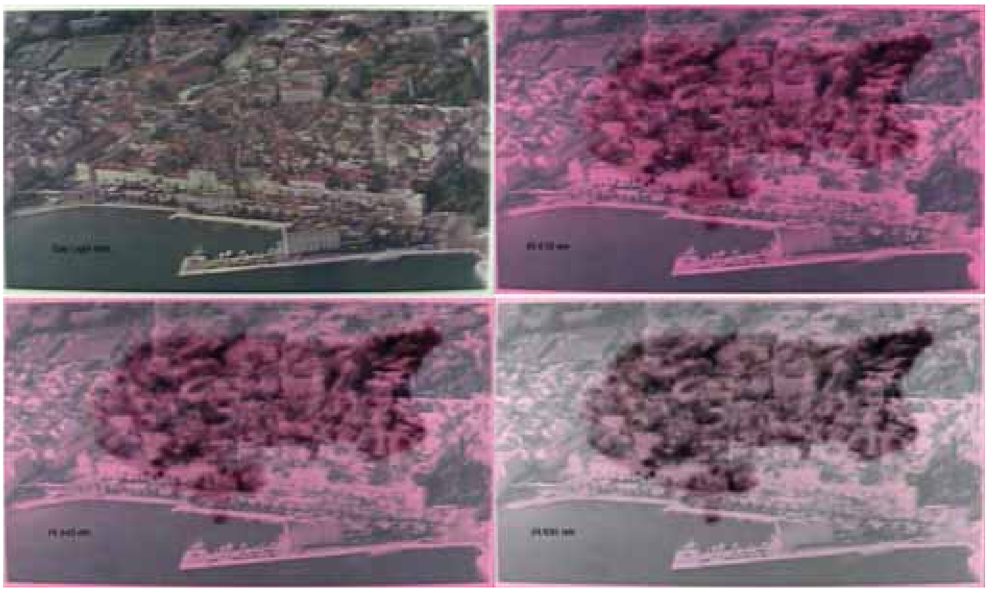


Fig. 8 – Result of double separation of the original A (city Split) with the mask B (city Dubrovnik) and scann: 610 nm, 645 nm, and 695 nm

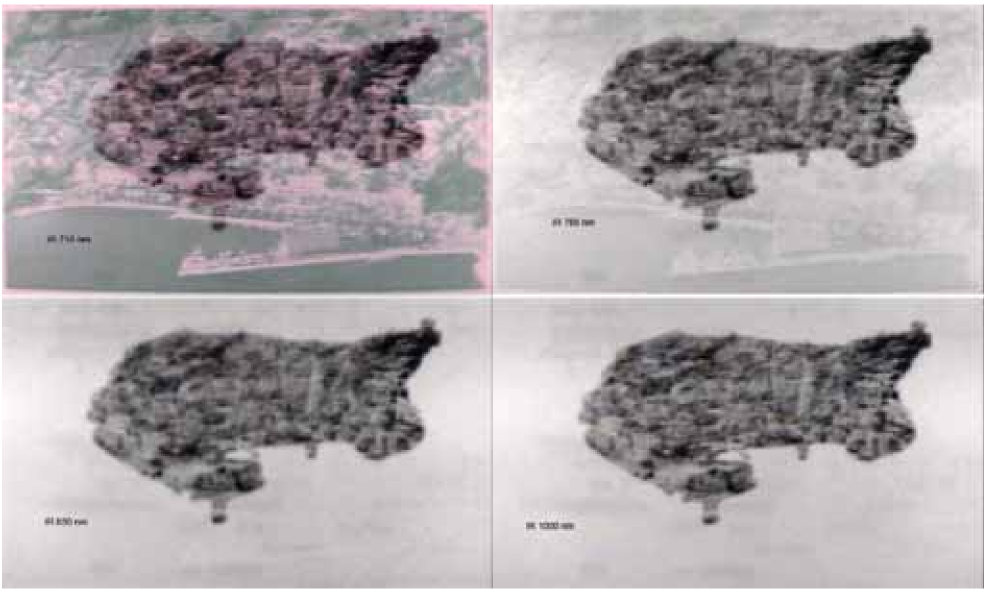


Fig. 9 – Result of double separation of the original A (city Split) with the mask B (city Dubrovnik) under 715 nm, 780 nm, 830 nm and 1000 nm

7. Conclusion

We are introducing a procedure into the system of RGB/CMYK color reproduction separation that enables controlled designing of graphics that appear in the infrared area. CMYKIR separation is meant for creating graphic product protection in the overall assortment: from books, newspapers, documents and securities. Printing is carried out only with CMYK printing inks and this makes multicolor application easier in the security printing. Designing of the security includes masking of the area that is designed as an IR image. This enables individualization of applying the IR effect because besides the basic graphic seen in daylight a graphic is introduced that will continuously appear under IR wavelengths, invisible to the human eye. Instrumental checking of IR graphics presence is carried out with IR cameras and scanners with the possibility of selective wavelength definitions in the near IR range.

IR graphic design is planned like planned separation process with the process inks that carries multiple information depending on the conditions of scanning in the infrared range. The image that is invisible in daylight can be covered with a realistic image, colorful image like result of stohastic pixel algorithm or vector graphics with equalizing different printing inks with the same hue in daylight. New in IR double separation is application of unlimited choice of colors on the same document which simulate spot security IR color. An IR graphic cannot be scanned, therefore it cannot be reproduced in such a manner that the identical IR information is maintained.

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Branko Ladanyi is Professor Emeritus at the Department of Civil, Geological and Mining Engineering of École Polytechnique, Université de Montréal, where he has been involved in teaching and research for over 40 years. He is well known for his work in permafrost engineering, rock mechanics and tunnelling. He has been in charge of the Northern Engineering Research and Documentation Centre of École Polytechnique since 1972. Professor Ladanyi has co-authored, with Prof. O.B. Andersland, a book on Frozen Ground Engineering, now in its second edition, written chapters of several geotechnical books, and published over 200 papers on various topics of geotechnical engineering, with a particular reference to foundations in frozen ground and ice.

During the years, Dr. Ladanyi has received many important scientific awards, such as: the Québec Scientific Award (1974), the R.F. Legget Award of the Canadian Geotechnical Society (1981), the E.E. De Beer Award of the Belgian Geotechnical Society (1987), the E.F. Rice Memorial Lectureship Award of the Technical Council on Cold Regions Engineering of the American Society of Civil Engineers (ASCE) (1991), the Roger J.E. Brown Memorial Award of the Canadian Geotechnical Society (1993), and the Canadian Northern Science Award from the Department of Indian Affairs and Northern Development. More recently, in 2003, he received the Harold R. Peyton Award from the ASCE, "for his continuous work in Cold Regions Engineering", and in 2008 the Julian C. Smith Medal from the Engineering Institute of Canada, for "Achievements in the Development of Canada".

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Reprint from Canadian Geotechnical Journal **42**: 136–146 (2005) where is described last inovation of Prof. Ladanyi

Short- and long-term sharp cone tests in clay

Branko Ladanyi and Hugo Longtin

Abstract: A recently developed in situ testing method, called the sharp cone test, which is in fact a continuous and automated version of the pressuremeter test, consists of pushing a low-angle truncated cone into a smaller diameter prebored or self-bored pilot hole. As the cone descends, it causes a continuous enlargement of the pilot hole, which, with proper instrumentation, can be translated into a relationship between radial pressure and radial (or shear) strain, similar to the expansion curve of a pressuremeter test. The present paper describes the use in the field of two new versions of this instrument: the first one with 2° taper, having on its lateral surface four total pressure transducers and a pore pressure transducer; and the second one with two successive taper angles of 1° and 2°, having five total pressure transducers installed at various distances from the tip. The latter probe was found to be capable of continuously furnishing five points on a pressure-expansion curve, which can be translated into a stress–strain relationship by using conventional pressuremeter data-processing procedures. The first probe, in turn, was used for simultaneously observing the decrease with time of both total lateral pressure and pore pressure during strain-holding periods of the test. In 2002, the two newly designed instruments were tested in a thick layer of saturated clay at a site near Montréal. A comparison of the results with those obtained at the same site by some other types of tests is very encouraging.

Key words: field tests, clay, sharp cone, pressuremeter, short term, long term.

Résumé : Une nouvelle méthode pour la mesure in situ des propriétés mécaniques des sols, appelée « Essai au cône effilé », consiste à pousser dans un trou pilote de plus faible diamètre, pré-foré ou auto-foré, une sonde cylindrique, légèrement effilée. En descendant, cette sonde élargit le trou d'une façon continue, ce qui, avec une instrumentation appropriée installée à sa surface latérale, peut se traduire en une relation entre la pression et la déformation radiale, tel que dans un essai pressiométrique. Dans cet article on présente l'utilisation de deux nouvelles versions de cette sonde: La première avec l'angle d'effilement de 2°, munie de quatre capteurs de pression latérale totale et d'un capteur de pression interstitielle, et la seconde, avec deux angle d'effilement successifs de 1° et 2°, munie de cinq capteurs de pression latérale totale. Cette deuxième sonde s'est avérée capable de fournir, d'une façon continue et en toute profondeur, cinq points d'une courbe quasi-pressiométrique, d'où un nombre illimité des courbes contraintes–déformations peut être déduit. La deuxième sonde, a pour sa part, servi à observer la chute des pressions totales et interstitielles lors des périodes d'arrêt de la sonde. Tous ces essais ont été effectués en 2002 sur un site près de Montréal, contenant une couche épaisse d'argile saturée. La comparaison de ces résultats avec ceux de quelques autres types d'essais, s'est avérée très encourageante.

Mots clés : essais in situ, argile, cône effilé, pressiomètre, à court terme, à long terme.

Introduction

The knowledge of mechanical properties of earth materials is an essential condition for the design of structural elements that will be transferring applied loads to soils and rocks. For determining the mechanical properties of soils, both laboratory and in situ methods are currently used. In the former, undisturbed soil samples are taken from borings at selected levels and are then subjected to certain tests pertinent to the purpose at hand. The in situ methods, in turn, do not require soil sampling, but the scope of mechanical properties they are capable of furnishing is limited, compared with the scope of those obtained from laboratory tests. On the other hand, the advantage of the in situ methods is their ability to furnish a continuous picture of the geotechnical profile of the site in real time.

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In situ testing methods

In the geotechnical field, the most frequently used in situ tests are the standard penetration test, the cone penetration test (CPT), the pressuremeter test (PMT), the flat dilatometer test, and the vane shear test (VST). Each of these tests produces very distinct types of deformation and failure conditions in the soil, making it possible, by means of an appropriate interpretation method (or statistical correlation), to deduce from the results certain deformation and strength characteristics of the soil.

The sharp cone test (SCT) is a new addition to in situ testing methods. The test consists of pushing a low-angle truncated cone into a predrilled or self-drilled cylindrical pilot hole of a smaller diameter. The purpose of the test is to produce in the soil the expansion of a quasi-cylindrical cavity, similar to that of a PMT. The test has up to now been conducted in two ways:

(*i*) Testing in a creep mode — The SCT method uses an ordinary noninstrumented truncated cone. The test is carried out by holding constant the axial load applied to the cone and by recording the relationship between cone penetration and time. Such a test makes it possible to determine the creep properties of a geological material, such as frozen soil, ice, rock salt, and other materials having distinct creep properties. A complete theory and a practical application of such a test were presented in three previous papers (Ladanyi and Talabard 1989; Ladanyi and Sgaoula 1992; Leite et al. 1993).

(*ii*) Testing in a continuous penetration mode — The instrumented sharp cone test (ISCT), which is the subject of this paper, uses a low-angle truncated cone, which is able to record, by a system of pressure transducers installed at several levels of the surface of the cone, the resistance of the soil against the enlargement of a predrilled pilot hole caused by the cone penetration. The test procedure is similar to that of a CPT, as the cone is forced to penetrate the pilot hole at a steady rate. By means of current PMT interpretation methods, certain mechanical properties of the material can be deduced from the recorded relationship between the vertical penetration of the cone, which is directly related to the enlargement of the pilot hole, and the total lateral pressure acting on the cone at several selected cone levels, as recorded by lateral pressure transducers (Fig. 1).

Principle and interpretation of the instrumented sharp cone test

Figure 1 schematically shows a low-angle truncated cone with three total pressure transducers installed at three levels of its lateral surface. The half-angle of the cone (the taper) is α. When the cone is pushed downward, it gradually enlarges the pilot hole from radius r to the radius R of the main borehole. Assuming that a pressure transducer is placed at a level x_i from the upper end of the pilot hole, it will record a pressure, p_i, necessary to enlarge the hole from r to

$$[1] \qquad r_i = r + x_i \tan\alpha$$

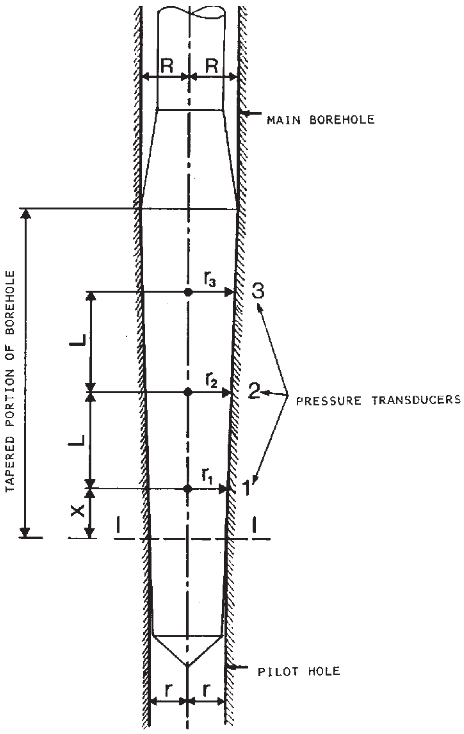
Adopting for simplicity Gibson and Anderson's (1961) strain measure, $\Delta V/V$, which, for a volume constant plane strain case, approximately equals the engineering shear strain, γ, one gets from geometrical considerations,

$$[2] \qquad \left(\frac{\Delta V}{V}\right)_i = 1 - \left(1 - \frac{\Delta r_i}{r}\right)^{-2} = 1 - \left(\frac{r}{r_i}\right)^2$$

where V denotes the current volume of the expanded cylindrical hole; and ΔV is its cumulative increase.

At any given lateral pressure measurement level, the strains will remain the same as long as the pilot hole precedes the cone, but the recorded pressure will vary according to soil properties. With the test in continuous penetration mode, taper angles of 1°–2° are found convenient for testing saturated clays, because they can cover the most important portion of the stress–strain curve. However, larger angles of

Fig. 1. Instrumented sharp cone (schematic).



up to 5° and more may be found more appropriate for testing very compressible or weak materials.

Following Gibson and Anderson's (1961) original idea, Ladanyi (1972) showed that knowledge of the p_i versus $\Delta V/V$ relationship makes it possible to determine the whole stress–strain curve of the soil in plane strain undrained shear, by applying the solution to any two consecutive points (i, i + 1) on the pressuremeter curve:

$$[3] \qquad q_{ps} \equiv (\sigma_1 - \sigma_3)_{ps} = \frac{2(p_i - p_{i+1})}{\ln(\Delta V/V)_i - \ln(\Delta V/V)_{i+1}}$$

from which the undrained cohesion under axial symmetry conditions, c_u, can be calculated: $c_u = (3^{1/2}/4)q_{ps}$. The corresponding axial symmetry compression strain, ε_{1a}, is related to the average shear strain, $\gamma_{i,i+1}$, by

$$[4] \qquad \varepsilon_{1a} = (\gamma_{i,i+1})/(3^{1/2}) = 0.577(\gamma_{i,i+1})$$

In the case of an ISCT, if lateral pressure transducers are installed at n levels, this will give n points of the "pressuremeter curve", or n points (n – 1 plus the origin) of the resulting stress–strain curve.

Clearly, the pressure transducers are actually measuring not the horizontal normal pressure, but the pressure acting

Table 1. Characteristics of sharp cone No. 1.

Level	Description	x_i (cm)	$d_i = 2r_i$ (cm)	$\Delta V/V$
0	Pilot hole	0.00	7.30	0.00
1	Bottom	8.90	7.92	0.15
2	Middle low	14.00	8.28	0.22
2.5	Piezometer	16.55	8.51	0.25
3	Middle high	19.10	8.64	0.28
4	Top	24.20	8.99	0.33

Note: d_i, diameter; r_i, radius.

Table 2. Characteristics of sharp cone No. 2.

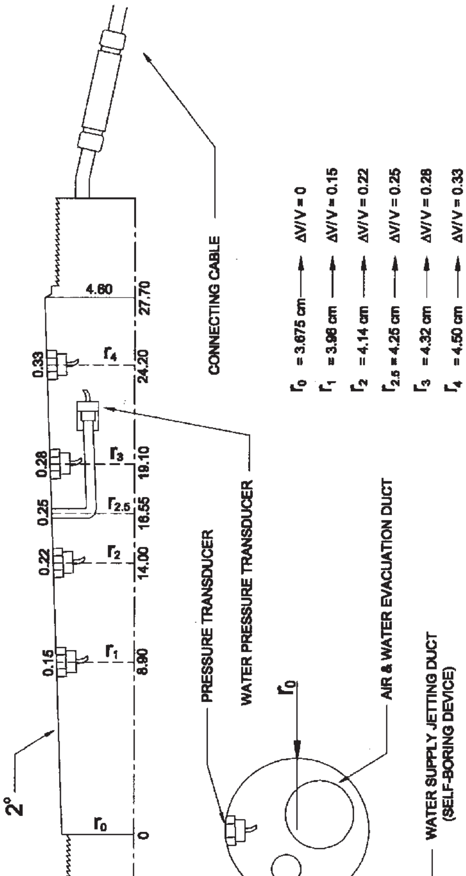
Level	Description	x_i (cm)	$d_i = 2r_i$ (cm)	$\Delta V/V$
0	Pilot hole	0.00	7.30	0.00
1	Bottom	3.23	7.46	0.03
2	Middle low	5.47	7.54	0.05
3	Middle	10.03	7.70	0.09
4	Middle high	15.41	7.98	0.15
5	Top	27.04	8.78	0.30

normally at the face of the probe. However, for a taper angle of only 1°–2°, the ratio between the horizontal component and the inclined resultant of the pressure is very close to unity. However, the adhesion mobilized on the face of transducers during penetration may be close to the clay undrained cohesion, c_u. This effect is also negligible, compared with the normal stress, because of the small area of the transducers (diameter, 8 mm; area, 0.50 cm^2). In sands, where friction on the transducers is proportional to the normal pressure, this effect cannot be neglected. A completely different situation occurs if lateral stress is deduced from measured axial force applied during penetration. The whole calculation procedure to be followed in this case was described in previous papers dealing with tapered piles (Ladanyi and Guichaoua 1985) and the use of a sharp cone for measuring creep properties of frozen sands (Ladanyi and Sgaoula 1992).

Development of the instrumented sharp cone

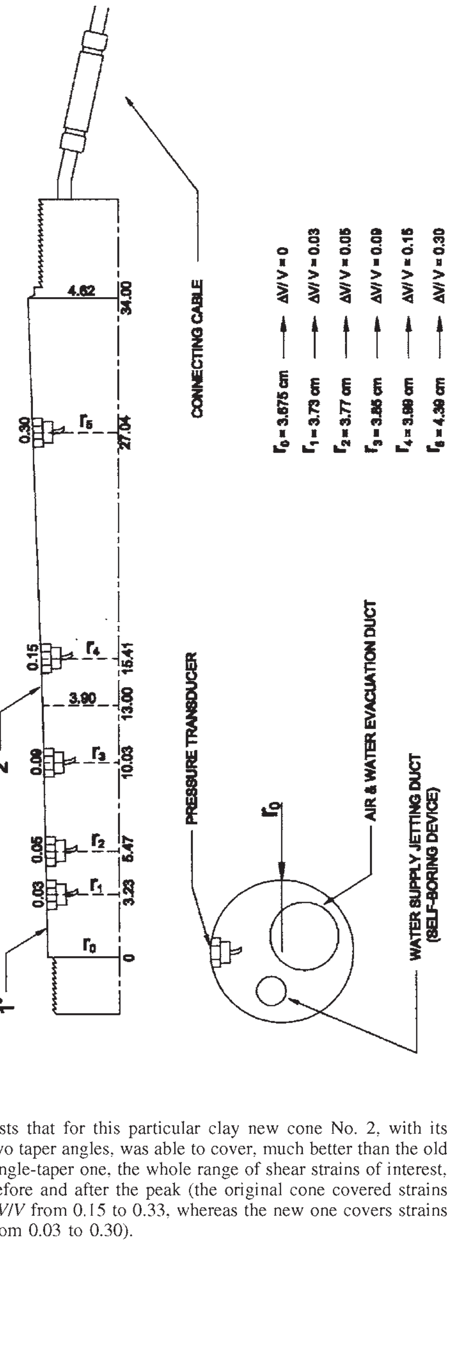
Through the last 10 years of the development of the sharp cone, several different cone designs have been tried. The main problem that had to be solved was related to the choice of the system for measuring the lateral total stress acting on the cone during penetration. The first design used an idea borrowed from the literature on measurement of the lateral pressure on piles. The method consisted in installing on the cone, at three levels, circular segmented steel portions embedded in rubber and connected to internal pressure transducers. This first design was used at the Saint-Hilaire site in 1994 (Ladanyi et al. 1995). Some satisfactory results were obtained, but it was found that this type of measuring system was too stiff and too slow to respond. In 1998, it was decided that, instead, four ordinary total pressure transducers would be installed directly on the lateral cone wall. Again, the tests were carried out at the Saint-Hilaire site, and the results were published by Ladanyi et al. (2000). Nevertheless, it was found that the four measuring points on this 2° taper cone were not sufficient to produce a reasonably complete pseudo-PMT curve. In addition, it was decided that a water pressure transducer (WPT) would be installed on the cone to enable it to measure simultaneously lateral stress relaxation and pore pressure dissipation during the strain-holding periods of the test. Finally, for the present tests (Longtin 2003), two new cones were fabricated by RocTest Ltd. (Montréal, Que.) and modified at the École Polytechnique: the first one, cone No. 1, was the original 2° taper cone, with a WPT installed at the middle of its length; and the second one, cone No. 2, had two taper angles, with its lower portion at 1° and

Fig. 2. Design drawing of sharp cone No. 1.



its upper portion at 2° taper. The main characteristics of the two new cones are shown in Tables 1 and 2; their design cross sections are shown in Figs. 2 and 3. It was found in the

Fig. 3. Design drawing of sharp cone No. 2.



tests that for this particular clay new cone No. 2, with its two taper angles, was able to cover, much better than the old single-taper one, the whole range of shear strains of interest, before and after the peak (the original cone covered strains $\Delta V/V$ from 0.15 to 0.33, whereas the new one covers strains from 0.03 to 0.30).

Test site

All previous tests with this instrument were carried out at a test site at Saint-Hilaire, near Montréal. At that site, the soil was a weak clay, so a self-boring system had to be used for drilling pilot holes. Although the results were satisfactory, a decision was made to find another site where the clay is stiffer so that pilot holes could be made by preboring. Clearly, a good self-boring system is always preferred for practical use. The new test site is about 20 km northeast of Montréal. It is a piece of government land at exit 34 of Highway 25 at Mascouche, Quebec. It is noted that Quebec department of highways and Université Laval geotechnical surveys had been made close by, so some comparison of field test results was possible.

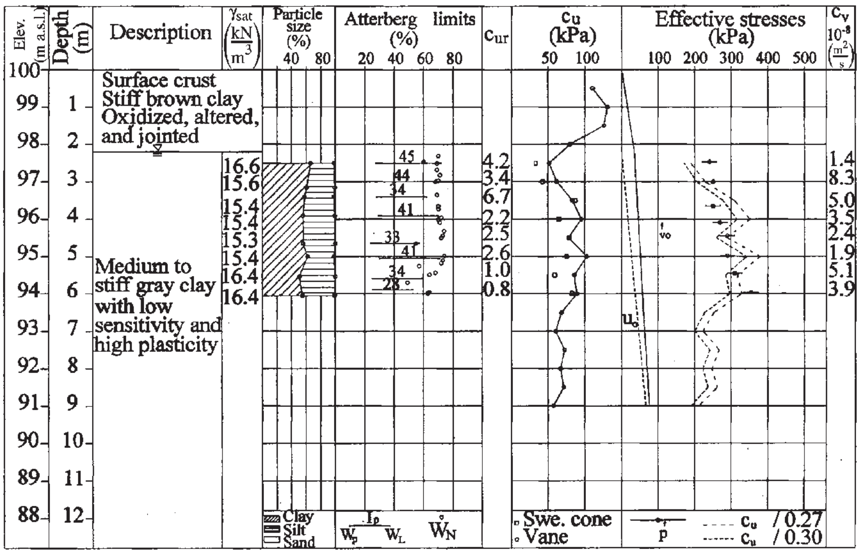
Figure 4 shows a complete geotechnical profile of the site. The upper 2 m is composed of a dried, weathered clay crust, below which there is a layer of gray, fairly stiff clay. The latter was found to reach to a depth of 6 m. This clay can be described as being not very sensitive, having high plasticity, and containing traces of sand and small grains of gravel. Grain size analyses have shown that the clay contains about 40% silt and about 1% sand. Its average water content is 70%. Oedometer tests have made it possible to establish a profile of preconsolidation pressures, which were found to increase generally with depth. The values for the overconsolidation ratio (OCR) were found to be of the order of 5–7. A series of consolidated isotropically undrained triaxial tests carried out on specimens taken at the depth of 4 m made it possible to determine the strength parameters of the clay in terms of effective stresses, $c' = 0$ and $\phi' = 33°$. The coefficient of vertical consolidation, c_v, determined from eight oedometer tests, was about 5×10^{-8} m^2/s. The value of the horizontal coefficient of consolidation, c_h, estimated from five strain-holding ISCTs as shown by Clarke et al. (1979) and Gillespie and Campanella (1981), was found to be about 2×10^{-6} m^2/s, giving the ratio $c_{v,\text{in situ}}/c_{h,\text{lab}}$ of 20, as found also by Clarke et al. (1979) for sedimentary clay deposits.

The at-rest coefficient of earth pressure, K_o, deduced from a series of conventional PMTs in which the lift-off method was used for estimating the value of the total horizontal pressure, p_o, was found to vary from 0.3 to 1.40, with an average value of $K_o = 0.8$. This value corresponds roughly to the predictions based on empirical formulas by Schmidt (1966) and Mayne and Kulhawy (1982). The scatter is due to the fact that the PMTs were made in tight prebored holes, rather than in self-bored holes.

Equipment and performance tests

The test procedure first requires the drilling of a pilot hole of a selected diameter, which should remain stable until the start of the test. This is possible in relatively stiff clays but requires a self-boring device with the use of drilling mud in weak soils. The cone is then pushed into the pilot hole at a selected rate, and the pressure variation with depth is recorded by pressure transducers. The necessary equipment includes a drilling rig, a CPT-type penetration rig, a self-boring device, and a data acquisition system. In the tests, a hole of 4 in. (10 cm) was drilled through the upper crust of the ground. The hole was subsequently enlarged to 10 in.

Fig. 4. Geotechnical profile of the test site at Mascouche, Quebec. Swe., Swedish.



(25 cm) and protected by a steel casing. The pilot hole was formed by repeatedly pushing a Shelby tube sampler into the clay, down to 6 m depth, in sections corresponding to its length of 71 cm. The cone was then pushed into the pilot hole by a hydraulic jack system at a rate of 20 cm/min, which corresponds to the strain rate produced by an ordinary PMT.

The recording and data acquisition system consisted of four or five pressure transducers and eventually one water pressure transducer, located on the lateral surface of the cone, as well as one displacement potentiometer with 1500 mm range, installed on the rig. The data from the transducers were automatically recorded against the time on a micrologger Toshiba satellite, in which the data acquisition program HP VEE, version 4.0, was installed. An acquisition program in Visual Basic was developed, making it possible to receive and treat in real time nine variables recorded during the test (i.e., time, displacement, displacement rate, and readings from five pressure transducers and one WPT). The loading and data acquisition system is presented schematically in Fig. 5.

Site tests

In 2001, five ISCTs were carried out with probe No. 1 in holes 76.2 mm in diameter, predrilled with a helicoïdal power drill (tests F-1-1 to F-1-5), and two ISCTs in which the hole was made by pushing a Shelby tube of 73.0 mm diameter into the bottom of a predrilled hole (tests F-1-6 and F-1-7). In 2002, all the holes for ISCTs and PMTs were prepared in such a manner. In that period, seven ISCTs were carried out with probe No. 1 (F-2-1 to F-2-7), and three were carried out with probe No. 2 (F-2-8 to F-2-10). The depth range covered in all these tests was 1.0–6.5 m.

In the same year, in addition to the ISCTs, seven PMTs (V-2-1 to V-2-7) and three VSTs (V-2-1 to V-2-3) were performed at the site. The PMTs were all carried out in 73.0 mm predrilled holes and covered the depth range of 2.40–7.00 m.

The groundwater level during the two test periods was measured independently with a piezometer. It was found that during the first test period, from July to September 2001, the groundwater level dropped from 1.15 m to 1.70 m and that during the second, from June to October 2002, it dropped from 1.00 m to 2.02 m.

Test results

The continuously recorded ISCT pressures along the pilot hole during penetration make it possible, in principle, to define at each level of the soil profile several points of an equivalent, or pseudo, pressuremeter curve corresponding to the number of available pressure transducers.

Figure 6 shows a profile of mobilized soil lateral resistances recorded by five lateral pressure transducers of cone No. 2. The profile clearly shows the presence of the dried upper crust of the clay, followed by a weak layer at about 2.30 m depth, and then a clay layer down to 6 m depth, the depth reached by the tests. Despite natural variation of the soil response, the soil reaction to increasing applied lateral strains can be clearly distinguished. Note that pressure transducer recordings were made at 5 s intervals, corresponding to each centimetre of penetration. The advantage of such information is that one can use the five recorded

Fig. 5. Schema of the loading and data acquisition system.

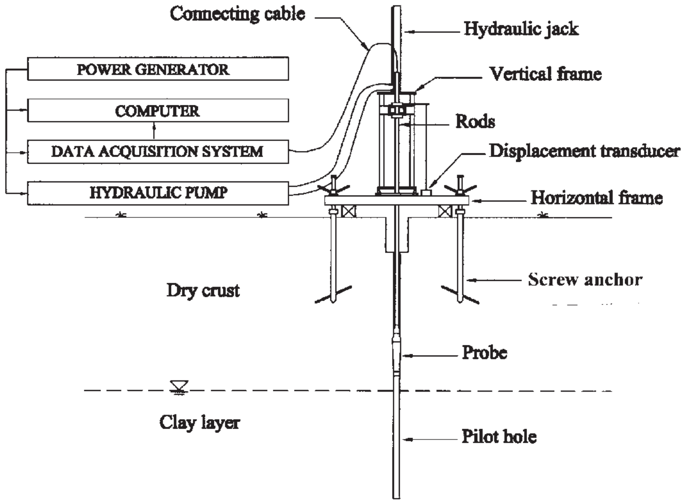


Fig. 6. A mobilized lateral total stress profile as determined by a typical instrumented sharp cone test. Recorded by cone No. 1, with five lateral pressure transducers (PTs).

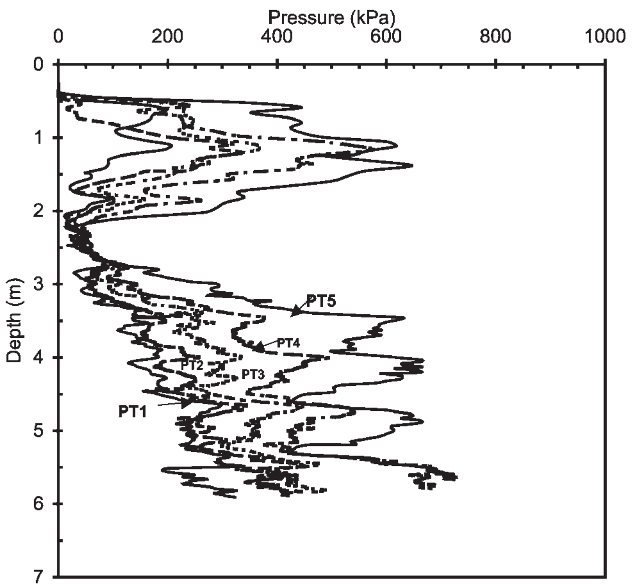


Fig. 7. Pressure-expansion curve deduced from five lateral pressure transducer recordings in Fig. 6, at a depth of 3.40 m.

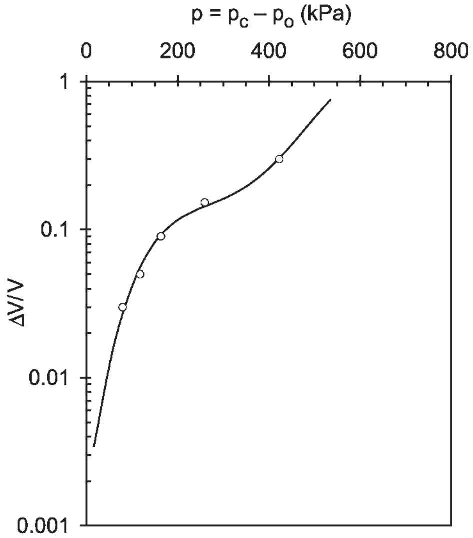
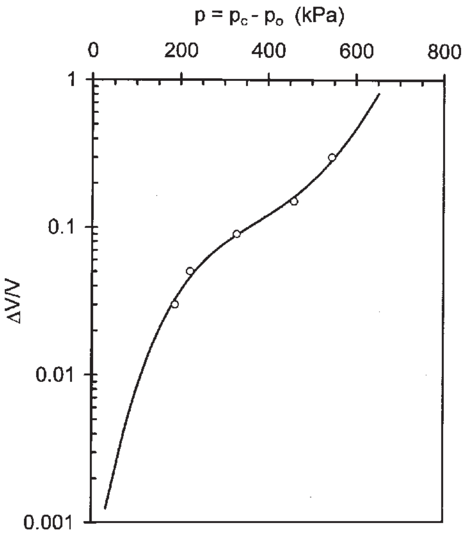


Fig. 8. Pressure-expansion curve deduced from five lateral pressure transducer recordings in Fig. 6, at a depth of 4.75 m.



mobilized soil resistances at any selected level of the test to produce a corresponding stress–strain curve as if from a multitude of PMTs.

Pseudo pressuremeter test curves

Figures 7 and 8 show pseudo PMT curves recorded in ISCT F-2-8 at the depths of 3.40 and 4.75 m, respectively. Three more such curves were deduced from the same test at levels of 1.10, 5.35, and 5.80 m, but an unlimited number of such curves could have been deduced from the same test. Continuous curves drawn through the recorded points were obtained from a polynomial approximation by using the program ORIGIN (OriginLab Corporation, Northampton, Mass.). The same method was used for treatment of conventional PMTs.

In principle, there is only a practical limit to the number of lateral pressure transducers that can be installed. Five were selected in this study for practical reasons, but a larger number is certainly recommended. The present test results have shown what can be done with just five transducers. That both peak and postpeak portions of the stress–strain curves could have been found from the tests proves that the position of transducers was well selected for this type of clay. The same transducer distribution may not be necessarily appropriate for some stiffer or less stiff clays.

Stress–strain curves

Figure 9 shows a set of stress–strain curves deduced from the ISCTs and the conventional PMTs within the depth interval 4.0–5.0 m. For obtaining net pressuremeter curves from the recorded ones, the value of the original total horizontal pressure, σ_{ho}, was computed independently of the effective vertical ground pressure and the hydrostatic pressure, by using the method described in Ladanyi (1972) and Marsland and Randolph (1977), with $\gamma_w = \gamma_{sat} = 16$ kN/m^3 and $K_o = 0.80$ as obtained from PMTs. Alternatively, the lift-off method was also used in connection with the conventional PMTs. The initial unit borehole volume, V_o, was calculated by assuming that the borehole diameter, D_o, was equal to the outside diameter of the Shelby tube: that is, $D_o = 73.0$ mm.

It can be seen in Fig. 9 that there is a clear tendency for PMTs to give somewhat higher peak strength values than the ISCTs do, which may be due to the limited number of points recorded in the latter.

Strain-holding test

Figures 10 and 11 show the results of a strain-holding test at the strain of $\Delta V/V = 0.25$, carried out at a depth of 5.56 m. The main purpose of this test was to observe simultaneously the variation with time of both the total lateral stress and the pore water pressure. The assumption was that the dissipaton of pore water pressure would be practically over after a short time, to be followed by long-term relaxation of lateral stresses. From Fig. 10 it appears that the relaxation was over after about 10 h, whereas dissipation continued for up to 20 h of observation. The advantage of such an ISCT over tests made by a pressuremeter is that the instrumented sharp cone is rigid and the data observed result from multiple total pressure transducers. From the results of the pore pressure dissipation test, it was also possible to determine the values of pore pressure u_{50} and the time t_{50} to 50% pore pressure dissipation (see Fig. 10).

Fig. 9. Stress–strain curves deduced from instrumented sharp cone tests (ISCTs) and conventional pressuremeter tests (PMTs), at depths between 4.0 and 5.0 m.

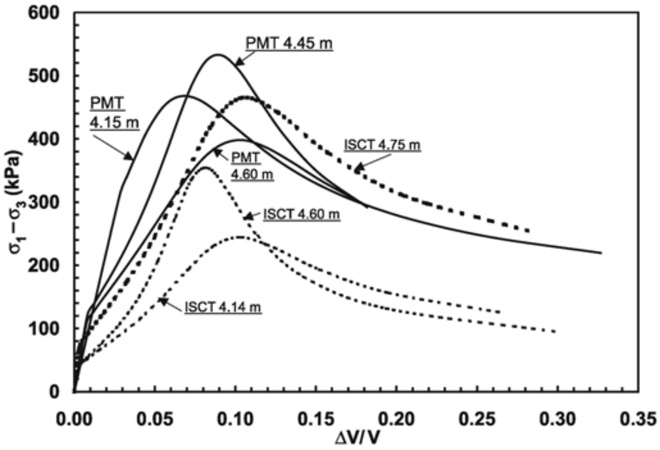
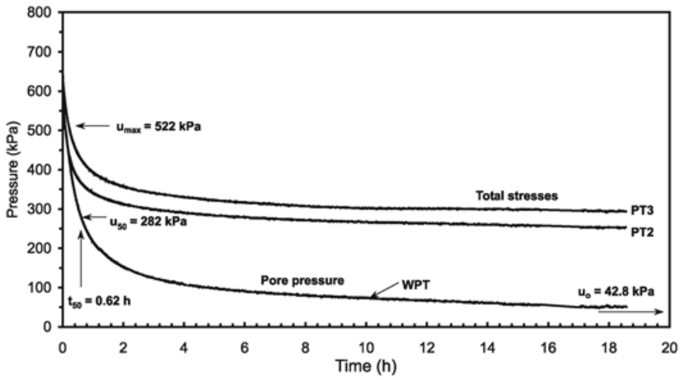


Fig. 10. Total lateral stress variation and pore pressure dissipation observed during an 18 h long instrumented sharp cone holding test, at a depth of 5.56 m. WPT, water pressure transducer; u_o, hydrostatic pore-water pressure in the ground.



A slightly different impression is obtained when the results from Fig. 10 are replotted as pressure versus log time, as in Fig. 11. The shape of the pore pressure dissipation curve so obtained is typical for slightly overconsolidated clays, as observed in pile model tests by Steenfelt et al. (1981) and in in situ piezocone tests (Burns and Mayne 1998, 1999, 2002). For comparison, Fig. 12 shows a pore pressure dissipation behaviour similar to that observed in a clay with OCR = 7.0 and c_h = 0.3 mm^2/s.

According to Burns and Mayne (1998), this initial pore pressure behaviour is due to the presence of a shear zone that developed around the pile or piezocone during penetration. This zone is 1–10 mm thick (or about 10% of the shaft diameter). As a result, the total pore pressure measured on the shaft of a piezocone includes the hydrostatic pore pressure, the excess pore pressure generated by changes in the mean octahedral normal stress, and pore pressures due to changes in the octahedral shear stresses in the shear zone. According to the observations, the normal component of the induced pore pressure is always positive, whereas the shear-induced component can be positive at low OCRs or negative at high OCRs. As this shear zone is relatively thin, compared with the plastic zone generated by penetration, the effect of presence of the shear zone is usually limited to a couple of minutes following penetration and is manifested by an initial increase of pore pressure, the amount of which

Fig. 11. Results from Fig. 10 replotted in a pressure vs. log time plot. PT, pressure transducer; WPT, water pressure transducer.

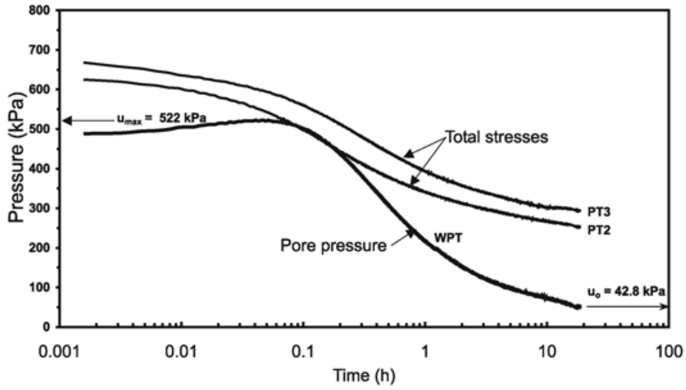
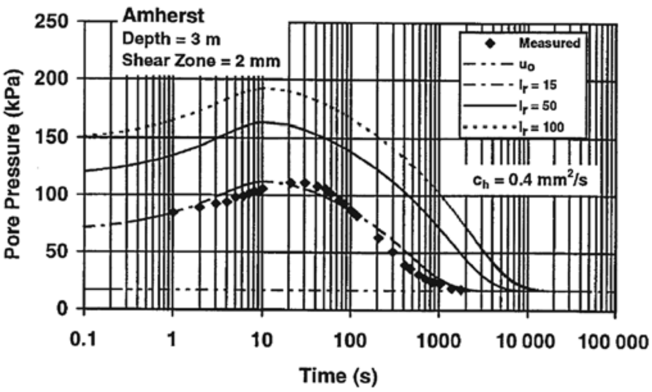


Fig. 12. Measured and calculated pore pressure dissipation during a piezocone test in a varved clay of low plasticity, recorded at Amherst, Massachusetts, by Burns and Mayne (1998). Modified from Burns and Mayne (1998).



is proportional to the OCR value, inducing dilation of the clay for an OCR exceeding about 3. A complete theoretical analysis of this phenomenon was presented by Burns and Mayne (1998, 1999).

Figure 13 shows effective stress recovery curves deduced from Fig. 10 by subtracting pore pressure from total pressure readings. It was found that after an initial pressure drop due to dilation effects, the effective stresses increase, but they are not yet completely stabilized after 20 h.

Comparison with other types of tests

Figure 14 shows a c_u profile of the site down to 7 m as recorded by three ISCTs, one VST, and seven conventional PMTs. As expected, the VST shows a rough internal envelope of the more detailed instrumented sharp cone c_u profiles, which were recorded every 5 cm. On the other hand, the peak c_u values from PMTs agree well with ISCT results within the uniform clay layer, but the PMTs were unable to correctly measure the strength of a weak inclusion between 2 and 3 m. The comparison of ISCTs and PMTs is even more evident in terms of average values, shown in Fig. 15.

Conclusion

Field experience with the new version of the ISCT described in this paper shows that the new system represents an interesting and workable alternative to some presently used field tests. Compared with the PMT, the proposed method furnishes data comparable to those measured by the PMT, but it can be also used for continuous sounding, which is not possible with current PMT equipment. Like the CPT, the proposed method can be used for continuous sounding, but it furnishes more complete information on the stress–strain behaviour of the soil. However, the proposed method requires a predrilled pilot hole, which must remain stable be-

Fig. 13. Effective stress recovery curves at a depth of 5.56 m, deduced from Fig. 10. PT, pressure transducer; WPT, water pressure transducer.

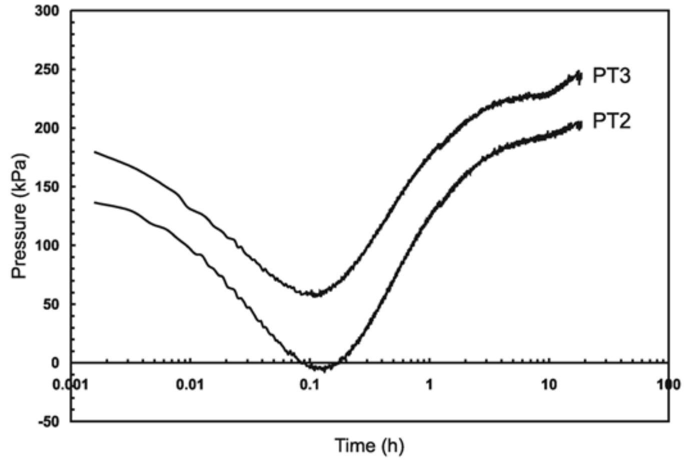


Fig. 14. Comparison of the results of three instrumented sharp cone tests (ISCTs) with those deduced from vane shear tests (VSTs) and conventional pressuremeter tests (PMTs).

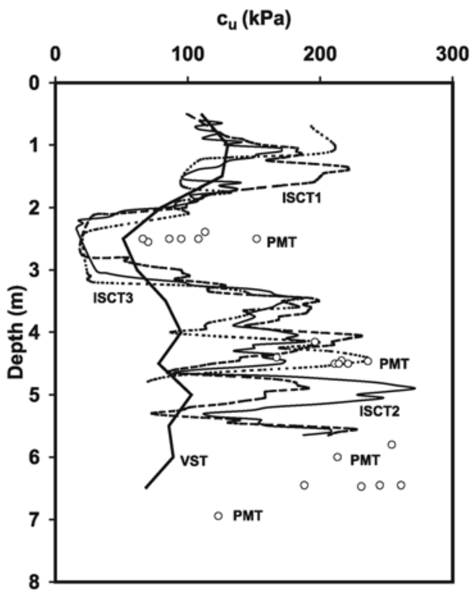
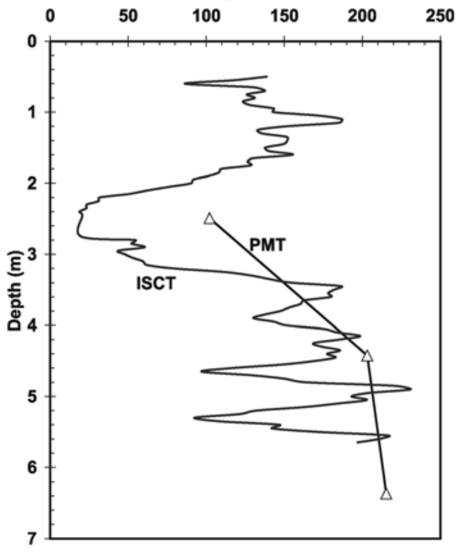


Fig. 15. Average values of the instrumented sharp cone (ISCT) and pressuremeter test (PMT) results shown in Fig. 14.



fore and during cone penetration. This is easy to realize in stiff materials, but it may present difficulties in weak soils, in which case a self-boring tool with the use of drilling mud would be necessary. The field study, using an upgraded cone with five lateral pressure transducers and a lateral pore pressure transducer (described in this paper), has given promising results. More such tests in soils of different types and stiffnesses are planned.

Acknowledgements

Financial support from the Natural Sciences and Engineering Research Council of Canada is gratefully acknowledged. The initial design and fabrication of the instrumented sharp cone were completed by the Roctest Ltd., Montréal, Quebec, and the new version was modified at the shops of the École Polytechnique, Montréal, with the help of André Ducharme, senior technician.

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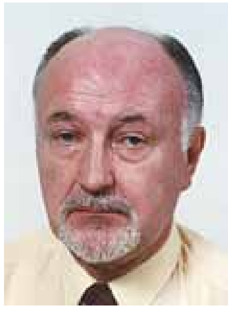
Programme Strategy from the new HATZ President and his Team for the next four years (2009 – 2013)

Governing Board of the Croatian Academy of Engineering



Prof. Stanko Tonković, Ph.D. (Zagreb, July 17, 1942) – **President;** full professor with permanent title at the Faculty of Electrical Engineering and Computing of the University of Zagreb. From 1965 he has been working at the Faculty of Electrical Engineering and Computing. In the academic years of 1992/94 he was appointed vice-dean for science and from 1994 to1998 dean of the Faculty of Electrical Engineering and Computing in two mandates. He has been the head of a number of scientific and technological projects, as well as projects for the industry. With his educational, scientific and professional activities he has excelled at most in biomedical engineering and technology, electronic measurements and instrumentation. He has received Croatian Award for Achievements in Education and Science "Order of Danica Hrvatska with the Face of Ruđer Bošković". He is a member of various professional societies both at home and abroad. *He has been full member of the Croatian Academy of Engineering from 1994, and from 2003 vice-president of the Academy. He is a member of the "Platform on Engineering Education" of Euro-CASE. In June 2008 he was elected member of the Board of Directors of CAETS for the years 2009/2010.*

Prof. Miljenko Lapaine. Ph.D. (Zagreb, April 4, 1952) – **Vice-President;** full professor with permanent title at the Faculty of Geodesy of the University of Zagreb. From 2005 he has been appointed head of the Chair for Geoinformation and in the years of 2003/05 and 2007/09 vice-dean for education. He is the founder and first president of the Croatian Cartographic Society, as well as a member of several professional societies at home and abroad. In his scientific works he deals with the application of mathematics and computing in geodesy and cartography. He received J. J. Strossmayer Award for the Best Publishing Enterprise in 1998. He has participated in over a hundred scientific and professional gatherings and published more than 650 articles in journals and conference proceedings. *In 1998 he was elected collaborating member* *of the Croatian Academy of Engineering and in 2005 full member. He was secretary-general from 2003 to 2005. He was responsible for web pages of the HATZ from 2003 up to 2007. He was elected head of the Center for Geoinformation and Cartography of the HATZ in 2008. He has written 20 works for the publications of the HATZ.*

Prof. Vilko Žiljak, Ph.D. (Sv. Ivan Zelina, December 18, 1946) – **Vice-President;** full professor with permanent title at the Faculty of Graphic Arts of the University of Zagreb. In his works he has been occupied with the research, development and application of information, computing and graphical techniques throughout various sciences. He is pioneer in three scientific fields; first in mathematic modelling and simulation, second in computer graphics and printing and third in visual research by computers. He has published first books in Croatian from those fields and organized classes on graduate and post-graduate studies. He has introduced several new technologies in graphic industry. He is the founder of post-graduate study Graphic Engineering at the Faculty of Graphic Art. He received "Zlatna kuna", life achievement award from the Croatian Chamber of Commerce. *He became full member of the HATZ in 1997. From 2003 he has been secretary of the Department of Graphical Engineering and also head of the Center for Graphical Engineering of the HATZ.*

Goran Granić, Ph.D. (Baška Voda, April 18, 1950) – **Secretary-General;** head of the Energy Institute Hrvoje Požar in Zagreb. From 1994 to 2000 he was director of the Energy Institute Hrvoje Požar. From the beginning of 2000 up to the end of 2003 he was Vice Prime Minister of Croatia. At the beginning of 2004 he was appointed head of the Energy Institute Hrvoje Požar. He has made special achievements in the development strategies for electrical engineering and energy sector. For his professional and scientific work he has received numerous awards and medals: "Hrvoje Požar" Award for Scientific Contribution (1998), National Award for Science (1999), "Order of Croatian Trefoil" (1996) and "Order of Danica Hrvatska with the face of Blaž Lorković" (1998). *He has been collaborating member of the HATZ from 1998 and associate member from 2007, as well as president of the Board for Regional Cooperation from 2004. In 2005 he was elected Secretary-General of the Academy. He is a member of the Euro-CASE "Platform on Energy and Environment".*

Prof. **Stanko Tonković**, Ph.D.
Prof. **Miljenko Lapaine**. Ph.D.
Prof. **Vilko Žiljak**, Ph.D.
Goran Granić, Ph.D.

Program of work for the new mandate

In the previous mandate many things have been done to improve working conditions, quality of work and to increase the activities of the Academy. Among others, we have a new office in Kačićeva 28. We have established excellent relations with CAETS and Euro-CASE, governmental institutions and representatives, University of Zagreb, Croatian Academy of Sciences and Arts, many similar academies in the country and in the world, as well as with a number of business organizations. For the next mandate, we present four basic program directions:

– HATZ must remain the first "technically and technologically oriented" scientific and expert organization in Croatia. We emphasize scientific and expert since in a small country such as Croatia, only with synergy and joint efforts we can achieve progress. Everything that has been done in the last few years must remain preserved but must also be extended. The Academy must become a partner of state institutions and economy. This is both, a commitment and duty of the new Board, Presidency, all organizational units of HATZ, as well as of all its members. Members must become aware that the membership in the Academy is not just a note in their biographies but that they must be actively involved in the work of the Academy. It is the duty of the Academy (Board and Presidency) to serve its members. Communication in both directions, "up - down" and "down - up" has a very important role. Personally, we have great faith and confidence in team work. As a president of the Academy, I will make every effort to be only "the first among the equals". Together with the Board and Presidency I will share opinions on all important decisions, but of course, as a President I am ready to take over the biggest responsibility for their implementation.

– Care over the building, overall logistics, and especially for the financing of the Academy's work will be the priorities of my work and efforts in order to continue the growing trend of business activities of the current

President and Board. I will make every effort, especially with the Ministry of Science, Education and Sports, to ensure better (enlargement) of "cold" force (logistics) of the Academy.

- Expert and scientific work of the Academy will be performed through the organization of meetings, round tables, expert debates and scientific projects on national and international level where an expert synergy of all units of the Academy is required. I intend to encourage the organization of 'Department Debate' (once a year) where interesting news and/or achievements of members of the Department or perhaps invited speakers would be presented. Special emphasis should be placed on increasing the level of activities of the Department (primarily the task of the Department's Secretary) and work, i.e. establishing new centers. Within this, it could be possible to organize, every or every second week, lectures by members of the Academy (meetings, round tables). We are already experiencing the change and transformation of educational approach and methods on the basis of "Bologna process" guidelines, but also of everything else that the technological progress brings alone. This is especially visible in the field of technical sciences. It is the duty of the Academy and its members to take the right and important position in this process. The second important and constant mission is a very demanding media promotion of awareness on the importance and influence of modern technologies on the nowadays world and everyday life. One of the activities we intend to initiate is the cooperation with all relevant industry sectors in the field of technical and biotechnical sciences, perhaps by establishing a new working body of the Academy (with their representatives as consultants?). Preparations for the 300th anniversary of the birth of Ruđer Bošković and the organization of scientific meetings once or twice a year are part of the already set program of work of the Academy.

- With the new Board, I would like to see members of the Academy get used to coming more frequently to the headquarters of the Academy in Kačićeva 28. The Academy should become the meeting point of the members for discussions, agreements and social gatherings, perhaps through establishing a "Club" (a day when the Academy would also be open in the afternoon for meetings and gathering).

International Cooperation of HATZ in 2008

REPUBLIC OF CROATIA
MINISTRY OF SCIENCE, EDUCATION AND SPORTS

CLASS: 910-01/07-01/00326
OUR NO.: 533-06-08-005

Zagreb, April 7, 2008

Croatian Academy of Engineering
Prof. Zlatko Kniewald, Ph.D.

Kačićeva 28
10000 Zagreb

Subject: Organization of the Celebration of the 300th Anniversary of the Birth of Rugjer Boscovich in 2011

-Cooperation proposal-

Dear Mr. Kniewald,

We would hereby like to inform you about the meeting with the ambassador of the Republic of Croatia to the Republic of France, Mr. Mirko Galić, held at the Ministry of Science, Education and Sports regarding the realization of important projects for Croatian culture, history and science announced within the framework of Croatian cultural season in France and French cultural season in Croatia.
Besides preparations for the international symposium celebrating the 200th Anniversary of the Foundation of Illyric Provinces, a project of the celebration of the 300th Anniversary of the Birth of Rugjer Boscovich has also been announced.
We would take the liberty to entrust you with the organization of the celebration with the participation of French and Croatian scientists and historians in 2011 with regards to all experiences acquired in the realization of the Nikola Tesla project. For the occasion a place for the Meštrović's statue of Rugjer Boscovich should be found in Paris, where there is only a memorial now, and a French partner as well.
If you are interested in our further cooperation, please take initial steps regarding this project.

(Contact person in the Ministry of Science, Education and Sports, Mrs. Tatjana Cindrić tatjana.cindric@mzos.hr phone 4594553)

Sincerely yours,

STATE SECRETARY

Radovan Fuchs, Ph.D.

Zagreb, September 12, 2008
Subject: Program of the Celebration of the 300th Anniversary of the Birth of Rugjer Boscovich
Our Sign: HATZ080912/5

PROGRAM OF THE CELEBRATION OF THE 300TH ANNIVERSARY OF THE BIRTH OF RUGJER BOSCOVICH
Proposal and Report on the Former and Future Activities of the HATZ
submitted to the Ministry of Science Education and Sports of the Republic of Croatia

1. Organization and Monitoring of the Anniversary
   It is recommended that:
   a. the President of the Croatian Parliament takes over the patronage of the Celebration and becomes president of the Organizing Committee
   b. the President of the Republic of Croatia takes over the auspices
   c. the Organizing Committee should be constituted out of the members of the Government of the Republic of Croatia, representatives of Croatian Army, Catholic Church, embassies of the states in which Rugjer Boscovich lived and worked, Croatian Academy of Sciences and Arts, Matica Hrvatska.

2. Program of the Anniversary in Croatia:
   a. Opening of web pages about Rugjer Boscovich and their systematical support and amendment up to the end of the year 2011 (100,000 KN)
   b. Tenders are invited for visual identity of the Anniversary with the purchase of the design, promotion material and systematic informing and communication with the public on all levels (200,000 KN)
   c. Celebration of the 300th Anniversary of the Birth of Rugjer Boscovich on Wednesday, May 18, 2011
      i. 10.00 - 11.00 a.m. - words of the patrons and guests in the Vatroslav Lisinski Concert Hall
      ii. 11.00 - 11.30 a.m. – „Sounds of Dubrovnik“ – musical program from XVII century
      iii. Lectures about the figure and work of Rugjer Boscovich by the scientists from homeland and abroad such as:
         1. scientists – members of famous Academies
         2. designers

3. writers
4. priests
5. diplomats

Organization, preliminary materials, celebration proceedings, lease of the hall and all accompanying activities, expenses for invited lecturers etc. (500,000 KN)

iv. Organization of round tables and printing of relevant materials throughout the year by:
Ad 1. Croatian Academy of Sciences and Arts (40,000 KN)
Ad 2. Faculty of Mechanical Engineering and Naval Architecture (50,000 KN)
Ad 3. Faculty of Philosophy (50,000 KN)
Ad 4. Catholic Faculty of Theology (50,000 KN)
Ad 5. Ministry of Foreign Affairs and European Integration (50,000 KN)

d. Ruđer Bošković Institute – Zagreb, Bijenička 54 – in the course of 2011 several thematic discussions about the application of the Boscovich's scientific achievements and their role in the global scientific development – where is Croatia? (6 x 10,000 = 60,000 KN)
e. Technical Museum in Zagreb – opening of a thematic part of the museum dedicated to the research of Rugjer Boscovich in the field of technical sciences (200,000 KN)
f. National and University Library in Zagreb – gathering of material and copies from abroad and Croatia, as well as organizing of an exhibition (300,000 KN)
g. Faculty of Geodesy in Zagreb, Matica Hrvatska and The Brothers of the Croatian Dragon – Rugjer Boscovich as forerunner of Croatian cartography with setting up of the relevant monuments of Rugjer Boscovich in Zagreb and Dubrovnik (100,000 KN)
h. Ministry of Science, Education and Sports of the Republic of Croatia – printing of the proceedings with biographies of all winners of the Ruđer Bošković State Award up to 2011 with ceremonial awarding of the 2011 prize on the occasion of the main celebration on May 18, 2011 (preparation, compilation of material and printing of the proceedings by the HATZ (200,000 KN) and awards according to actual costs of the Ministry)
i. Organization of exhibitions and lectures about Rugjer Boscovich in primary and secondary schools in the Republic of Croatia in collaboration with Narodna tehnika. Celebrations in all schools named after R. Boscovich and in several high schools in Croatia (some 20 lectures x 10,000 KN = 200,000 KN)
j. Celebration of Rugjer Boscovich in his home town Dubrovnik with exhibition and lectures (200,000 KN).

3. Program of the Anniversary Abroad:
   a. The seat of the UNESCO in Paris – opening of the exhibition about Rugjer Boscovich and his scientific, diplomatic and educational life with lectures for the mission representatives of the member nations of the UNESCO, (600,000 KN)
   b. Lecture on the Life and Work of Rugjer Boscovich in coorganization with the French Academy of Science and French Academy of Engineering (100,000 KN)

c. Installation of the Rugjer Boscovich sculpture (by Ivan Meštrović) in Paris. Transfer from the Ruđer Bošković Institute in Zagreb to Paris at the spot to be agreed with French authorities (the initiative should settle a number of issues). No cost estimation.
d. Installation of relevant memorials on/in the institutions where Rugjer Boscovich has worked or been elected member of the Academy (6x 40,000 KN = 240,000 KN)
e. Installation of a memorial in Milan, Italy where Rugjer Boscovich has died. (40,000 KN)
f. Visit to the grave of Rugjer Boscovich and laying a wreath on the occasion of the 300th Anniversary of his birth or the day of his death. (40,000 KN).

4. Cost of the Celebration:

Above mentioned activities in total	3,120,000 KN
Organization, monitoring and administrative support, meetings of the Committee and coordination 2008 – 2011	450.000 KN
Unexpected costs (only with prior consent of the Committee)	430.000 KN
Total	**4,000.000 KN**

5. Implementation and Administrative, Expert and Technical Services
    a. The task was given to the Croatian Academy of Engineering by the letter of the Ministry of Science, Education and Sports dated April 7, 2008, at the meeting of the Presidency of the HATZ the proposal was accepted and the Ministry and all the members of the Academy informed about it.
    b. Posters of the Celebration and leaflets about Rugjer Boscovich have been made in English, French, Croatian and Russian and they have been distributed among the members of Euro-CASE and CAETS requesting coorganization.
    c. Bilingual bulletin of the Academy (in Croatian and English) has been published with the text on the cover about the significance of the work and figure of Rugjer Boscovich. The bulletin has been edited in 500 copies and besides the Academy members sent to all member institutions of the HATZ, their libraries, members of the Government of the Republic of Croatia and the Office of the President of the Republic of Croatia, certain ambassadors in Croatia, our embassy in France and all members of CAETS and Euro-CASE.
    d. At the convention of Euro-CASE in Paris a meeting has been organized with Croatian ambassador in France Mirko Galić where Prof. Stanko Tonković, vice president of the HATZ and I have learned about the initiative to transfer the statue of Rugjer Boscovich (by Meštrović) from the present location in the Ruđer Bošković Institute to Paris in collaboration with French Academy of Science. We have been informed that some employees of our embassy in Paris have gathered a significant number of documents about the work of Boscovich during his stay in France which they are willing to make available to the Academy. We have also learned that in front of the French Academy of Science in Paris there is a memorial of Rugjer Boscovich. On that occasion we have also had a meeting with the president of French Academy of Engineering that is a member of Euro-CASE and host of the seat of Euro-CASE. The president has promised his own and every possible support in the organization of the HATZ activities in France.

e. At the session of CAETS in The Hague this year CAETS has taken over the coorganization of the Celebration, as in the case of Nikola Tesla before.

f. A meeting has been held with Mrs. Cindrić, adviser at the Ministry of Science, Education and Sports who has informed us that future communication regarding the Celebration is going to be made with Mrs. Ivana Puljiz, head of Directorate for International Cooperation of the Ministry.

g. Due to the fact that the Celebration is partly connected to culture (as to the transfer of the Boscovich statue from Croatia), a meeting with the minister of culture, Mr. Božo Biškupić has been proposed. On September 8th, 2008 a meeting was held in the Ministry of Culture with Mrs. Jasminka Lokas-Strpić, head of the Office for International Cooperation and Mrs. Nina Obuljen, State Secretary. Their associate prepared a note with suggested program to be sent as information to the Minister. On the occasion we have also mentioned the Nikola Tesla exhibition to be opened in Madrid and I have learned that in Croatian embassy in Madrid Mrs. Nikola Židak is in charge of the exhibition, our ambassador is Mr. Filip Vučak and the organizer of the exhibition in Zagreb is Mrs. Ankica Pandžić from Croatian History Museum.

6. Advertising and Visual Identity

Upon receiving the proposal for the Celebration of Rugjer Boscovich graphical engineer and designer of the Hrvoje Požar Institute has created visual identity of the Celebration which should serve as initiative up to the final constitution of the Committee for the Celebration of the 300th Anniversary of Rugjer Boscovich.

Zlatko Kniewald
September 12, 2008

Foreign and Croatian Scientists
at the Symposium about Bošković in Vienna

Rugjer Boscovich is our Contemporary

International Symposium about Rugjer Boscovich, Croatian philosopher, astronomer, mathematician, physicist, engineer, writer and diplomat from Dubrovnik was held in October 2008 in Vienna, Austria. The Rugjer Boscovich Symposium was convened on the occasion of the 250th anniversary of the first edition of his book Philosophiae naturalis theoria, Vienna, 1758. The Symposium was attended by Volker Bialas (Munich), Zvonimir Čuljak (Zagreb), Inge Franz (Leipzig), Luca Guzzardi (Milan), Ivan Koprek (Zagreb), Stipe Kutleša (Zagreb), Anto Mišić (Zagreb), Thomas Neulinger (Vienna), Maria Petz-Grabenbauer (Vienna), Georg Schuppener (Leipzig), R. W. Soukup (Vienna), Nikola Stanković (Zagreb), Josip Talanga (Zagreb) and Hans Ullmaier (Aachen), the author of a remarkable book about the Boscovich's Theory.

Professor Ullmaier had a lecture about Rugjer Boscovich and the modernity of his scientific work, as well as about his diversified activities as a diplomat at the reunion of Croatian cultural community Colonia Croatica in Cologne, Germany on November 26, 2008. We have taken the opportunity to talk to Hans Ullmaier, Ph.D. about his research of the work and figure of Rugjer Boscovich.

When did you get the idea to organize a Symposium about Rugjer Boscovich in Vienna?

– During my stay in Vienna in the spring of 2006 after a visit to Jesuit church I found myself in front of the Rugjer Boscovich's memorial placed over the entrance of the Jesuit house where he lived in 1757/8. It occurred to me then that a Symposium would be a good way to remind the public that 250 years ago Boscovich wrote here and edited his principal work Philosophiae naturalis theoria. During my visit to the president of the Austrian Society for the History of Science, I presented him the idea and he immediately accepted it. We agreed that I would be in charge of the scientific program, while he would foster the organization. Indeed, he soon successfully acquired financial help from the Austrian Ministry of Science and Department for Culture of the City of Vienna in the amount of nine thousand euro. Austrian Academy of Sciences ceded their premises. It seemed to me particularly symbolic that the hall in which the Symposium was to be held was only eighty meters away from the place where Rugjer Boscovich had lived and worked.

What was the cooperation of the organizers and Croatian participants like?

– Invited lecturers from Croatia came from two institutions: the Institute of Philosophy of the University of Zagreb (Kutleša, Čuljak, Talanga) and the Jesuit Faculty of Philosophy (Koprek, Mišić, Stanković). All participants cooperated well, sent their papers on time, held excellent and well-prepared lectures and supported me with all their efforts, especially Prof. Stipe Kutleša and the Provincial of Croatian Jesuits, Fr Ivan Koprek. At the symposium Prof. Koprek made a short and impressive opening speech apart from his own lecture. I was disappointed because Prof. Ivica Martinović (Dubrovnik/Zagreb) could not come to the Symposium, having been the most renowned researcher of the works of Rugjer Boscovich in Croatia whom I met in Dubrovnik in 2003 where we had interesting conversations. After that he did not respond to my letters and e-mails. Of course, I invited him among the first to participate on the Vienna Symposium about Boscovich, but he did not react to it. Perhaps he has perceived me as a competitor? If so, he is wrong, because my main task is to reaffirm the importance of Boscovich and his work in the German speaking countries and nothing else.

How would you summarize the results of the Symposium in Vienna for a layman interested in the scientific work of Rugjer Boscovich to understand?

– When having planned the Symposium we did not take usual way of releasing general invitations, but we invited colleagues who we deemed competent and suggested them the themes of their lectures. I was surprised that everyone accepted our suggestions and thus succeeded in getting a representative review of almost every aspect of the life, work and scientific surroundings of Boscovich. Each attendee could get information about the subject he/she was interested in. Thereto also contributed the fact that in the end a discussion evolved about Boscovich's attitude towards human soul and God, the themes that must have been interesting to laymen as well.

All lectures will be published in mid 2009 as proceedings of the Austrian Academy of Sciences entitled "Sitzungsbericht der Österreichische Akademie der Wissenschaften". Thus they will be available to the public and at disposal of all those who could not attend the Symposium.

As far as I know, Rugjer Boscovich and his work are not widely renowned in international scientific community. Why is it so?

– While Boscovich is well appreciated and appraised in Anglo-Saxon countries, Italy and Croatia of course (as well as partly in other countries of former Yugoslavia), he is almost forgotten in other European countries. There are many reasons for it. Throughout the territories of the Habsburg Empire, France, Spain and Portugal all universities were administered by the Jesuits and during those times Boscovich was favoured in entire Europe (all scientific publications about physics, chemistry and mathematics referred to his works). After the dissolution of the Jesuit order and dismissal of their professors obvious efforts were made to annul the memory about their activities as soon as possible – a common tendency in "overturns". Additional reason was in German speaking countries. For that purpose I would quote physics historian F. Rosenberger who wrote in 1884: "Boscovich is often spontaneously called the creator of atomistics in which the atoms are described as active forces. By all means he has tightly connected Newton's discoveries with old atomistics and therefore on his paths the science has even more progressed up to now. Nevertheless, particularly in Germany, the merits of Boscovich have little been perceived and acknowledged, but grew dimmed due to the theories of our great philosopher Kant who thirty years after Boscovich in his metaphysical basics of natural sciences described the matter with two forces, repulsive and attractive, that together with their effects behaved as one, the force of Boscovich."

Boscovich is a typical renaissance man, intellectual who has moved in various spiritual worlds. What knowledge of his, in short, has remained significant up to now?

– Your characterization of Boscovich is correct, but it should not implicate that he would therefore be better suited for the 15th century. On the contrary, his attempt to create an integral theory of the matter was set up in the way that it was very much ahead of his time, that due to the absence of many prerequisites it could not attain its objective or attained it with great restrictions. In spite of that in his theory Boscovich has been the first to elaborate knowledge which (at least qualitatively) is worth even today and has exercised a long term influence on the development of natural sciences. Only a few examples: First, fields (force) that "keep the world together" we nowadays call nuclear, i.e. atomic energy of links establishing basic cells of all solid and liquid forms of the matter. At longer distances those forces are alternately being attracted and repelled the result of which are meta (stable) positions of micro particles, i.e. atoms in molecules, solid bodies, liquids etc. Second, geometric arrangement (structure) of basic cells is also important and not only the variety (for example graphite, diamond and other carbons with different appearance, colour, strength…since atoms inside them are arrayed differently). Third, in the research of microcosm common human sense fails, even becomes counterproductive at times. Sometimes progress has to be made by loosing the evidence. Boscovich's philosophy of nature provides an example. In his book Puncta mathematical points are described as immeasurably small. Nevertheless they have got mass and are subjected to dullness and gravity. It is unthinkable to common sense and requires from us lot of disregarding of consideration, and obviously a lot more in later discoveries such as the theory of relativity or quantum mechanics.

Croatians are proud of their universal genius Rugjer Boscovich. But several years ago Belgrade weekly NIN included him on the list of hundred most eminent Serbs. Italians also reach out for Boscovich in their extensive literature about him and his activities. Has Boscovich declared himself as son of Dubrovnik and his Croatian people?

– As I could make out (but I am no expert for it), the conflict about the "nationality" of Boscovich is based on the preface of the translation to English of his Theoria in 1922 by J. M. Child (Manchester). The author of the chapter called the Life of Roger Boscovich was Branislav Petronijević, professor of philosophy of the University of Belgrade. He wrote: "On his father's side, the family of Boscovich is of purely Serbian origin, his grandfather, Boško, having been an orthodox Serbian peasant from the village of Orakova (sic!) in Herzegovina. His father, Nikola, was first a merchant in Novi Pazar (Old Serbia), but later settled in Dubrovnik (Ragusa, the famous republic in Southern Dalmatia), whither his father, Boško, soon followed him, and where Nikola became a Roman Catholic." I can neither prove nor deny that his grandfather Boško was orthodox Serbian peasant in Orakova (which is in fact called Orahov Dol) since in that area near the sea there are virtually no Serbs. It is certainly inaccurate that the father of Boscovich, Nikola was a merchant in Novi Pazar where he was sent by his employer Gleđević after he had worked for him for several years in Dubrovnik. Besides Petronijević I have not encountered anywhere else that Nikola converted from an orthodox to a catholic in Dubrovnik.

It was no Child's ill intention to give Petronijević to write the preface in the translation of Boscovich's Theoria into English (otherwise excellent first translation to a foreign language), and the reason could be found in traditional British ignorance of the history of Southern Slaves and in the fact that the project has mainly been financed by the government of the Kingdom of the Serbs, Croats and Slovenes. But if it were true that the father of Boscovich was of Serbian origin, no reasonable man could designate him a Serb. Mozart, for instance, was not German because his father has grown in Augsburg, Germany and aferwards as a young man came to Salzburg. I can better understand the endeavours of the Italians who claim Boscovich for themselves. However he has finished his education in Rome, worked there and in Milan for many years and has written most of his letters in Italian. Italy has done a lot and is still engaged a lot in the research of the opus of Boscovich with considerable finances. This theme seems superfluous to me especially due to the fact that our Europe is ever more uniting. And the fact that Boscovich, despite his universalism and cosmopolitism, has been closely connected to his homeland legitimizes him as a modern European. He has never denied his connections to his native town, province and people. Here are some examples. When d'Alembert in one of his publications called him “Italian mathematician of great reputation”, Boscovich corrected it in his work Voyage astronomique et geographique by indicating that he was Dalmatian from Dubrovnik and not Italian. Most of his letters to his relatives and friends in Dubrovnik were written in Croatian (Illyric). It is evident, for instance, in his letter from Vienna in 1757 to his brother Božo in Dubrovnik in which he has described his encounter with the officers of Croatian formations who have travelled through Vienna to the battlefields of the Seven Years' War. In the end of the letter he zealously wrote: “Eviva Haddick e i nostri Croati!”. Finally one should mention his relentless solicitations in many diplomatic missions assigned to him by the Republic of Ragusa at the courts of Vienna, Paris and London, as well as in embassies of other countries which have almost always been concluded in favour of his native town. In order to avoid any suspicion of plagiarism, I would like to emphasize here that most of the mentioned observations and arguments do not derive from my research, but I have taken them over from various sources, especially from excellent Biography of

Boscovich by Žarko Dadić (Croatian-English edition, 1987) and, among others, from the works of Ž. Marković and I. Marinović.

You are connected to Croatia not only by works about Boscovich, but also by your biography. Can you tell us something about it?

– I was born in Lower Austrian town of Stockerau where a family of friends of ours took care of young Croatian soldiers on drill in the barracks of the then German Wehrmacht. After the war a former soldier who worked as doctor in the hospital in Graz contacted us. It was Đuro Radaković who on the occasion of a visit to the mentioned family fell in love with one of the daughters. Afterwards they were married and returned to Sarajevo where Đ. Radaković, M.D. continued to work at the hospital. In Požega his sister Milka married Maks Bleiziffer, a master mechanic whose family had settled there in the time of the Military Border. Maks and Milka had a daughter Mira whom I met in Stockerau when she came for a visit as a girl of seventeen. It was the love at first sight. In 1961 I married Mira in Požega (in the church and as a foreigner what was considered a provocation by the authorities). Owing to the help of some high officials, the patients of Mr. Radaković, M.D., Mira has relatively soon got her emigration permit. In 1964 we went to Oak Ridge, USA where I worked as physicist in the National Laboratory. In 1977 we returned to Jüllich, Germany where I got a job in the Institute for Nuclear Physics. My son Johannes was born in Jüllich, studied two terms in Zagreb with Prof. Žmegač and started his master's thesis here. My wife has died too early, but I've kept close relations with her family. My occupation with Boscovich has brought me new friends in Zagreb and Dubrovnik.

Gojko Borić

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Euro-CASE

Euro-CASE
European Council of Applied Sciences, Technologies and Engineering

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Euro-CASE Executive Committee meeting n° 33
London, 4 November 2008, 9.00-13.30

The Royal Academy of Engineering - 3 Carlton House Terrace - SW1Y 5DG London - United Kingdom

Present

Mr Finbar Callanan (IE)	
Mr Pere Brunet Crosa (ES)	
Mr Keith Davis (UK)	
Prof. Antonio Falcão (PT)	
Prof. Peter Glavic (SI)	
Prof. Janos Ginsztler (HU)	
Prof. Derrick Gosselin (BE)	
Prof. Ferdinand Gubina (SI)	
Dr Hans Hänni (CH)	
Mr Michael Hayden (IR)	
Dr Milos Hayer (CZ)	
Prof. Rolf Hügli (CH)	
Mr Bruno Jarry (FR)	Secretary General
Mr Hein Johnson (NO)	
Ms Olga Kalantzopoulou (EL)	
Prof. Zlatko Kniewald (HR)	
Prof. Reiner Kopp (DE)	
Mr Konstantinos Kremalis (EL)	
Ir Hendrik Kuiken (NL)	Treasurer
Prof. Emanuel Maranha das Neves (PT)	
Prof. Manuel Manuez Balin (ES)	
Mr Shane McHugh (UK)	
Björn O. Nilsson (SE)	
Prof. Kurt Richter (AT)	
Prof. Asbjørn Rolstadaas (NO)	
Mr Peter Saraga (UK)	
Dr Carsten Schröder (DE)	
Mr Lasse Skovby Rasmusson (DK)	
Mrs Lena Treschow Torell (SE)	Chairman
Prof. Henrik Wolff (FI)	
Prof. Petr Zuna (CZ)	

Apologies
Italian Council of Applied Science and Engineering
Romanian Academy of Technical Sciences

In attendance

Ms Nadia Pipunic	Minutes Secretary

MINUTES

Mrs Treschow Torell opens the meeting and welcomes the participants with special words for Per Brunet Crosa (ES), Antonio Falcão (PT), Ferdinand Gubina (SI), Michael Hayden (IR), Rolf Hügli (CH), Olga Kalantzopoulou (EL) and Björn O. Nilsson (SE).

On behalf of all the Euro-CASE members, Lena Treschow Torell thanks the Royal Academy of Engineering for having hosted the first Euro-CASE Annual Conference and this Board meeting.

1. Minutes of last meeting n° 32, Paris, 14 May 2008

The minutes are approved.

2. Euro-CASE finance

2.1. Accounts to 31 September 2008 and Budget 2008

Hendrik Kuiken goes through the accounts to 30.09.2008, budget 2008 and concludes that the accounts are clean. The table should be modified as mentioned in Annex1.

2.2. Budget 2009

The budget 2009 is presented. Based on the 2008 forecast with an increase of 3% it is approved.

2.3. Euro-CASE member fees for 2008 and 2009

Regarding 2008, all academies have paid except France. NATF is currently administratively reorganised but will pay as soon as possible as the main system is in place.

After a thorough review by the Executive Committee, the request of Belgium to open a discussion on the subscription formula is rejected.

After discussion the proposed 3% raise in member fee is agreed for 2009 in order to take inflation rate into account.

2.4. Euro-CASE Reserve fund

The reserve fund has been invested in securities at Société Générale, a major french bank. In view of the recent financial turmoil, Mr Kuiken states that the secretariat will take contact with the bank to investigate on the bank guaranty

All the Academies agree upon contributing to the reserve fund for Euro-CASE. A proposal will be sent to all academies which have not yet participated.

Action: secretariat

2.5. Financial audit for ordered by the European Commission (2002, 2003 and 2004) Contracts IST-2001-34071 (EISTP) and IST-2001-37623 (EISTP-Nominees)

The procedure is under way. At this stage no irregularities have been discovered. Mr Jarry will keep the Board members informed about the outcome and will forward the final report when received to all academy members.

Action: secretariat

3. European Institute of Technologies

Lena Treschow Torell reminds that EIT is based in Hungary and Prof. Martin Schuurmans was elected Chairman of EIT Governingh Board. Prof Schuurmans did agree to meet with Mrs Treschow Torell and other Euro-CASE Executive Committee members in March or April. An EIT platform will be set up to prepare a contribution from Euro-CASE to EIT. This activity could be chaired by AcTI-nl.

An EIT Seminar "The EIT Shaping the Knowledge and Innovation Commmunities (KICs)" will take place in Bratislava on 24 November 2008. The invitation will be forwarded to all the Board members.

Action: secretariat

It is suggested that each Academy member of Euro-CASE, takes contact with the national representative of the EIT Governing Board.

Action: secretariat

4. Euro-CASE vision

Euro-CASE will now focus on

- Development of the website as a communication platform
- Organisation of an annual conference
- Development of projects run by member academies

It is important to define a longer term vision. A working group will be set up and chaired by Reiner Kopp. Follows The Euro-CASE Board members to be involved:
Prof. Reiner Kopp (DE), Acatech
Mr Hendrik Kuiken (NL), AcTI-nl
Mr Lasse Skovby Rasmusson (DK), ATV
Prof. Asbjørn Rolstadaas (NO), NTVA
Prof. Petr Zuna (CZ), EA CR

The objective will be to produce a mission statement with perspective of 30 – 50 years. Vision toward Europe, Engineering European bodies, EU agenda, to raise problems and and time frame should be taken into account. This activity will not be financed by the Euro-CASE secretariat.

The first meeting of this working group will take place in January or February 2009. It is expecetd that a proposal could be ready and available for discussion for the next Board meeting in May 2009.

Action: Prof. Reiner Kopp

5. Euro-CASE Annual Conference

Lena Treschow Torell congratulates the staff of the Royal Academy of Engineering.

The 2009 Euro-CASE Annual Conference will be organised by IVA and will take place in Stockholm on 5 November 2009. The theme proposed by IVA is "Young people in engineering studies". It is agreed.

Lena Treschow Torell confirms the importance of having high level representation from industrialists and politicians from Brussels and Sweden at the conference. 170 persons could attend.

It is recommended to stick on the UK format with a vote by the end of the journey. The results of this vote and discussion panel should be used to enhance the Euro-CASE visibility (ex: press article in Guardian). Web cast should be considered.

It is also suggested to have less presentations and more discussion.

Björn O. Nilsson will be in charge of this event and will be pleased to receive comments and suggestions from other Board members.

Action: IVA

Regarding 2010, Germany or Spain could make a proposal. Mr Kniewald suggests organising the 2011 Conference in Croatia linked to the 300^{th} anniversary of the birth of Ruder Boskovic.

6. Euro-CASE activities

6.1. Energy and Environment

After a thorough discussion it is decided to stop the work in this platform but not the interest in Energy and Environment.

Derrick Gosselin confirms the project "Energy Prize" previously proposed by BACAS is not feasible for the time being. BACAS can not lead this project.

All Euro-CASE academies are welcome to send concrete proposals and to lead this platform in the future.

6.2. Engineering Education

Minutes of the platform meeting are circulated.

The platform formulates suggestions of which:

- Assessment of the extent of the mobility of professors and students
- Ways of ranking technical universities
- Educating the Engineering Leaders of tomorrow
- Financing of technical universities
- Collect all important European Institutions which are dealing with Engineering Education.

Regarding the questionnaire on the implementation of the Bologna process in engineering education, the document summarising the academies answers will be updated with the Greek input. An Executive summary will be written by Reiner Kopp and Petr Zuna.

Björn O. Nilsson will join the Platform on Engineering Education.

Furthermore the Slovenian academy suggests leading a project on "Comprehensive University Ranking – a European Ranking Methodology." A proposal of evaluation of the ranking system will be sent to the Engineering Education Platform and to the Executive Committee taking into account reservations expressed by some Board members.

This proposal should focus on:

- Examine the existing ranking methodologies
- Collect all the advantages and disadvantages
- Analyze best practices, etc...

The platform, led by Acatech Prof. Kopp, will review the proposal and propose an action plan to the Board.

Action: Prof. Reiner Kopp

6.3. Transport and Mobility

Bruno Jarry gives a short presentation of the work realised by this Platform.

6.3. Security and safety

Prof. Asbjørn Rolstadaas presents the proposal raised by NTVA and explained the difference between Security (Preventing from illegal events) and Safety (Creating a safe environement).

After discussion it is agreed to go on the discussion being specific and careful with wording. Interested academies should take contact with NTVA.

Action: interested members and NTVA

7. 300th anniversary of the birth of Ruder Bošković in 2011 (HR)

Euro-CASE should be pleased to co-support the ceremony of the 300th Anniversary of birth of Ruder Boskovic, including the use of Euro-CASE logo. However this does not include any financial contribution.

8. The Euro-CASE website

During this meeting it is technically impossible to make a demo.

Nevertheless some academies have still to nominate a contact person as soon as possible.

9. Euro-CASE enlargement

Bruno Jarry will meet soon with Mr Lukasik, a NATF member, to know more about the Polish Academy of Sciences.

10. Next meetings

Executive Committee meeting, Tuesday 3 February 2009 from 12.30 to 16.30 in Paris
Board dinner, Monday 11 May 2009 at 20.00
Executive Committee meeting, Tuesday 12 May 2009 from 8.30 to 10.00 in Paris
Board meeting, Tuesday 12 May 2009 from 10.30 to 14.00 in Paris
Executive Committee meeting, Monday 7 September 2009 from 12.30 to 16.30 in Paris
Executive Committee meeting, Wednesday 4 November 2009 from 15.00 to 18.00 in Stockholm
Annual Conference, Thursday 5 November 2009 in Stockholm
Board meeting, Friday 6 November 2009 from 9.00 to 13.00 in Stockholm

11. Any Other Business

11.1. Australia

On 3 October 2008, a first meeting has been organised in Paris with the Australian Academy who would like to organise a workshop in Europe with European Academies (France, Italy, Netherlands and United Kingdom) on: Old age, Health and New technologies.

11.2. China

Acatech, NATF, FFCSA and SATW are associated to the Chinese Academy of Sciences and the Chinese Academy of Technologies to organise a conference on "Energy, Housing and Health" in 2009.

11.3. USA

NAE is in the process to enhance its contacts with the European Commission. It is suggested to include Euro-CASE in the communication network.

Action: secretariat

11.4. Science and Technology in Society Forum

Prof. Zlatko Kniewald reports and gives the statement on the 5^{th} annual of the Science and Technology in Society forum which took place in Kyoto on 7 October 2008. He suggests to put a link on the Euro-CASE website and to keep contact with this organisation.

11.5. Finland

Prof. Henrik Wolff informs that FACTE has merged with the Millenium Foundation. The new Finnish representative to Euro-CASE is the Technology Academy Foundation.

The chairman thanks the participants and closes the meeting.

Paris, 05.12.2008

Annex 1

Realised 2008 - Euro-CASE activities

For Euro-CASE Basic secretariat
Period: 01.01.2008 - 30.09.2008

	Realised 01.01.2008 30.09.2008	Projected 01.01.2008 31.12.2008	Budget 01.01.2008 31.12.2008	Budget 01.01.2009 31.12.2009
Income				
Membership fees	92 087,50	109 626,00	109 626,00	112 364,00
Contracts, current year				
Contracts, previous years				
Contribution by academies				
Other income				
Total Income	**92 087,50**	**109 626,00**	**109 626,00**	**112 364,00**
Expenditure				
Staff	52 768,56	65 000,00	64 540,00	
Operating costs	6 039,25	9 000,00	7 000,00	
Service	7 041,52	8 000,00	4 000,00	
Accounant & audit	2 361,00	3 500,00	5 000,00	
Web site	9 390,46	10 000,00	11 000,00	
Travel expenditure	668,00	4 000,00	4 000,00	
Meeting	1 546,59	2 000,00	5 000,00	
Annual meeting		0,00	4 086,00	
Amortization		4 000,00	5 000,00	
Total Expenditure	**79 815,38**	**105 500,00**	**109 626,00**	**112 364,00**
Surplus/(Deficit)	**12 272,12**	**4 126,00**	**0,00**	**0,00**

Paris, 04.11.2008

Željko Jurić,
Department for Renewable Energy Sources and Energy Efficiency
Energy Institute Hrvoje Požar, Croatia

Euro-CASE Annual Conference: **"How can Europe meet its 2020 Renewables Targets?"**

Royal Academy of Engineering London,
3rd November 2008

Contribution to Discussion on Achievement of European 2020 Targets

In the framework of Session 5 of Euro-CASE Conference, Croatian representative, together with representatives from the Netherlands, France and Switzerland, participated in the panel discussion on 5 policy questions. The purpose of discussion is to present needed greenhouse mitigation policies for meeting the overall EU goal of a 20% greenhouse emission reduction by 2020. After panel discussion on policy questions, the delegates voted for one or more proposed options. Croatian representative's contribution to this discussion is given hereafter.

Policy questions:

1. What is the most pressing obstacle in achieving the 2020 targets?

1. Lack of technology
2. **Lack of appropriate incentives**
3. Skills deficits
4. Supply chain constraints
5. Insufficient grid adaptability
6. Closed energy markets
7. Unfavourable economic conditions
8. Lack of political will
9. Public perceptions/ Consumer behaviour
10. Over-ambitious scope of targets

There are many obstacles in achieving the 2020 targets. The most important barrier in Croatia could be lack of appropriate incentives, especially for heat and cool production from RES and EE in the building sector. Production of electricity from RES is regulated in 2007 by package of five sublaws. The incentive prices (feed-in tariffs) for production of electricity from RES were established, as well as the national indicative target of minimum share of electricity production from RES by 2010 (5.8%). So far, the production of heat and cool from RES is not regulated. Additionally, the support of Croatian Environmental Protection and Energy Efficiency Fund was limited to companies, local/regional self-government and other institutions, although the large potential belongs to RES and EE in the residential sector and natural persons. Consequently, **lack of appropriate incentives** is chosen as the most pressing obstacle in achieving the 2020 targets.

2. What other energy technologies offer most potential for carbon savings in Europe? (pick three)

1. **Nuclear Fission**
2. **Carbon capture and storage**
3. Geothermal energy
4. **Hydrogen & Fuel cells**
5. Nuclear Fusion
6. Microgeneration
7. Demand side reduction technologies
8. Process efficiency improvements

In order to achieve 20%, or even 30%, of GHG emission reduction in 2020, it will be necessary to implement all cost-effective EE measures and increase usage of RES. For achievement of such ambitious targets, nuclear energy, geothermal energy (especially geothermal heat pumps) and hydrogen in fuel cells have to participate, as well as demand and supply side energy efficiency improvement. Usage of fossil fuels could be also possible with carbon capture and storage (CCS) technologies. However, it seems that CCS technology will be ready for implementation after 2020.

If we analysis the potential for carbon savings on wider horizon, for example till 2050, the targets for Europe will be probably more than 50% of GHG emission reduction (60-70%). In this contest, it seems that without **CCS technologies, nuclear fission and hydrogen & fuel cells** won't be able to achieve needed GHG emission reduction and successfully solve global worming and climate change problems.

Unfortunately, we don't have a possibility to choose one or other option, it will be necessary to use all options/technologies for carbon savings.

3. Is there a need for a European energy grid?

1. Yes
2. No

European energy grid is important to ensure a competitive and healthy market. It is necessary to develop national electricity and natural gas grids in some countries, as well as improve connection between the neighbouring countries. Better coordination of national regulators at European level is also needed. Accordingly, **European energy grid is needed**, in order to lead not only to competitive market but also to improve the security of supply.

4. Should the EU maintain its commitment to raise the target for renewable energy to 30% of all energy needs by 2020 if a successor Treaty to Kyoto is signed?

1. Yes
2. No

EU should not raise its RES 2020 target to 30%. There is a huge potential of GHG emission reduction by enhancement of energy efficiency, especially in building sector. Heating and cooling participate about 40-50% in total final energy demand, and it is possible to significantly improve energy efficiency by appropriate insulation and energy efficient windows. It will be difficult to reach already defined ambitious 20% of renewable energy. However, targeted GHG emission reduction in expecting new Treaty for post-Kyoto era (20% or 30%) should be possible to reach by revival of nuclear option, together with 20% of RES in total primary energy supply and 20% increase of energy efficiency.

5a. Can the EU meet its 2020 targets?

1. Yes
2. No

According to the performed analyses of Kyoto target achievements in EU-15, twelve countries project that they will achieve their individual

GHG emission reduction Kyoto targets, four of them expect reaching a level below their Kyoto obligations, while three countries indicate that they will not meet their obligations. Concerning EU 2020 targets, it will be very difficult to meet targets without significant further efforts from member states. It will be necessary to implement not only EE and RES cost-effective measures, but also improve supporting mechanisms for RES and consumer behaviour in some countries. Consequently, **EU can meet its 2020 targets**, but it will obviously raise energy costs.

5b. And does it matter?

1. Yes
2. No

Achieving EU 2020 targets is very important, but without inclusion of all countries, especially USA and fast developing large countries China and India, the needed anthropogenic GHG emission reduction on global level can not be achieved. All countries have to participate in achieving global goals, depending on their economic power and available potential of GHG emission reduction.

CURRICULA VITAE – **Željko Jurić**

Željko Jurić (1967) is a Senior Researcher in Department for Renewable Energy Sources and Energy Efficiency at the Energy Institute Hrvoje Pozar. Before joining Energy Institute Hrvoje Pozar in 2006, he worked for EKONERG – Energy Research and Environmental Protection Institute. He obtained B.Sc. degree from Faculty of Mechanical Engineering and M.Sc. degree from Faculty of Electrical Engineering and Computing in Zagreb (thesis: "Model for Air Emission from Energy Sector").

He is a member of the Carbon Market Task Force in the framework of World Energy Council, Croatian Air Pollution Prevention Association, Croatian Energy Society and Croatian National Committee of CIGRÉ (International Council on Large Electric Systems).

Conference Report

European Commission put forward the overall goal of meeting 20% of EU's primary energy consumption from renewable sources by 2020. If Europe is to achieve this target in the space of twelve years, it will need to see a concerted effort by all stakeholders to tackle the regulatory, institutional, legal, technical and supply chain barriers that are holding back new renewables build.

The conference was co-hosted by Royal Academy President Lord Browne, Euro-CASE chair professor Lena Treschow Torell and EU Energy Commissioner Andris Piebalgs.

This conference was intended as a first attempt to address the engineering elements of that challenge. Leading engineers from the 21 Euro-CASE Academies met at The Royal Academy of Engineering in London to discuss solutions to important technical, supply chain and engineering policy problems. The conference highlighted the vital role of Europe's engineers in implementing renewable energy policy.

The conference was organised in 5 sessions, as follow:

1. Wind Power
2. Solar Power
3. Hydro, Wave and Tidal Power
4. Biomass, Biofuels and Biogas
5. The Broader Context of the 2020 Renewables Targets

First session was focused on near-future technology and efficiency improvements in wind power generation and asked if Europe is able to put sufficient industrial and engineering capacity in place for its planned increases in wind generation capacity. There were three presentations by representatives from Ocean Power Delivery Ltd – UK, Group Government Relations Department, Vestas Wind Systems A/S – Denmark and Energy Technologies Institute – UK.

Second session investigated how improved technologies and delivery mechanisms could encourage greater use of solar power in Central and Southern Europe, and examined how European engineers are promoting the uptake of solar power in neighbouring countries (e.g. north Africa countries).

The speakers came from Abengoa – Spain, European Commission Joint Research Centre and Technische Universität Berlin – Germany.

Third session looked at the prospects for commercial wave and tidal generation in Europe in the short to medium term and assessed the attempts by Europe's engineers to moderate the environmental impact from large scale hydro projects. Three speakers came from Norwegian University of Science and Technology, Trondheim – Norway, ESB International – Ireland, University of Wales – UK.

Fourth session looked at the environmental, economic and food security impacts of biofuels and asked whether new generations of biofuels, improved supply chains and more thorough assessment frameworks can help resolve these problems. There were also three speakers from Biofuels Committee – France, Umeå University – Sweden and Czech Technical University in Prague – Czech Republic.

Finally, fifth session was panel discussion on 5 key policy questions. As the CO_2 emission reductions associated with the Commission's renewables targets will go less than halfway to meeting the overall EU goal of a 20% GHG emissions reduction by 2020, this session examined what GHG mitigation policies are needed to complement this effort – both in Europe and globally. Four panellists analysed needed GHG mitigation policies for meeting the overall EU goal of a 20% greenhouse emission reduction by 2020. Panellists come from Royal Dutch Shell Plc – Netherlands, NATF Fellow – France, Swiss Academy of Engineering Sciences – Switzerland and Energy Institute Hrvoje Požar – Croatia.

CAETS

International Council of Academies of Engineering and Technological Sciences

Introduction to CAETS:

International Engineering and Technological Sciences Excellence

CAETS is the **International Council of Academies of Engineering and Technological Sciences, Inc.** It consists of those national academies of engineering and technological sciences that have satisfied an agreed set of criteria for membership. It was established in 1978 and was incorporated as a charitable non-profit corporation in the District of Columbia (US) in 2000. Its Articles of Incorporation, Bylaws and Operating Procedures set down its objectives and governance arrangements. Its membership and achievements are set down in the CAETS publication ***The First 25 Years 1978-2003.***

CAETS Objectives

Consistent with its Articles of Incorporation and in support of its mission, CAETS will:

a) Provide an independent non-political and non-governmental international organization of engineering and technological sciences academies, prepared to advise governments and international organizations on technical and policy issues related to its areas of expertise;

b) Contribute to the strengthening of engineering and technological activities in order to promote sustainable economic growth and social welfare throughout the world;

c) Foster a balanced understanding of the applications of engineering and technology by the public;

d) Provide an international forum for discussion and communication of engineering and technological issues of common concern;

e) Foster cooperative international engineering and technological efforts through meaningful contacts for development of programs of bilateral and multilateral interest;

f) Encourage improvement of engineering education and practice internationally;

g) Foster establishment of additional engineering academies in countries where none exist; and

h) Undertake other projects, programs, and activities not inconsistent with section 501 (c)(3) of the Internal Revenue Code and any applicable law of the District of Columbia.

Mission

The mission of CAETS is to foster effective engineering and technological progress for the benefit of societies of all countries. Specifically, CAETS provides the mechanism through which the engineering and applied science academies of the world work together on internationally important issues in ways that enable each academy to draw on the total global experience and expertise of all member academies in addressing issues at the national level; and which ensure that the best technological and engineering expertise is made available to, and used to best advantage by, the key global intergovernmental institutions for the benefit of all the peoples of the world.

Vision

The vision of CAETS is of a world in which national and international decision-making on economic, social, and environmental issues is properly informed on relevant scientific, technological and engineering considerations and in which the peoples of all countries benefit to the full from the capabilities of science, technology and engineering.

Origin and Membership

CAETS was established in 1978 with five founding academies and held its first Convocation that year in Washington, DC at the invitation of the US National Academy of Engineering (NAE). Each CAETS member academy consists of peer-elected members representing for that nation the highest standard of excellence and achievement in their profession. With a well established program of service on important national and international issues with significant engineering and technological content, many of these national academies are called upon by their governments to provide authoritative, objective advice on technological issues of national importance. Working together in CAETS, the academies form a worldwide engineering resource that can address with the highest skills and capabilities major global issues that require the considered judgment of the world's most outstanding engineering talent.

Governance

The administrative and policy body of CAETS, on which each academy has one representative, is the Council, which elects the Officers (President, President-elect, Past President and Secretary/Treasurer), and the Board of Directors, which consists of the Officers (the Executive Committee) and four other members, each, with the exception of the Secretary/Treasurer, serving one-year terms.

Officers 2006

The Officers and Members of the Board of Directors during 2006 are:

- Prof. Achiel van Cauwenberghe, Royal Belgian Academy of Applied Sciences (BACAS), President
- Prof. Jun-ichi Nishizawa, Engineering Academy of Japan (EAJ), President-elect
- Dr. John Zillman, Australian Academy of Technological Sciences and Engineering (ATSE), Past President
- Mr. William C. Salmon, Secretary/Treasurer
- Dr. Gerardo Ferrando-Bravo, Academy of Engineering (AI), Mexico
- Dr. Rene Danliker, Swiss Academy of Engineering Sciences (SATW)
- Dr. R. Natarajan, Indian National Academy of Engineering (INAE)
- Dr. Asko Saarela, The Finish Academies of Technology (FACTE)

Convocations and Annual Meetings

The major CAETS events are its biennial Convocations, its annual Council meetings, and its host academy-sponsored symposia in alternate, non-Convocation years. Recent Convocations have dealt with the following:

- "Creating Wealth in Harmony with the Environment" (Eleventh Convocation), Kiruna, Sweden, 18-21 June 1995
- "Engineering, Innovation and Society" (Twelfth Convocation), Edinburgh, United Kingdom, 21-23 May 1997
- "Technology and Health" (Thirteenth Convocation), Sophia Antipolis, France, 24-27 May 1999
- "World Forests and Technology" (Fourteenth Convocation), Espo, Finland, 11-15 June 2001
- "Entertaining Bytes" (Fifteenth Convocation), Hollywood, United States, 18-22 May 2003
- "Oceans and the World's Future" (Sixteenth Convocation), Cairns, Australia, 10-14 July 2005.

Following its Sixteenth Convocation, CAETS issued a major statement on *Oceans and the World's Future,* addressed to national and international organizations with responsibility for the oceans.

The forward program of CAETS Convocations and annual meetings will be as follows:

2006 Annual Meeting, BACAS, Belgium, Brussels, 1-2 June, "Hydrogen Economy: Clean Energy for this Century"

2007 Seventeenth Convocation, EAJ, Japan, Tokyo, 23-26 October, "Environment and Sustainable Growth"

2008 Annual Meeting, Netherlands Society of Technological Sciences and Engineering (NFTW), Netherland

2009 Eighteenth Convocation, Canadian Academy of Engineering (CAE), Canada

2010 Annual Meeting, Danish Academy of Technical Sciences (ATV), Denmark

2011 Nineteenth Convocation, Mexican Academy of Engineering (AI), Mexico

Strategy 2006 - 2010

CAETS Priorities for 2006 – 2010 are:

- Engaging with the United Nations Specialised Agencies and related international organizations;
- Fostering and strengthening National Academies of Engineering and Technological Sciences;
- Convocations, Symposia and Reports – support Member Academy initiatives; and
- Addressing issues of common concern of the Member Academies.

Engagement with the United Nations (UN) System

In respect of its first-listed priority above, CAETS seeks to develop and implement an ongoing advisory/consultative role with the relevant scientific/technological organizations of the United Nations (UN) System. It has adopted the following immediate goals for 2006 – 2007:

- Identify and establish initial working contacts with at least two key UN System agencies;
- Arrange CAETS representation, by invitation, at one or more UN System governing body sessions;
- Provide all relevant UN System agencies with an introduction to CAETS and its activities; and
- Establish working relations with WFEO, IAC, ICSU and other relevant non-governmental bodies in respect of CAETS linkages with the UN.

Information on CAETS

The CAETS web site, www.caets.org, includes information on all aspects of CAETS activities, as well as mailing addresses and web site links for Member Academies. CAETS incorporated in the District of Columbia, USA, June 30, 2000 and is an IRS 510(c)(3) tax-exempt, charitable organization.

Member Academies

National Academy of Engineering (ANI)
Av. Pte. Quintana 585 - 3er Piso
1129 Buenos Aires
ARGENTINA

Australian Academy of Technological Sciences and Engineering (ATSE)
197 Royal Parade
Parkville 3052
AUSTRALIA

Royal Belgium Academy of Applied Sciences (BACAS)
Hertogstraat 1, rue Ducale
1000 Brussels
BELGIUM

The Canadian Academy of Engineering (CAE)
180 Elgin Street, Suite 1100
Ottawa, Ontario K2P 2K3
CANADA

Chinese Academy of Engineering (CAE)
China Science and Technology Hall
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Beijing 100038
CHINA, PEOPLE'S REPUBLIC OF

Croatian Academy of Engineering (HATZ)
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Engineering Academy of the Czech Republic (EA CR)
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117 20 Prague 1
CZECH REPUBLIC

Danish Academy of Technical Sciences (ATV)
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DK 2800 Lyngby
DENMARK

The Finnish Academies of Technology (FACTE)
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FIN-00170, Helsinki
FINLAND

National Academy of Technologies of France (NATF)
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75007 Paris
FRANCE

acatech
Hofgartenstr. 2
Munchen 80539
GERMANY

Hungarian Academy of Engineering (HAE)
Kossuth Lajos ter 6/8
H-1055 Budapest
HUNGARY

Indian National Academy of Engineering (INAE)
6th Floor, Vishwakarma Bhawan
IIT Campus, Shaheed Jeet Singh Marg
New Delhi 110016
INDIA

The Engineering Academy of Japan (EAJ)
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Tokyo 108-0014
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The National Academy of Engineering of Korea (NAEK)
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Netherlands Society of Technological Sciences and Engineering (NFTW)
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1000 GC Amsterdam
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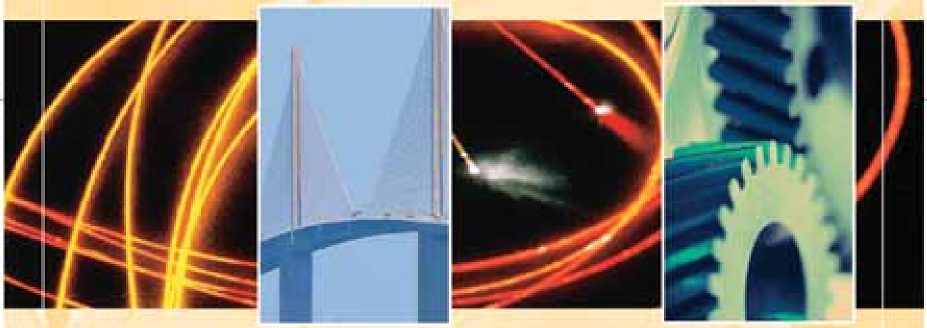
CAETS

International Council of Academies of Engineering and Technological Sciences



The First 30 Years 1978 - 2008

International Council fo Academies of Engineering and Technological Sciences, Inc. (CAETS)

Incorporated June 30, 2000
District of Columbia, U.S.A.
E.I.N. 52-2251297
An IRS Section 501 (c) (3) organization

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AUSTRALIA

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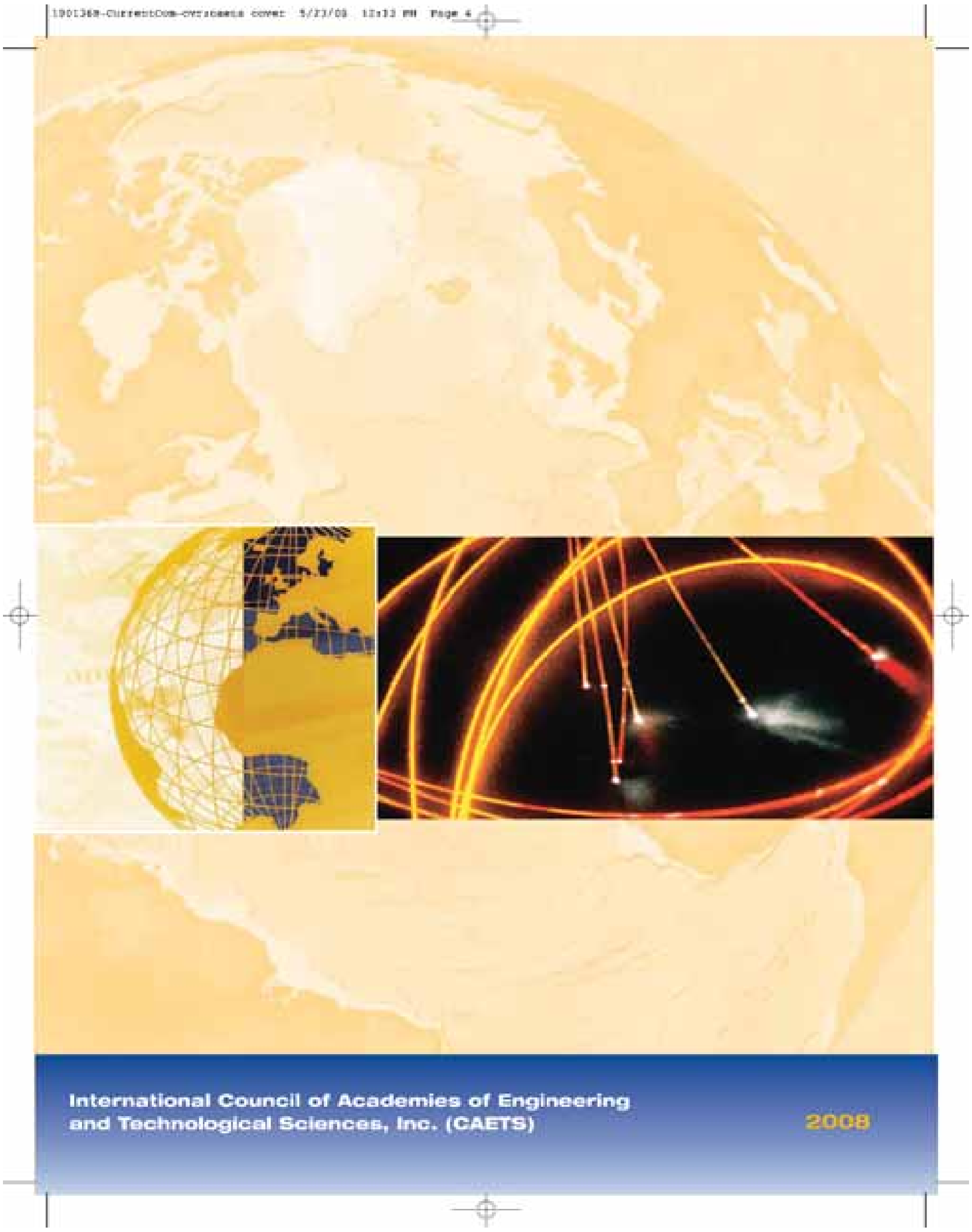
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International Council of Academies of Engineering
and Technological Sciences, Inc. (CAETS)
2008

Introduction

The 1st International Convocation of Academies of Engineering and Similar Institutions was held in 1978. Slight changes were made in the title of subsequent convocations during 1980 to 1985. Later in 1985, the name Council of Academies of Engineering and Technological Sciences (CAETS) was agreed. On incorporation in 2000, the name became the International Council of Academies of Engineering and Technological Sciences, Inc. (CAETS).

The five Founding Academies were involved in the 1978 convocation, the subsequent convocations, and helped form the nature of and the launching of CAETS in 1985. Thereafter, new member academies were added through the election process.

The Growth of CAETS identifies the steps taken in developing the organizational structure of CAETS, the member academies involved in hosting convocations and other meetings called to consider dealing with the growth of the membership.

The Officers are listed for the period (1978 to 1985), when the leadership was known as the Convocation Steering Committees, for the growth period (1985-2000), and for the post-incorporation period (2001-2008).

The Proceedings of the CAETS Convocations, CAETS Reports and CAETS Statements provide some sense of the breadth of interest of the membership of CAETS.

The CAETS Rotation Schedule describes the non-elective process that identifies the potential future member academies that may host convocations, annual meetings of the Council and provide their members for CAETS leadership positions.

There is much related to the growth of CAETS that has not been recorded here. The existence of CAETS, as well as its membership requirement for self-government, has encouraged the creation and development of national academies focused on engineering and technological sciences. The exchange of experiences among the member academies has fostered efforts by individual member academies to become more effective in contributing to important national issues with significant engineering content, and regional groupings of academies to contribute to similar regional issues.

To support the activities of CAETS, each member academy is responsible for its participants' expenses. In the early years, hosts of convocations covered the meeting expenses. Later, as convocation attendance grew, registration fees helped to offset some - but not all - meeting expenses. Also in the early years the NAE (US) covered all costs of the secretariat. In the late 1980s, as the membership grew, the member academies agreed to share the direct costs of the secretariat each year after expenses were totaled, with the NAE (US) providing the operating funds for each year. Beginning in 2001, dues collected at the beginning of the year went to cover costs of that year. CAETS repaid NAE (US) over the next four years for the secretariat expenses for the year 2000.

This material was compiled from several sources, including History and Summary of Activity, 1978 – 1999, a CAETS report prepared by Steven N. Anastasion, Vice President and Secretary of CAETS, 1985 - 1999.

Objectives

CAETS is an independent non-political, non-governmental international organization of engineering and technological sciences academies, one member academy per country, with the following objectives, as stated in the CAETS Bylaws, Article 1, a-g:

(a) Prepared to advise governments and international organizations on technical and policy issues related to its areas of expertise;

(b) Contribute to the strengthening of engineering and technological activities to promote sustainable economic growth and social welfare throughout the world;

(c) Foster a balanced understanding of the applications of engineering and technology by the public;

(d) Provide an international forum for discussion and communication of engineering and technological issues of common concern;

(e) Foster cooperative international engineering and technological efforts through meaningful contacts for development of programs of bilateral and multilateral interest;

(f) Encourage improvement of engineering education and practice internationally; and

(g) Foster establishment of additional engineering academies in countries where none exist.

CAETS Strategy 2008 - 2012

Preamble

CAETS, the International Council of Academies of Engineering and Technological Sciences, Inc., consists of those national academies of engineering and technological sciences which, as judged by their fellow members, have satisfied an agreed set of criteria for membership. CAETS was established in 1978 and was incorporated as a charitable non-profit corporation in the District of Columbia (USA) in 2000. Its Articles of Incorporation, Bylaws and Operating Procedures set forth its objectives and governance arrangements.

Vision

CAETS envisions a world in which national and international decision-making on economic, social, and environmental issues is properly informed by relevant engineering, scientific and technological considerations and in which the peoples of all countries benefit fully from the capabilities of engineering, science and technology.

Mission

The mission of CAETS is to foster engineering and technological progress for the benefit of societies of all countries.

CAETS provides the organizational mechanism through which engineering and technological science academies of the world can work together on important issues at the intersection of technology and society. Through communication and sharing of best practices, each academy may draw on the total global experience and expertise of other member academies to address issues at the national level and, collectively, to encourage use of the best engineering and technological advice by key global intergovernmental institutions for the benefit of all peoples of the world.

Priorities

Join forces with member academies to address global problems.

Themes for the biennial Convocations of CAETS reflect, to a significant extent, the host academy's view of its current national engineering and technological issue(s), and hosts of alternate year annual meetings schedule them to be in conjunction with a meeting of general interest to CAETS member academies. Also, CAETS member academies differ from one and other in financial resources and national and international impact and outreach. With a view to increasing the benefit of such CAETS activities, cooperation among member academies is encouraged, possibly including co-organization or co-hosting of meetings and collaboration on publications.

Issues for possible consideration by CAETS include: application of technologies for realizing sustainable economy; engineering education, including e-learning; promotion of public understanding of the valuable role of engineering and technological sciences; new materials and technologies; water management and production; transport; sustainability and management of natural resources; and energy.

Immediate Goals:

- Conduct a successful Eighteenth Convocation in Canada in 2009 and a successful Nineteenth Convocation in Mexico in 2011; and
- Address issues of common concern to the member academics at annual Council meetings and supporting workshops.

Consolidate and strengthen CAETS advisory/ consultative role and working relations with relevant engineering/scientific/technological organizations of the United Nations System, the InterAcademy Council, the International Council of Scientific Unions, the World Federation of Engineering Organizations, and other non-governmental partners.

CAETS has developed initial working relations with the United Nations Educational, Scientific and Cultural Organization (UNESCO), its Intergovernmental Oceanographic Commission (IOC) and the World Meteorological Organization (WMO). Initial contacts have also been made with the Food and Agriculture Organization (FAO), the UN Development Programme (UNDP), the UN Environment Programme (UNEP) and the UN Commission for Sustainable Development (CSD).

CAETS provides input, through Observer capacity representation at governing body sessions, to UNESCO, IOC and WMO. CAETS member academies have advised their national delegations to the governing bodies of these organizations, including sessions of the General Conference of UNESCO and the World Meteorological Congress.

CAETS intends to strengthen and broaden these working relations in coming years. In particular, CAETS will:

- Explore the scope for working relations with other relevant UN bodies;
- Regularly brief the Executive Heads of UN System bodies on CAETS role and activities, such as through provision of the latest versions of the "Introduction to CAETS;"
- Invite key UN System bodies to attend sessions of CAETS Council as observers;
- Complement the efforts of CAETS member academies by alerting them to relevant engineering/scientific/technological developments and issues in the UN System and assisting with their input to national briefs and delegations to relevant UN System activities, including the UN Millennium Development Goals; and
- Strengthen its working relations with ICSU, IAC and WFEO and collaborate closely in joint relations with the UN System.

In the shorter term (over the next two years) CAETS will:

- Evaluate its experience of working with UNESCO, IOC and WMO as a guide to future involvement with them and with other elements of the UN System;
- Arrange CAETS representation at governing body sessions of other UN organizations as appropriate;

- Review its working relations with ICSU, IAC and WFEO; and
- Develop proposals for specific joint projects with at least one UN System organization and one non-governmental partner.

Build global capacity for technological advice and consultation by fostering, strengthening and increasing the number of academies of engineering and technological sciences worldwide.

Representatives of CAETS member academies should be more proactive in contacting emerging engineering bodies and academies in other countries. CAETS should encourage the creation of new academies of engineering in countries where none exists. In those countries where it is unlikely that separate engineering academies will be established in the near to intermediate term, special arrangements should be adopted with a view to enabling engineering subgroups of Academies of Science to be active in CAETS.

For many academies, which derive their major income from personal membership, the dues to CAETS may be an important obstacle to active membership. CAETS should therefore maintain a dues structure which facilitates their membership.

Over the next two years CAETS will:

- Continue implementation of specific strategies to increase its membership by 50% by 2012, without altering its criteria for membership; and
- Develop a list of possible candidate academies from Asia, Africa, the Middle East, South America and countries which were part of the former USSR based on proactive member academy contact with engineering bodies in these regions.

Help member academies deal more effectively with their own national issues and academy operational issues through organized presentations and discussions at annual Council meetings.

Experience has shown that there are a number of issues of common concern among member academies; for example engineering education has received attention on an almost regular basis at annual Council meetings. When merited, such an issue should be the subject of an organized portion of a Council meeting for discussion, possibly followed by a workshop, to assist participating member academies to better deal with the issue in their own countries.

Immediate Goal:

- Members of the Board of Directors will lead Council discussions on topics of common concern to benefit those member academies interested in the subject.

Member Academies

Founding Member Academies (1978)

Australian Academy of Technological Sciences and Engineering (ATSE)
[Formerly Academy of Technological Sciences (ATS)]

Royal Academy of Engineering of the United Kingdom (RAEng)
[Formerly the Fellowship of Engineering (FoE)]

Academy of Engineering (Mexico) (AI)
[Formed in 2002 by a merger of the National Academy of Engineering (ANI, Founding Member) and the Mexican Academy of Engineering (AMI)]

National Academy of Engineering (United States) (NAE)

Royal Swedish Academy of Engineering Sciences (IVA)

Elected Member Academies	Year Elected
Danish Academy of Technical Sciences (ATV)	1987
Swiss Academy of Engineering Sciences (SATW)	1988
National Academy of Technologies of France (NATF) [Formerly Council for Applied Sciences of the French Academy of Sciences (CADAS)]	1989
The Finnish Academies of Technology (FACTE) [Represents the Finnish Academy of Technology and the Swedish Academy of Engineering Sciences in Finland]	1989
The Engineering Academy of Japan (EAJ)	1990
Royal Belgian Academy Council of Applied Sciences (BACAS)	1990
The Norwegian Academy of Technological Sciences (NTVA)	1990
Canadian Academy of Engineering (CAE)	1991
Netherlands Academy of Technology and Innovation (AcTI.nl) [Formerly Netherlands Society of Technological Sciences and Engineering (NFTW)]	1993
Hungarian Academy of Engineering (HAE)	1995
Chinese Academy of Engineering (CAE)	1997
Ukrainian Academy of Engineering Sciences (UAES) (Inactive)	1998
Academy of Engineering in Poland (AIP) (Inactive)	1998
National Academy of Engineering (Argentina) (ANI)	1999
Engineering Academy of the Czech Republic (EA CR)	1999
Indian National Academy of Engineering (INAE)	1999
Royal Academy of Engineering of Spain (AIE)	1999
The National Academy of Engineering of Korea (NAEK)	2000
Croatian Academy of Engineering (HATZ)	2000
Slovenian Academy of Engineering Sciences (IAS) (Inactive)	2000
National Academy of Engineering of Uruguay (ANIU)	2000
German Academy of Science and Engineering (acatech)	2005

The Growth of **CAETS** 1978 - 2008

Washington, D.C., United States, 1978

During the early 1970s, members of the U.S. National Academy of Engineering (NAE) and the Royal Swedish Academy of Engineering Sciences (IVA) discussed the notion that occasional meetings of engineering academy leaders would benefit all organizations involved. On October 31, 1978, that notion became reality when the NAE (US) organized and chaired the 1st International Convocation of Academies of Engineering and Similar Institutions in Washington, D.C. Representatives from the Australian Academy of Technological Sciences (ATS); the Danish Academy of Technical Sciences (ATV); the Academy of Engineering (ANI, Mexico); the Fellowship of Engineering of the United Kingdom (FoE); the U.S. National Academy of Engineering (NAE); the Royal Swedish Academy of Engineering Sciences (IVA); and the Finnish Academies of Technology (FACTE). Engineers from Israel and India were also present. In addition to presentations on the respective academies' histories, functions, and objectives, the participants discussed the relationships of an engineering academy to its own national society, its sister academy of sciences, and to other national academies of engineering. IVA was asked to chair a planning committee to organize a second convocation.

Melbourne, Australia, 1980

ATS (Australia) hosted the 2nd Convocation of Engineering and Like Academies in Melbourne on April 8-9, 1980. Representatives from the academies of Sweden, the United States, the United Kingdom, Mexico, and Australia addressed the theme, while participants from Yugoslavia, India, and Japan also made statements. The participants agreed to establish an informal secretariat for information exchange among the interested academies, and NAE (US) agreed to be its host.

Oaxaca, Mexico, 1981

ANI (Mexico) hosted the 3rd Convocation of Engineering Academies and Like Organizations in Oaxaca on September 21-22, 1981. Participants gave presentations on national developments in engineering education. At the meeting's end, the participants decided that some structure for this loose "international federation" would be useful. A Steering Committee was formed with ATS (Australia) as president, ANI (Mexico) as vice president, and IVA (Sweden) and NAE (US) as members.

Stockholm, Sweden, 1983

IVA (Sweden) hosted the 4th Convocation of Engineering Academies in Stockholm on May 29-June 1, 1983. Using a revised format, each of the five academies organized a session with three or four speakers. It was not necessary that all speakers be from CAETS member countries. At its meeting following this convocation, the Steering Committee agreed that in view of growing interest and participation by other engineering academies it would be useful to form an umbrella organization. The organization, called the Convocation of Academies of Engineering and Technological Sciences, would have a president and vice president; these positions would rotate among members every two years, and the president's academy would host the convocation. ANI (Mexico) was named president and NAE (US) the vice president. NAE (US) agreed to provide the Convocation Secretariat, and guidelines for the Convocation's organization and attendance were adopted. Further, the Fellowship of Engineering of the United Kingdom (FoE) was invited to join the Steering Committee.

Washington, D.C., United States, 1983

The Steering Committee met again on November 3, 1983 in Washington, D.C. In addition to discussing the location and theme of the next convocation, committee members considered the objectives, nature, and character of the organization, as well as the criteria and method for admitting new members. The Steering Committee asked ANI (Mexico) and NAE (US) to prepare a draft document of objectives and rules for discussion at the next Steering Committee meeting.

London, England, 1985

The FoE (UK) hosted the 5th Convocation in London on June 10-14, 1985. At the meeting that followed, Steering Committee members considered the draft rules prepared by ANI (Mexico) and NAE (US). The group made a number of changes and asked that a revised version be prepared. At the end of the meeting, NAE (US) became the president and ATS (Australia) the vice president.

Washington, D.C., United States, 1985

The Steering Committee met in Washington, D.C., on October 4, 1985, to plan the 6th Convocation and to consider the revisions to the draft rules. After making additional changes, the Committee adopted the General Rules of the Council of Academies of Engineering and Technological Sciences (CAETS). The General Rules provided for a Governing Board of the Council to include a representative of each member academy. The Board began with the five founding members: the Australian Academy of Technological Sciences and Engineering (ATS); The Fellowship of Engineering of the United Kingdom (FoE); the National Academy of Engineering of Mexico (ANI); the U.S. National Academy of Engineering (NAE); and the Royal Swedish Academy of Engineering Sciences (IVA).

Washington, D.C., United States, 1987

The NAE (US) hosted the 6th Convocation in Washington, D.C., on May 30-April 1, 1987. The format was more integrated, with speakers invited from other member academies. At the Governing Board meeting following the Convocation, the Council elected the Danish Academy of Technical Sciences (ATV) to membership. Denmark was placed at the bottom of the rotation list, the mechanism used to identify the member academies which would serve as president and host a convocation in the future.

Sydney, Australia, 1988

ATS (Australia) hosted the 7th Convocation in Sydney on October 12-14, 1988. At its meeting on October 16, 1988, the Governing Board approved the first CAETS Financial Policy, with the principle of equal cost-sharing by members for operations. The Board also considered membership applications from the Swiss Academy of Engineering Sciences (SATW), the Council for Applied Sciences of the French Academy of Sciences (CADAS), the Norwegian Academy of Technological Sciences (NTVA), and the Finnish Academies of Technology (FACTE). It admitted SATW, bringing total membership to seven. It postponed considering CADAS' and NTVA's applications until it received more information about their activities. Further, FACTE's application was deferred to a later meeting because of inadequate time for its review.

Stockholm, Sweden, 1989

At its October 29, 1989 meeting in Stockholm, the Governing Board convened a Working Group to review the structure and operation of CAETS in light of the prospective increase in membership, and to review the General Rules and suggest appropriate revisions. The Board elected CADAS (France) and FACTE (Finland) to membership, bringing total membership to nine.

Copenhagen, Denmark, 1990

The Working Group met in Copenhagen on June 7-8, 1990, and recommended amendments to the General Rules. Included in its recommendations were that the Governing Board continue to include all CAETS member academies; the positions of president and first vice president each have two-year terms; the position of vice president/secretary be filled by Board appointment; and voting by written proxy be permitted on all specific Board action items. The Steering Committee would now consist of the president, first vice president, vice president/secretary, and the past president.

Acapulco, Mexico, 1990

ANI (Mexico) hosted the 8th Convocation in Acapulco on November 6-9, 1990. The format included three plenary topics, followed by three working groups, each dealing with one of the plenary topics and preparing views for consideration at the closing plenary. At its meeting on November 9, the Governing Board decided that the consensus conclusions and findings of the closing plenary session deserved international dissemination as a special CAETS report. The report, "Harnessing Technology for Development: A Summary of the Eighth Convocation," served as a summary of the Convocation and was well received.

In other action on November 9, the Board approved the recommendations of the Working Group (Copenhagen, June 7-8, 1990), thus amending the General Rules. The Board also elected to membership the Engineering Academy of Japan (EAJ), the Royal Belgian Academy Council of Applied Sciences (BACAS), and the Norwegian Academy of Technical Sciences (NTVA), bringing the total membership to 12.

Paris, France, 1991

The Governing Board met in Paris, France on September 12, 1991. The Board approved creating a CAETS Reserve Fund, with all current members contributing $2,000 (US) and each new member academy contributing the same amount upon election to membership. The fund would be used sparingly for special projects, such as printing CAETS reports. Also at this meeting, the Governing Board elected the Canadian Academy of Engineering (CAE) to membership.

Copenhagen, Denmark, 1992

ATV (Denmark) hosted the 9th Convocation in Copenhagen on May 19-22, 1992. At its meeting on May 23, 1992, the Board reviewed CAETS' growth, increasing costs, encouragement and selection of new members, and mode of operations. The president convened a Working Group to report its findings at the next Board meeting.

Trondheim, Norway, 1992

The Working Group met on November 10-11, 1992 in Trondheim and recommended that CAETS continue to operate with minimum bureaucracy and at low costs and that meetings of the Governing Board should be held annually and include all member academies. Attendees agreed that the rotation list was working well as the basis for officer selection and convocation host.

Irvine, California, United States, 1993

The Governing Board met on January 8, 1993 in Irvine, California. The Trondheim report was presented and approved as principles for CAETS operations. In response to member academies' expressed interests, this meeting was scheduled for a full day, rather than the usual half-day. In addition to the business portion of the agenda, half of the meeting was devoted to discussion of member academy activities and issues each considered to be high priority.

Zurich, Switzerland, 1993

SATW (Switzerland) hosted the 10th Convocation in Zurich on September 14-18, 1993. The Board approved the Guidelines for CAETS Operations and changes to the General Rules and Financial Policy at its September 17 meeting. Included in the Guidelines were statements of guiding principles and recommendations for CAETS operations, convocations, finances, products, association with member activities, and institutional associations. The Guidelines were meant to amplify portions of the General Rules and to document statements of policy derived from the General Rules and from Board decisions. The Board also elected the Netherlands Society of Technological Sciences and Engineering (NFTW) as the 14th Council member.

Helsinki, Finland, 1994

At its meeting on October 31, 1994 in Helsinki, the Board decided that a draft policy paper on "Engineering and Environment" should be prepared to represent the CAETS position on this important international issue. The paper, to be drafted initially by NAE (US), would be based on the contributions of member academies, circulated before the next convocation, discussed at that meeting, and revised in light of that discussion.

Kiruna, Sweden, 1995

IVA (Sweden) hosted the 11th Convocation in Kiruna on June 18-21, 1995. The Governing Board meeting that followed on June 22 was held in two sessions. During the first session, the Board elected the Hungarian Academy of Engineering (HAE) as the 15th Council member. During the second session, the Board reviewed the third draft of the "Engineering and Environment" document, considered additional suggestions and adopted a final document, which was signed by the member academy representatives present.

Tokyo, Japan, 1996

The Governing Board met in Tokyo on September 13, 1996, following the Engineering Academy of Japan's 4th International Symposium. The Board approved revisions to the General Rules, the Financial Policy, and the Guidelines for CAETS Operations. Thereafter, each member reviewed its programs and plans and identified its high-priority issues. In light of interests expressed by many of the member academies, the Board decided that two hours of the next Board meeting would be devoted to a discussion of engineering education. The RAEng (UK) representative agreed to prepare a short issue paper to help focus the discussion.

Edinburgh, Scotland, 1997

The RAEng (UK) hosted the 12th Convocation in Edinburgh on May 21-23, 1997. Governing Board members continued discussion of engineering education at the the Governing Board meeting on May 23. In response to the query on how CAETS could best contribute to the broad array of concerns expressed by the members, NFTW (Netherlands) offered to take the lead in setting up a CAETS Working Party. The Board also approved the formation of a CAETS Strategy Review Group (SRG) to consider the future direction of CAETS, its objectives, organization and management, membership, activities, and international associations. The SRG, consisting of the Steering Committee and representatives of interested member academies, would present its findings at the 1998 Board meeting. The Chinese Academy of Engineering (CAE) was elected to membership at this meeting.

London, England, 1997

The SRG met in London on September 23-24, 1997. The report of its discussion included mission and objectives; relationship to international bodies and external partners; process of convocations; criteria for membership; regional groupings within CAETS; organizational changes; and financial arrangements.

Ottawa, Canada, 1998

The Governing Board met in Ottawa on June 5, 1998 and adopted the SRG's recommended changes to the General Rules and Guidelines for Operations. The changes included adopting a mission statement for CAETS: "To foster effective contributions to engineering and technological progress for the benefit of societies of all nations." The Board also received the summary report of the Working Party on engineering education from NFTW and asked that NFTW formulate its report into a document to be reviewed at the next meeting before being distributed to all members.

On review of the Financial Policy, the Board adopted a change to the annual assessments to the CAETS Operating Fund (COF), effective in Fiscal Year 1999. The change provided for a level assessment ($3,000 US), not to be exceeded for several years. An annual budget continues to be presented for Board review and approval, and any balance remaining in the Operating Fund at the end of a fiscal year is added to the CAETS Reserve Fund.

Also at this meeting, the Ukrainian Academy of Engineering Sciences (UAES) and the Academy of Engineering in Poland (AIP) were elected as the 17th and 18th members of CAETS. The Indian National Academy of Engineering's application was deferred without prejudice until after the CAETS Steering Committee could visit the academy, to follow a new policy that CAETS send a delegation to visit applicant academies before their election.

1998

Sophia Antipolis, France, 1999

CADAS (France) hosted the 13th Convocation in Sophia Antipolis on May 24-27, 1999. On May 28, the Governing Board discussed and accepted NFTW's draft report on engineering education. The final report was published and copies were sent to all members and several non-member academies.

The CAETS membership increased to 22 academies at this meeting, with the election of the National Academy of Engineering of Argentina (ANI), the Engineering Academy of the Czech Republic (EA CR), the Indian National Academy of Engineering (INAE), and the Academy of Engineering of Spain (AIE). The National Academy of Engineering of Korea's application was deferred until after a CAETS delegation could visit Korea.

1999

The Board created another Strategy Task Group (STG) to consider various options for the future functioning of CAETS. The STG was charged with making proposals and recommendations available for Board review at its meeting in October 2000. The vice president/secretary was asked to prepare a Statement of Purpose for the STG meeting.

Stockholm, Sweden, 1999

On October 21, 1999, the Steering Committee met in Stockholm and accepted the draft prepared by the vice president/secretary. The STG meeting was scheduled for Paris during March 27-29, 2000. The draft was distributed to member academies for comment. The revised Statement of Purpose, with member comments enclosed, was sent to all members.

Paris, France, 2000

During the Paris meeting, the Strategy Task Group agreed to incorporate CAETS in the District of Columbia, US, subject to approval by the Governing Board. It also agreed to consider incorporating in the United Kingdom or Switzerland, if doing so would be advantageous to CAETS. Draft Articles of Incorporation and Bylaws were discussed. It was agreed that these would be based on current CAETS General Rules and Guidelines, with several significant exceptions. The senior body would be the Council, which would consist of one representative from each member academy. The Board of Directors would include the five officers and a certain number of additional member academy representatives. The terms of the president, president-elect, vice president, and past president would be for one year; the secretary-treasurer would continue to be provided by a member academy and subject to Council approval. The transition to one-year terms from the two-year terms for officers should maintain the existing commitments to member academies for hosting convocations through 2007 by amending the rotation list, as mutually agreed to by member academies, and also include hosts for Council

2000

meetings and presidents for the non-convocation years. The name of the organization would include the word "international," and the acronym "CAETS" would continue to be used. Revised documents would be circulated by e-mail for member comments and agreement.

On June 30, 2000, CAETS was incorporated in the District of Columbia as the International Council of Academies of Engineering and Technological Sciences, Inc. (CAETS).

Beijing, China, 2000

The CAETS Governing Board met on Friday, October 13, 2000, following an international three-day Convocation on Engineering and Technological Sciences in Beijing hosted by the Chinese Academy of Engineering. The Board approved the incorporation of CAETS and approved the Bylaws, with the exceptions that the vice president position was eliminated to make the "presidential ladder" three years; and the Board of Directors would include four officers and four members. The new Bylaws would take effect on January 1, 2001. In addition, the Governing Board agreed to consider undertaking a CAETS study on energy and climate change. Two committees would be formed; one would prepare a scope of work for the study, and the second would prepare general study procedures for CAETS. Finally, the National Academy of Engineering of Korea (NAEK), the Croatian Academy of Engineering (HATZ), the Slovenian Academy of Engineering Sciences (IAS), and the National Academy of Engineering of Uruguay (ANIU) were elected to membership at this meeting, bringing total membership to 26.

Espoo, Finland, 2001

The 14th Convocation was held in Espoo Finland on June 11-15, 2001. At its meeting on June 11, the CAETS Council agreed to the procedure for selecting members of the Board of Directors: using the rotation list, every fifth member academy below that holding the office of president-elect, up to a total of four, would provide a director. The Council also approved the CAETS Operating Procedures and creation of an Audit Committee, and agreed in principle to a draft Study Procedures.

Prague, Czech Republic, 2002

The Annual Council meeting in 2002 was held in Prague and hosted by the Engineering Academy of the Czech Republic. The Committee's scope of work for the proposed CAETS study on energy and climate change did not gain the support of a majority of member academies. It was agreed that CAETS' interests in the subject would be devoted to working with NTVA (Norway) on its "Future Energy and Sustainable Use" seminar, to be held in conjunction with the CAETS Council meeting in May 2004.

Hollywood, California, United States, 2003

On the CAETS 25th anniversary, NAE (US) hosted a successful 15th CAETS Convocation in Hollywood, California on May 18-22, 2003. The topic was "Entertaining Bytes" and dealt with the interaction of computers, simulated environmental experience and training and entertainment. At the Council meeting that followed, members approved a Board recommendation on Inactive Status, which is included in the CAETS Operating Procedures. Member academies were asked to prepare papers on specific topics, to be included in a CAETS project on Outstanding Engineering Challenges. This project targeted high school students and the general public and focus on how engineering can improve the quality of life of all peoples.

Stavanger, Norway, 2004

The CAETS Council met on May 28, 2004 in Stavanger, Norway, after a two-day seminar on "Global Energy Foresight." The seminar papers presented, along with other invited papers, were published. At the meeting, the President encouraged that CAETS undertake more dynamic activities in the future. To be a more global organization, additional members are needed. Toward that end, the President encouraged member academies to promote the creation of national academies of engineering in neighboring countries and to take other steps to promote CAETS membership. To be more dynamic, additional funds are needed.

Cairns, Queensland, Australia, 2005

ATSE hosted a well-received and informative 16th CAETS Convocation in Cairns, Queensland, Australia, July 10-14, 2005. The Convocation theme was "Oceans and the World's Future." The Council discussed a draft reflecting the papers and discussion of the Convocation and agreed to a CAETS Statement titled the same as the Convocation theme. The Council voted unanimously to elect the German Academy of Technical Sciences (acatech) to membership in CAETS. The Council discussed a draft Strategy 2006 – 2010. The Council also agreed to establish the Committee on International Organizations (CIO) and the Committee on CAETS Membership (CCM). In light of the majority support, the Council agreed to a tiered structure. Finally, the Council agreed NAE (US) should continue to host the CAETS Secretariat.

Brussels, Belgium, 2006

The 2006 CAETS Council meeting was held in Brussels, Belgium on Friday, June 2, following a BACAS symposium on "Clean Energy, including the Hydrogen Economy." The Council discussed a draft reflecting the papers and discussion of the symposium and agreed to a CAETS Statement on "The Role of Hydrogen in Our Energy Future." The President noted that distribution of the CAETS Statement "Oceans and the World's Future," comments of visiting academy representatives, the reports of the CAETS Committee on International Organizations (CIO) and the Committee on CAETS Membership (CCM), and the cooperative relations with several international organizations served to further the priorities and goals of the CAETS Strategy 2006-2010, which had been published and distributed. The Council agreed that cooperation with WMO should continue and that cooperation with WFEO should also be undertaken. The Council also agreed to CAETS' endorsement of the INAE proposed International Conference on "Engineering Education," to be held in Chennai, India, in January-February 2007.

Tokyo, Japan, 2007

The successful 17th Convocation, hosted by EAJ in Tokyo, Japan, October 23-26, 2007, focused on "Environment and Sustainable Growth." A procedure was agreed for developing a CAETS Statement and followed, producing the CAETS Statement reflecting the theme, papers and discussions of the Convocation. The Council agreed to a Bylaw amendment to extend the term of Members of the CAETS Board of Directors to two years, to permit greater involvement of Board members in the management of substantive discussion topics during Council meetings. The Council agreed to a proposal by IVA for a workshop on "Noise Control Technologies;" to a proposal by SATW on "Strategies for Highly Efficient Conversion and Reuse of Matter and/or Energy;" and to a proposal by ATSE for a project on "Accelerating the Response to Climate Change."

2008 Highlights

AcTI.nl will host an international symposium on "Delta Technology: Enabling Life in River Deltas" in Delft, Netherlands, June 26, 2008. The CAETS Council meeting will be held in The Hague on June 27, 2008.

Officers & Members of the Board of Directors

CAETS Officers 1978 to 2000 Convocation Steering Committee 1978 – 1985

Chairman	1978	N. Bruce Hannay	NAE, United States
	1978-1981	Gunnar Hambraeus	IVA, Sweden
President*	1981-1983	Robert Ward	ATS, Australia
	1983-1985	Alejandro Lopez Toledo	ANIAC, Mexico
Secretary	1980-1985	Hugh Miller	United States

** Served as vice president the previous year.*

Council of Academies of Engineering and Technological Sciences 1985 – 2000

President*	1985-1987	H. Guyford Stever	NAE, United States
	1987-1988	David Zeidler	ATS, Australia
	1988-1990	Marco Murray Lasso	ANIAC, Mexico
	1991-1992	Erik B. Rasmussen	ATV, Denmark
	1993-1994	Luc Tissot	SATW, Switzerland
	1995-1996	Hans G. Forsberg	IVA, Sweden
	(to 9/13/96)	First V.P. William Barlow	RAEng, UK
	1997-1998	David E.N. Davies	RAEng, UK
	1999- 2000	Michel Lavalou	CADAS, France
	(to 12/31/99)	First V.P. Juhani Ahava	FACTE, Finland
Vice President/	1985 to 1999	Steven N. Anastasion	United States
Secretary	2000	William C. Salmon	United States

** Served as vice president (1985-1990) or first vice president (1991-1999) the preceding two years and past president the subsequent two years; exceptions noted for 1996 and 1999.*

CAETS Officers and Members of the Board of Directors (from January 1, 2001)
International Council of Academies of Engineering and Technological Sciences, Inc. (CAETS)

President*	2001	Jaakko Ihamuotila	FACTE, Finland
	2002	Petr Zuna	EACR, Czech Republic
	2003	Wm. A. Wulf	NAE, United States
	2004	Arne Bjørlykke	NTVA, Norway
	2005	John Zillman	ATSE, Australia
	2006	Achiel Van Cauwenberghe	BACAS, Belgium
	2007	Jun-ichi Nishizawa	EAJ, Japan
	2008	Gerard van Oortmerssen	AcTI.nl, Netherlands
Secretary	2001 -	William C. Salmon	United States

** Serves as president-elect the preceding year and past president the following year.*

Members of the Board of Directors

2001	Tomokazu Tokuda	EAJ, Japan	Hans Leuenberger	SATW, Switzerland
	David Davies	RAEng, United Kingdom	Juraj Bozicevic	HATZ, Croatia
2002	Raul Flores Berrones	AI, Mexico	Jeno Baratossy	HAE, Hungary
	Anumolu Ramakrishna	INAE, India	Ki-Jun Lee	NAEK, Korea
2003	Claude Lajeunesse	CAE, Canada	Lena Torell	IVA, Sweden
	Andres Ripoll	RAI, Spain	Alvaro Cutinella	ANIU, Uruguay
2004	Torben Klein	ATV, Denmark	XU Kuangdi	CAE, China
	Arturo J. Bignoli	ANI, Argentina	Germain Sanz	NATF, France
2005	Ben Veltman	NFTW, Netherlands	Alec Broers	RAEng, UK
	Ki Jun Lee	NAEK, Korea	Zlatko Kniewald	HATZ, Croatia
2006	Gerardo Ferrando-Bravo	AI, Mexico	Rene Dandliker	SATW, Switzerland
	R.Natarajan	INAE, India	Asko Saarela	FACTE, Finland
2007[1]	Pan Yunhe	CAE, China	Pere Brunet	AIE, Spain
	Bruno Jarry	NATF, France	Petr Zuna	EA CR, Czech Republic
2008[2]	János Ginsztler	HAE, Hungary	Lena Treschow Torell	IVA, Sweden
	Oscar A. Vardé	ANI, Argentina	Eduardo R. Alvarez Mazza	ANIU, Uruguay

[1] *Member is encouraged to participate as Board member, without vote, in 2008.*
[2] *Term of office is two years, this year and the next.*

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CAETS Statements

Based on the presentations and discussions at the respective meetings, these Statements reflect the collective judgment of the CAETS member academy representatives and other experts present, with the texts agreed at the Council meeting.

2005 Occans and the World's Future

2006 The Role of Hydrogen in Our Energy Future

2007 Environment and Sustainable Growth

CAETS Reports

The producing organization and, where different, the publisher is listed.

1987 The International Meeting on Engineering Education for the 21st Century; Proceedings; The Fellowship of Engineering, United Kingdom

1991 Report of the Third Workshop on Engineering Education;
The Fellowship of Engineering, United Kingdom

1991 Harnessing Engineering and Technology for Economic Growth: Opening the Dialogue Between the Engineering Communities of the East and West; Summary Report of the Budapest Conference; National Academy of Engineering, United States

Harnessing Technology for Development; Summary Report of the Eighth Convocation; National Academy of Engineering, United States

1992 Technical Resource Information for Central and Eastern Europe;
National Academy of Engineering, United States

1993 The Role of Technology in Environmentally Sustainable Development; Declaration of the Council of Academies of Engineering and Technological Sciences; Royal Swedish Academy of Engineering Sciences (Edition for the 1996 UN Conference on Human Settlements [HABITAT II] published by the National Academy of Engineering, United States)

1994 Engineering Education Report of the Working Party; Netherlands Academy of Technology and Innovation (formerly Netherlands Society of Technological Sciences and Engineering); published by CAETS

2004 Global Energy Foresight; The Norwegian Academy of Technological Sciences; published by CAETS

2006 Clean Energy for this Century, Royal Belgian Academy Council of Applied Sciences (BACAS)

2007 International Engineering Education; Indian National Academy of Engineering

Proceedings of CAETS Convocations

1980 The Management of Technological Change; Proceedings of the Second Convocation; Australian Academy of Technicological Sciences and Engineering

1981 Engineering Education; Proceedings of the Third Convocation; National Academy of Engineering, Mexico

1983 Important Technological Trends; Proceedings of the Fourth Convocation; Royal Swedish Academy of Engineering Sciences

1985 The Global Interaction of Technology; Proceedings of the Fifth Convocation; The Fellowship of Engineering, United Kingdom

1987 Globalization of Technology: International Perspectives; Proceedings of the Sixth Convocation, National Academy of Engineering, United States

1988 Technology for Living on the Frontiers; Proceedings of the Seventh Convocation Australian Academy of Technological Sciences and Engineering

1990 Harnessing Technology for Development; Proceedings of the Eighth Convocation; National Academy of Engineering, Mexico

1992 The Technological Future; Proceedings and Executive Summary of the Ninth Convocation; Danish Academy of Technical Sciences

1993 Sustainable Development: The Challenge of Developing Transportation for Society; Proceedings of the Tenth Convocation (with SATW supplement on Sustainable Mobility); Swiss Academy of Engineering Sciences

1995 Creating Wealth In Harmony With the Environment; Proceedings of the Eleventh Convocation; Royal Swedish Academy of Engineering Sciences

1997 Engineering Innovation & Society; Proceedings of the Twelfth Convocation; The Royal Academy of Engineering, United Kingdom

1999 Technology and Health; Proceedings of the Thirteenth Convocation; Council for Applied Sciences of the French Academy of Sciences

2001 World Forests and Technology; Proceedings of the Fourteenth Convocation; The Finnish Academies of Technology

2003 Entertaining Bytes; Proceedings of the Fifteenth Convocation; National Academy of Engineering, United States (CD only)

2005 Oceans and the World's Future; Proceedings of the Sixteenth Convocation; Australian Academy of Technological Sciences and Engineering, Australia

2007 Environment and Sustainable Growth; Proceedings of the Seventeenth Convocation; The Engineering Academy of Japan

The CAETS Rotation Schedule

(as of January 1, 2008, with actual 2001-2008 and scheduled 2009-2011 positions)

This schedule is updated each January 1. The member academy at the top of the list provides the president and hosts the Annual Meeting of the Council, as well as a Convocation on odd-numbered years. The second member academy on the list provides the president-elect.

When elected, new member academies are placed at the bottom of the list in the order completed applications are received. At the end of the year, the member academy providing the president goes to the bottom of the list and provides the past president for the next year.

The Council elects the members of the Board of Directors for the next year at its annual meeting. Member academies with representatives on the Board must be members in good standing. Members served one-year terms until 2008, and two-year terms thereafter. Terms begin January 1 and end December 31. By mutual agreement and with approval from the Board of Directors, member academies may exchange places on the schedule.

Member Academy	Office and Year*	Host of Meeting
AcTI.nl, Netherlands	BM 05, PE 07, P 08, PP 09	2008 Annual Meeting
CAE, Canada	BM 03, PE 08, P 09, PP 10	2009 Convocation, 18th
ATV, Denmark	BM 04, PE 09, P 10, PP11	2010 Annual Meeting
AI, Mexico	BM 02, BM 06, PE 10, PP11	2011 Convocation, 19th
SATW, Switzerland	BM 01, BM 06, PE11	
HAE, Hungary	BM 02, BM 08	
IVA, Sweden	BM 03, BM 08	
CAE, China	BM 04, BM 07, BM 11	
RAEng, United Kingdom	BM 01, BM 05, BM 10	
INAE, India	BM 02, BM 06, BM 10	
AIE, Spain	BM 03, BM 07	
ANI, Argentina	BM 04, BM 08	
NAEK, Korea	BM 02, BM 05, BM 09	
HATZ, Croatia	BM 01, BM 05, BM 09	
ANIU, Uruguay	BM 03, BM 08	
NATF, France	PP 01, BM 04, BM 07, BM11	
FACTE, Finland	P 01, PP 02, BM 06, BM 10	2001Convocation, 14th
EA CR, Czech Republic	P 02, PP 03, BM 07	2002 Annual Meeting
NAE, USA	P 03, PP 04, BM 09	2003 Convocation, 15th
NTVA, Norway	PE 03, P 04, PP 05, BM 10	2004 Annual Meeting
acatech, Germany	BM 09	
ATSE, Australia	PE 04, P 05, PP 06, BM11	2005 Convocation, 16th
BACAS, Belgium	PE 05, P 06, PP 07	2006 Annual Meeting
EAJ, Japan	BM 01, PE 06, P 07, PP 08	2007 Convocation, 17th

**P – President; PE – President-elect; PP – Past President; BM – Board Member*

CAETS Committee on International Organizations (CIO)

The CIO was established by the CAETS Council in July 2005 to pursue one of the priorities of the CAETS Strategy: 2006 – 2010:

Engagement with the United Nations specialized agencies and related international organizations

Mission: Develop and implement an ongoing advisory/consultative role, with appropriate CAETS recognition, with the relevant scientific/technological organs of the United Nations(UN) System.

The UN agencies/activities in need of informed, objective advice on scientific, technological and engineering matters include: UN Environment Programme (UNEP); UN Development Programme (UNDP); UN Commission on Sustainable Development (CSD); UN Educational, Scientific, and Cultural Organization (UNESCO); Food and Agriculture Organization (FAO); and World Meteorological Organization (WMO).

Member States and Territories of the UN, through their national delegations to sessions of these bodies have the opportunity for input and advice developed through their own domestic consultative arrangements, including that on scientific, technological and engineering issues from their own national academies. The envisaged role of CAETS over the next few years is to reinforce and complement the role of its member academies and provide consolidated input at the highest levels of the UN System by:

(i) Seeking Observer/Consultative status with key UN Agencies and Programmes with CAETS representation at the regular sessions of their governing bodies;

(ii) Encouraging and assisting CAETS member academies to be involved in the preparation of their national briefs and composition of national delegations to the governing sessions of these bodies;

(iii) Preparing a brief digest of major initiatives by CAETS and its member academies for input to the UN System and use by CAETS representatives in governing body sessions;

(iv) Inviting key relevant UN System Agencies and Programmes to be represented at CAETS Convocations; and

(v) Maintaining working relations on an equal basis with international, non-governmental engineering and scientific organizations, including the World Federation of Engineering Organisations (WFEO),Inter Academy Council (IAC), and the International Council for Science (ICSU), to facilitate cooperation and coordination in their input to UN System activities on engineering, technology, and scientific matters.

Immediate goals: Over the next two years, CAETS will:

- *identify and establish initial working contacts with at least two key UN System agencies;*
- *arrange CAETS representation, by invitation, at one or more UN System governing body sessions;*
- *provide all relevant UN System agencies with an introduction to CAETS and its activities;*
- *establish working relations with WFEO, IAC, ICSU and other relevant non-governmental bodies in respect of CAETS linkages with the UN.*

CIO is chaired by John Zillman (ATSE) and includes Tsuneo Nakahara (EAJ), Bruno Jarry (NATF), George Bugliarello (NAE,US), Achiel Van Cauwenberghe (BACAS), and CAETS Secretary, Bill Salmon.

Delta Technology for a Sustainable and Habitable Planet

A CAETS Statement

Delft and The Hague, Netherlands, June 25-27, 2008

The 30th Annual Meeting of the International Council of the Academies of Engineering and Technological Sciences (CAETS) took place in Delft and The Hague (Netherlands) from 25-27 June 2008. The accompanying technical symposium focused on sustainable development of the world's deltas, which will accommodate an estimated 70% of the global population by 2050. Presentations focused on the effects of climate change and land subsidence in these regions and their interaction with "Delta Technology."

CAETS is the International Council of Academies of Engineering and Technological Sciences, Inc. It consists of those national academies of engineering and technological sciences that have satisfied an agreed set of criteria for membership. It was established in 1978 and was incorporated as a charitable non-profit corporation in the District of Columbia (US) in 2000. Its Articles of Incorporation, Bylaws and Operating Procedures set down its objectives and governance arrangements. These documents and its membership and achievements are posted on the CAETS website, www.caets.org.

Delta Technology

"Delta Technology" is a recent term of art that refers to a cluster of disciplines that deal with living in vulnerable delta regions, river banks and coastal zones.* These disciplines focus on the socio-economic and environ-

* For brevity, frequently referred to collectively as "deltas" in the following.

mental processes and on their uncertainty. Delta Technology establishes links in and between traditional engineering disciplines such as hydraulic engineering, dredging engineering, geo-engineering, and eco-engineering, and seeks to advance technology at the interface of civil engineering with 21st-century breakthrough technologies such as bio-, nano-, and sensor technologies and ICT (information and communication technology). Delta Technology envisions embedding technology in the societal decision-making processes relevant to sustainable development of and adaptation to global change in delta and coastal areas – *high-tech, high-touch*. Delta Technology considers water quality; river basin and coastal design for flood protection; subsurface water and underground space; and construction of infrastructures on soft soils consistent with the impact of agricultural, industrial and urban activities and soft soil behavior. Successful outcomes include enlightened management and use in order to provide healthy water, sustainable soil and materials systems, and building with nature, using the natural resilience of water systems.

Findings

Delta areas have major economic potential because of their strategic location close to seas and waterways. The ground is fertile and rich in minerals and raw materials. But their vulnerability is increasing because of rising sea levels, extreme river levels, subsiding soft soils, and increasing pressure on space and environment.

Delta zones are frequently subject to intense human intervention, including pressures derived from activities of productive sectors with great economic impact, such as agriculture, fishing, tourism and energy. Living in delta zones means living with uncertainty. In many instances, it is desirable to forego initial development or further development of such regions, but the reality is that many people currently live in delta regions, and their number is increasing every day.

Thus, management of the natural and manmade systems in these areas and of their adaptation to global change requires an integrated application of all aspects of delta engineering.

Socioeconomic and environmental developments related to safety, transportation, nature and living in deltas reflect complex interrelations with different spatiotemporal scales. In such a dynamic environment, achieving a sound balance between the various interests is a major technological feat. Prior to implementing technological solutions, societal implications must be considered, taking into account all the spatial, economic and administrative consequences of the use and management of water and soil that will lead to the most sustainable solution.

Recommendations

1. Building with Nature

Living in deltas has always required human intervention. Often, this intervention conflicts with the natural environment, requiring constant maintenance and further intervention, which in turn leads to degradation of the overall conditions in these areas. The aim of Building with Nature is integrated delta development making use of the forces, interactions and materials present in nature. New design methods are elaborated to optimize the opportunities offered by natural ecosystems. New materials – "*smart soils*" – are eco-designed. Sand is transformed into sandstone by bio-organisms, saltwater seepage is blocked by activating natural processes, and the effects of land subsidence may be reduced by preserving soft soils such as peat. Knowledge of this kind will contribute to the balanced assessment of ecological, economic and societal values and may even lead to a redesign of the civil engineering discipline as we now know it.

Recommendation 1: We recommend a sustainable development of deltas in accordance with naturally occurring forces, interactions and materials, in order to preserve the environment and to meet the future requirements of the global population.

2. In Control (Measurements, models, predictions)

Effective management of natural and manmade systems in delta areas requires an understanding of 'normal' conditions, but extreme scenarios should be anticipated. The living environment in many deltas is at risk of major impact by flooding and changes in natural conditions. Economic or other gaps in our knowledge mean that it will never be possible to exclude these risks totally or to anticipate their consequences fully. However, new approaches to monitoring, surveillance and forecasting, as well as advances in simulations, will enable us to make sensible choices to develop more accurate warning and forecasting systems that have greater influence on the effects of these events.

By simulating the effects of interventions in delta areas, one can address environmental sustainability and safety issues, assess risks, and show how different systems are linked in terms of hydrology, ecology, and so on. Such analyses illuminate the impact and need for an integrated approach. In this way, complex knowledge, including technical and ecological, can be made accessible so that it is comprehensible and easily applicable for decision-makers, stakeholders and the general public, with the final goal of environment preservation.

Recommendation 2: We recommend full development of simulation, forecasting and sensor technologies in the context of Delta Technology, including introduction of local- and global-scale monitoring and diagnostic systems applicable to real-time warning systems.

3. The Knowledge Base (Use of information technology for knowledge sharing at the global scale, new learning systems)

Traditionally, civil engineering is highly empirical. Modern ICT development allows for the integration of theoretical knowledge, computer simulations, empirical models and practical experience into new expert systems. Artificial intelligence can be used to develop ‘third-generation’ design environments. Web-based methods subsequently facilitate knowledge sharing worldwide and thus accelerate the application of new insights.

Future Delta Technologists will benefit from interactive learning tools such as serious gaming. Their skills should include the assessment of uncertainties in decision-making processes, risk management, communication and spatial planning.

Recommendation 3: We recommend the development of a worldwide system of knowledge sharing for application to delta-region decision making; and an advanced risk management framework to include risk assessment, risk mitigation and risk-based communications.

4. Technology Embedded in Societal Processes (high-tech, high-touch, in touch)

In water and soil issues, technological standards matter, as do natural developments, spatial policies, and governance and legal processes. By implication, control over water is a social issue (*delta life*) that is becoming more pressing as a result of the impact of climate change on the weather and on sea levels.

The integrated management of river banks and basins, estuaries, deltas and coastal areas requires experts, managers and researchers trained to have a multidisciplinary vision of physical and biogeochemical processes and their legal, environmental and socio-economic foundations.

The engineering sciences in the broad sense should make their full impact on the challenges that humanity is facing. Communication between the public and the professionals is vital, as is educating the public about possible risks and countermeasures. To do that, it is vital to bridge the gap between society's needs and expectations, the potential of technological developments in the engineering profession and in the education of future engineers.

Recommendation 4: We recommend that social and technical sciences should work closely together to increase awareness of the challenges humanity is facing in the enlightened use of deltas; to inform and educate the public and to find support for the necessary research, development and data collection to promote design of innovative solutions; and to shorten the time lag between availability and application of new technologies.

Conclusion

The interplay between the technical, social and human issues related to living in and protecting fragile deltas, river basins and coastlines is complex, but the engineering community – as exemplified by the CAETS academies – is well prepared to present objective data for facilitating debate by governments and national communities on the tradeoffs this interplay demands. Worldwide cooperation is necessary to face the impact of the new climate change uncertainty and ever-increasing population pressure. CAETS members recognize the need to promote policies to encourage the avoidance and mitigation of human impact on the delicate natural environments of deltas and pledge to promote the wise utilization of these gifts of nature.

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Royal Swedish Academy of Engineering Sciences (IVA)
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Royal Academy of Engineering (RAEng)
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CAETS International Council of Academies of Engineering and Technological Sciences, Inc.

COUNCIL MEETING
0920 - 1615 Friday, June 27, 2008
Royal Institution of Engineers KIVI NIRIA, The Hague, Netherlands
Summary Minutes
(keyed to the Agenda items)

Draft 30Jun08

OPEN SESSION

1. The President welcomed all and asked attendees to briefly introduce themselves. The agenda was approved as distributed.

2. The Council approved the Summary Minutes of the Council Meeting of October 26, 2007. The Council recorded its appreciation for the CAETS Convocation and meetings hosted by the EAJ in Tokyo during October 22-26, 2007

3. The Secretary briefly reviewed the actions and discussions of the Board of Directors at its meeting held on Wednesday, June 25, 2008. The Board received the Report of the Audit Committee and approved the proposed 2009 Budget.

4. a. The Council elected the following for the 2009 Board of Directors:

President-elect	Klaus Bock	ATV, Denmark
Member	Ho Nam Chang	NAEK, Korea
Member	Stanko Tonkovic	HATZ, Croatia
Member	Charles M. Vest	NAE, USA
Member	Reiner Kopp	acatech, Germany

b. As recommended by the Board, the Council approved continuation of the current dues structure for FY2010. [*The current dues structure is:$1,000: ANI, Argentina; BACAS, Belgium, HATZ, Croatia; EA CR, Czech Republic; FACTE, Finland; HAE, Hungary; AcTI.nl, Netherlands; ANIU, Uruguay. $3,000: CAE, Canada; ATV, Denmark; NATF, France, acatech, Germany; NAEK, Korea; AI, Mexico, NTVA, Norway; RAI, Spain; IVA, Sweden; SATW, Switzerland. $6,000: ATSE, Australia; CAE, China; INAE, India; EAJ, Japan, RAEng, United Kingdom, NAE, United States.*

[*For the record, from the Council meeting of July 14, 2005, "...and noting that certain reservations had been expressed after the dues structure had been agreed. The reservations included: those academies paying the lowest level of dues should do so on a well justified basis and endeavor to strengthen their financial basis and increase their dues payment to the middle level in the near term, decisions by the Board on these matters should be transparent and without the potential for conflict-of-interest.*]

c. Achiel van Cauwenberghe, CAETS representative to the IAC, reported on the IAC's recent annual meeting and its proposed new studies.

The membership of the CIO and the CCM is reported in the Board of Directors meeting summary minutes.

d. Several member academy representatives reported on the efforts made to distribute the CAETS Statement, "Environment and Sustainable Growth," based on the Tokyo Convocation. Member academies were encouraged to make further distribution of this statement and to undertake active distribution of future CAETS Statements.

The EAJ reported that its proposal for follow-up action from the Tokyo Convocation on Eco-Innovation (innovation to realize sustainable development, harmonizing the quality of life while limiting impact on global environment and resources). This project would include a platform in CAETS to promote cooperation on the environment and sustainability studies by member academies. It was agreed that member academies would contact EAJ regarding their response to this proposal.

e. Future Meetings

- 2009 18th Convocation, CAE, Calgary, Canada; ExCom and Board Meetings, Monday, July 13, Convocation Tues. - Thurs., July 14-16; CAETS Council Meeting, Friday, July 17
    - CAE (Canada) described its Convocation program and the schedule of meetings and activities. Suggestions for speakers are needed prior to the end of July 2008.
- 2010 Annual Meeting, ATV, Denmark; ExCom and Board Meetings, Monday, June 28; Symposium, Tuesday, June 29; CAETS Council Meeting, Wednesday, June 30.
    - The ATV proposed that the Symposium topic be the future of the agricultural sector. Main topics would be: What would be the desired nature of the agricultural sector in 2030; what are the present state and use of relevant research, innovation, and technology; conditions for competition; products needed; and sustainability. The Council welcomed the topic.
- 2011 19th Convocation, AI, Mexico
- 2012 Annual Meeting, SATW, Switzerland
- 2013 20th Convocation, HAE, Hungary

5. Petr Zuna led the discussion on engineering education. He presented his summary of responses to his questionnaire sent to all member academies and other observations.

6. John Zillman reported on the progress of the ATSE proposal on "Accelerating Technological Response to Climate Change."

7. Tor Kihlman, IVA, presented the report of the Workshop on "Transportation Noise in Europe" held June 2-4, 2008 in Southampton, England. The Council approved that the Committee's study on noise control technology be extended from the European to the global scene and that noise at the workplace and noise produced by industrial and consumer products be included. This expanded study would be facilitated through a workshop to be held during the second quarter of 2009, with a report of its findings to be given to the CAETS Council at its meeting in Calgary, Canada, in 2009 July.

8. Draft III of the proposed CAETS Statement on "Delta Engineering: Enabling Life in River Deltas", distributed earlier in the day, was discussed. It was agreed to proceed with publishing the Statement after polishing and minor additions approved by the President. It was suggested that the Statement be the subject of a press release issued by the President.

9. Bruno Jarry led a discussion on International Activities. Tony Marjoram, Head of Engineering Sciences, Natural Sciences Sector, UNESCO, described engineering activities in UNESCO and proposed possible areas of cooperation for CAETS and UNESCO. It was noted that the best means of influencing UNESCO and its efforts in engineering is through national UNESCO commissions; member academies should be active in informing their respective commissions on the importance of engineering in UNESCO. Thomas Roswell, Executive Director, International Council for Science (ICSU) described the activities of ICSU and noted current cooperative activities with CAETS. It was agreed to raise this topic again at the next Council meeting based on further considerations by the CAETS Committee on International Organizations.

10. The SATW Project "Strategies for Highly Efficient Conversion and Reuse of Matter and/or Energy" was reviewed. Member academies were invited to participate in the project's steering group with the objective of reporting at the next CAETS Council meeting. Member academies are asked to e-mail SATW soon regarding their interest in participation in this project.

11 and 12 Contributions from member academies are welcome and will be posted on the CAETS web site.

13. New Business

Robert St. Leger, South Africa Academy of Engineering, reported on recent activities of the SAAE. He noted that he would recommend to his academy that it apply for membership in CAETS and he expected that a formal letter would be forthcoming in the near future.

Peter Glavic, President, Slovenian Academy of Engineering, reported on recent action taken by the Slovenian Government in recognition of his academy. On behalf of his academy, he asked that measures proceed for his academy to return as a regular member of CAETS.

Tapio Alvesalo, Secretary General, Technology Academy Foundation, Finland, reported on the recent presentation ceremony of the Millennium Prize. Also, he reported on the formation of the Technology Academy Foundation, Finland, which has assumed the former responsibilities of FACTE, including membership in CAETS.

Responding to a request by HATZ, the Council agreed to co-sponsor the HATZ celebration of the 300th anniversary of the birth of Ruder Boskovic.

14. Certificates of appreciation for services rendered to CAETS were presented by the President to Jun-ichi Nishizawa and Pan Yunhe.

15. The President thanked all for attending and adjourned the meeting.

Attachment:
List of Attendees

Supporting Documents:
several
Issues of Concern
Activities of Interest

CAETS Council Meeting, The Hague, Netherlands, June 27, 2008

Attendance of Member Academy Delegations Representatives (Rep.), Observers, and Guests
* - Member, 2008 Board of Directors, NA - no rep. attending

ANI, Argentina
Rep. Oscar A. Varde*
ATSE, Australia
Rep. John Zillman
BACAS, Belgium
Rep. Achiel van Cauwenberghe
CAE, Canada
Rep. John Leggat*
C. (Ravi) Ravindran
Michael A. Ball
CAE, China
Rep. PAN Yunhe*
SONG Xuemin
KANG Jincheng
SONG Dexiong
ZHENG Xiaoguang
HATZ, Croatia
Rep. Zlatko Kniewald
EA CR, Czech Republic
Rep. Petr Zuna*
Milos Hayer
ATV, Denmark
Rep. NA
FACTE, Finland
Rep. Tapio Alvesalo
NATF, France
Rep. Bruno Jarry*
acatech, Germany
Rep. Reiner Kopp
MMA, Hungary
Rep. Janos Ginsztler*
INAE, India:
Rep. Prem Shanker Goel
Manu Ji Zarabi
EAJ, Japan
Rep. Tsuneo Nakahara
Jun-ichi Nishizawa*
Kozo Iizuka
Toshiyuki Yamada

NAEK, Korea
Rep. Ki Jun Lee
Ho Nam Chang
Bo Hyung Cho
Kun Woo Lee
Bo Hoon Kim
Eun Yeong Park
AI, Mexico
Rep. Gerardo Ferrando
Octavio Rascon Chavez
AcTI.nl, Netherlands
Rep. Gerard van Oortmerssen*
Henk Dits
NTVA, Norway
Rep. Hein Johnson
RAI, Spain
Rep. Pere Brunet*
IVA, Sweden
Rep. Björn O. Nilsson*
Tor Kihlman
SATW, Switzerland
Rep. René Dändliker
Arthur Ruf
Rolf Hügli
RAEng, United Kingdom
Rep. Peter Saraga
Hayaatun Sillem
NAE, United States
Rep. George Bugliarello
Lance A Davis
William Lang
ANIU, Uruguay
Rep. Eduardo Alvarez Mazza*

CAETS
Sec./Treas. William C. Salmon*

Guests:
Peter Glavic, President, Slovenian Academy of Engineering
Robert St.Leger, South African Academy of Engineering
Thomas Roswell, Executive Director, International Council for Science (ICSU)
Tony Marjoram, Head of Engineering Sciences, Natural Sciences Sector, UNESCO
Jan Dekker, President, The Royal Institution of Engineers in the Netherlands;
Tjeert ten Wolde, Engineering Department, International Institute of Noise Control
Jasper van Alten, The Royal Institution of Engineers in the Netherlands;

CAETS 2009 CALGARY

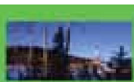
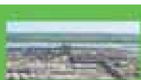
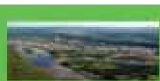
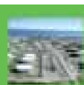
18th Convocation of the International Council
of Academies of Engineering and Technological Sciences

"Our Heritage of Natural Resources - Management and Sustainability"

July 13 - 17, 2009
The Westin Calgary Hotel - Calgary, Alberta, Canada

The Canadian Academy of Engineering

www.acad-eng-gen.ca



CAETS Week in Calgary - July 13 to 17, 2009

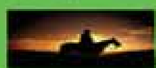
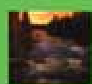
Monday	CAETS Executive Committee and Board Meetings
Tuesday	CAETS Convocation begins, evening welcoming reception
Wednesday	CAETS Convocation and Convocation Dinner
Thursday	CAETS Convocation concludes, technical tour planned in the afternoon, CAETS Council Dinner
Friday	CAETS Council Meeting and conclusion

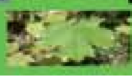
Come Experience Calgary. Nestled in the foothills of Canada's Rocky Mountains, Calgary is a place where visitors come to explore the heritage of the Canadian West. This safe, clean and vibrant city offers the best of all worlds: a cosmopolitan city of over 1 million people and breathtaking outdoor adventure in pristine wilderness. Visitors are always impressed with Calgary's cosmopolitan and legendary western hospitality, as well as a tantalizing array of pre- and post-meeting outdoor adventures in the spectacular Canadian Rockies, only an hour's drive from the city's centre.

We hope to see you in Calgary - July 13 to July 17, 2009

Arrive early and enjoy the Calgary Stampede (July 3 - 12, 2009)
or hit the links at the Kananaskis Golf Course.





Some photos provided courtesy of Tourism Calgary

PROGRAM SESSIONS

The following topics will be addressed:

WATER

Today the availability and quality of water are approaching a crisis of global proportions. The World Water Council notes that the world population tripled last century, while the use of renewable water grew six-fold. The population is forecast to grow a further 40 to 50 percent over the next 50 years. This, coupled with increasing industrialization and urbanization, will cause the demand for water to spiral. Today, 1.1 billion people lack access to safe drinking water and 2.6 billion people lack adequate sanitation. Even in Canada and Alberta, water is becoming a critical issue, due to population growth, increasing personal water use, expanded agriculture and water-intensive industries, changing weather patterns, and changes in atmospheric water vapour from human activities. Progress on water issues depends on a better understanding of the issues through R&D and the innovative applications of knowledge from the social and natural sciences as well as technology. An integrated approach is needed to ensure the sustainable and equitable use of water. These innovative actions are based on fundamental changes in our attitudes towards water use, changes in regulation and legislation, and the application of new technologies.

ENERGY

Today the world seems to have an insatiable appetite for energy. The efficient functioning of our society is dependent upon adequate supplies of energy to satisfy the needs of stationary power generation, transportation systems and personal power needs. Humanity is faced with two great challenges in the energy sector. Our prosperity is largely dependent upon hydro-carbon based energy sector: reserves are finite, and use is contributing in a significant way to climate change. Technology offers solutions to the emerging energy dilemma. Alternate and renewable approaches to energy generation are being developed and new approaches are available to the use of traditional non-renewable resources. As we go forward new perspectives are needed on the management of energy and the use of scarce resources to meet our future energy needs. Meaningful shifts are needed that greatly reduce our dependence on fossil fuels and that foster the creation of clean and sustainable sources of energy for the future.

MINING AND MINERALS

Canada's North holds vast mineral reserves that have the potential of meeting future national and global needs. The North, however, is an environmentally sensitive and up until recently largely inaccessible. The effects of climate change are most evident in Canada's North with significant increases in temperature forecast for the coming decades. Warming will open up previously ice-blocked water ways and reduce the inhospitable nature of the climate. Mineral recovery from Canada's Arctic region will need to be carried out with exceptional care. New technologies and approaches to resource extraction will be required so that these activities do not adversely affect the local environment thereby contributing to the demise of an ecostructure that is clearly being highly stressed. The Mining and Minerals sector will be challenged to develop innovative solutions to harvesting the resources of Canada's North.

FORESTS

From engineering or an economic perspective, forests are a valuable renewable source of building materials, paper products, energy and chemicals. Canada has 402 million hectares of forest and other wooded land, representing 10% of the world's forest cover and 30% of the world's boreal forest. As one of the largest industrial employers in Canada, the forest products industry is a cornerstone of the economy, sustaining over 320 communities, supporting about 800,000 direct and indirect jobs, from coast to coast—almost 5% of all jobs in Canada, and it is one of the nation's largest exporters, shipping over $40 billion of goods to markets around the world. As concerns increase about the depletion of non-renewable resources, renewed interest is being shown in the forest bio-refinery as a renewable, carbon-neutral source of fuels and chemicals that does not compete directly with food production. Beyond their economic impact, forests serve humanity in other important ways: as a habitat for wildlife, as a large chemical reactor that consumes carbon-dioxide, gives off oxygen regulates our climate, and as an area of spiritual, aesthetic and recreational value. "Renewable" must not be confused with "inexhaustible". Throughout our history, we have seen local forest ecosystems collapse from overuse, along with it the societies that depended on them. We also have excellent examples of sustainable forest management in densely populated regions. In this meeting we wish to address the challenges of sustainable resource management as the forest industry takes on a new role of becoming a supplier of renewable energy and chemicals.

"Our Heritage of Natural Resources – Management and Sustainability"

The 2009 CAETS Convocation will address the grand challenges associated with the management and sustainability of natural resources. Canada is a country whose prosperity since its early years relied to a significant extent on the development of its abundant natural resource base. Early settlement was driven by the fur trade. In the 1800's forestry was dominant, and as the country moved into the 20th century, mining and minerals became increasingly a part of the country's resource based economy. Canada's resource base today is extensive and includes significant quantities of oil and gas, fresh water, and forest and mineral reserves. The recovery and utilisation of these resources has spawned leading Canadian capability in the resource sector, which is recognized world-wide.

The challenges facing the resource sector in Canada are evolving quickly as a result of both global and local pressures. Demand threatens to outstrip supply in many areas; exploration, extraction, refinement, and utilization are contributors to greenhouse gases and climate change; and resource activity is increasingly impacting societal priorities in both positive and detrimental ways.

New approaches are needed to managing both our national resources and the supply chains that they feed. We need to rethink how to address the use of our natural resources and how we can ensure that the needs of humanity are fulfilled over the very long term. A balance needs to be struck between economic gain to be derived from resource exploitation and utilization, and the environmental and societal implications. Sustainable development, stewardship, conservation, re-use, substitution and responsibility need to be factors to be considered when assessing the present and future management of our natural resource base.

The engineering challenges associated with management for sustainability are significant, and the solutions lie in an integrated approach that brings together the needs of society, the policies to address these needs and the appropriate technology to bring about new and innovative approaches to resource development and utilization.

The 2009 CAETS Convocation will examine the new reality in natural resource management. The Convocation theme is "Our Heritage of Natural Resources – Management and Sustainability". The Convocation will help define the transitions to sustainable management and environmental stewardship in the resource sector and the role for engineering and technology in these transitions. It will examine the interdependencies in the sector and provide a forum for the discussion and elaboration of integrated views for resource management. We hope to bring forward emerging plans and strategies that hold promise for sustaining a resource base that will be able to meet the needs of world for a long time to come. With rapidly depleting natural resources (many of them are non-renewable), how do we harness the power of engineering to come up with alternative technologies and solutions.

The Convocation will begin with presentations from CAETS member academy experts on the greatest challenges facing the natural resource sector. These presentations will provide a general overview of the sector and set the scene for the rest of the Convocation. The remaining sessions will tackle the question of engineering leadership and solutions in the energy, minerals/mining, water management and forestry areas. The sessions will stress an integrated approach in two ways, first as it applies to the interdependencies among areas and second as it addresses stewardship, environmental responsibility, societal needs and technology. Energy needs will be a cross-cutting theme as we explore solutions that may include increased dependence on nuclear, hydrogen, fuel cells etc.

The world is experiencing rapid change as populations grow and develop. Engineers are well placed to lead and to provide a new vision for the future for resource management. CAETS will provide a global forum for the discussion of new and needed approaches to sustaining our natural resource heritage for present and future generations.

The Canadian Academy of Engineering is looking forward to welcoming its sister CAETS member academies to Calgary in July 2009.

Science and Technology in Society *forum*

S

Science

Yasuo FUKUDA
Prime Minister, JP

Olivia N. MUCHENA
Minister of Science and Technology Development, ZW

Susan HOCKFIELD
President,
Massachusetts Institute of Technology (MIT), US

T

& Technology

Koji OMI
Member of the House of Representatives,
Founder and Chairman, STS forum, JP

S

in Society

Charles O. HOLLIDAY, JR.
Chairman and CEO,
DuPont (E.I. du Pont de Nemours and Company), US

forum

2008

FIFTH ANNUAL MEETING

October 5-7, 2008

Science and Technology in Society *forum*

Kyoto, Japan

Picture from STS forum

Picture from STS forum

Science and Technology in Society (STS) *forum*

"Lights and Shadows of Science and Technology"

Fifth Annual Meeting

October 5-7, 2008

Kyoto International Conference Center (ICC Kyoto)

Summary of Proceedings

Science and Technology in Society (STS) forum (NPO)
Sanno Grand Building [illegible], 2-14-2 Nagatacho, Chiyoda-ku, Tokyo 100-0014, Japan
Tel +81-3-3519-3351 Fax +81-3-3519-3352 Website: www.stsforum.org

Sunday, October 5, 2008

Monday, October 6, 2008

Tuesday, October 7, 2008

In this summary, all the names, job titles and functions reflect those current as of the date of the forum; personal titles have been omitted.

Sunday, October 5, 2008

10:30-11:30 OPENING PLENARY SESSION

100 "Science and Technology and the Future of Humankind"

Chair:
Omi, Koji, Member, House of Representatives; Chairman and Founder, STS *forum*, JP

Speakers:
- **Noda**, Seiko, State Minister in charge of Science and Technology and Consumer Affairs, JP, on behalf of Taro Aso, Prime Minister of Japan
- **Furukawa**, Kazuo, Representative Executive Officer, President, CEO and Director, Hitachi Ltd.; Vice Chairman, Nippon Keidanren (Japan Business Federation), JP
- **Garmendia Mendizábal**, Cristina, Minister of Science and Innovation, ES
- **Kindler**, Jeff, Chairman and CEO, Pfizer Inc, US
- **Lu**, Yongxiang, President, Chinese Academy of Sciences (CAS), CN
- **Molina**, Mario, Professor, Department of Chemistry and Biochemistry, University of California, San Diego (UCSD), (Nobel Laureate in Chemistry, 1995), MX

Koji Omi opened the Fifth Annual Meeting of the STS *forum*. He said that although advances in science and technology have brought tremendous benefits to our daily lives, they have also brought problems such as global warming, ethical concerns in biosciences and information security issues in ICT. These are the "lights and shadows of science and technology," he explained. Scientific progress influences us all, and it is not just an issue for scientists and engineers, but for policymakers, business leaders and the media as well. The problems that result cannot be solved by one or two countries alone, international cooperation and system harmonization are essential. Thus the STS *forum* is a crucial platform for people of different backgrounds to discuss these issues, to seek a common direction and to strengthen human networking.

Seiko Noda spoke on behalf of the Prime Minister of Japan. She said Japan will promote research and development of technologies such as induced pluripotent stem cell treatment and alternative energy, and will combine science and diplomacy to resolve issues such as global warming and infectious diseases. The STS *forum* provides an opportunity for scientists and political leaders to discuss problems created by science and technology. She hopes to bridge the gap between scientists and the general public.

Jeff Kindler said advances in technology are the key to solving global economic problems. New medicines are being developed, but good health and prevention are also necessary investments. Fewer workers are contributing to the economy today. As populations age, prolonged health and productivity will be necessary. The public and private sectors must continue to develop as partners. The appropriate application of science is necessary for the benefit of humanity.

Lu Yongxiang said the number of young people from developing countries involved in science and technology is expected to increase greatly. Science and technology will combine research and innovation in IP licensing and knowledge-sharing. Renewable, safe and clean energy, green manufacturing, safe drinking water, security, disaster prevention, and health are critical issues. Access to new ICT technology must be widened. The benefits of science and technology must be shared.

Cristina Garmendia Mendizábal warned that the benefits of science and technology are not reaching most of the population. In spite of advances, social and economic problems are increasing because of unequal access. The IT revolution has changed our way of life, but there is a gap between developed and developing countries in the number of Internet users. Biomedical research has improved quality of life, but equal access to health care is necessary. Clinical trials should consider differences in nationality and racial identity. Gender gaps are present in both scientific and economic achievements in high-tech fields.

Kazuo Furukawa spoke about the importance of science and technology in the creation of new 21st century industries that aim to achieve a century of human affluence by preserving the Earth's environment and providing a healthy society. He also mentioned the role of science and technology in industries' initiatives to tackle the many global issues facing humankind today. "Fusion" will be a key word in the process: fusion of knowledge between institutions; the needs of society and individuals, and between policies and systemic reform on a global scale.

Mario Molina emphasized that the atmosphere has a finite capacity to absorb the by-products of human activity. The cost of the damage caused by climate change will be much greater than the cost of preventing it. Use of renewable energy sources and increased energy efficiency are necessary. Government leaders must act now. We have a responsibility to leave an acceptable environment for future generations. He concluded: "An earlier speaker said that science and technology open the doors to both heaven and hell. I hope we can open the doors to heaven a little wider."

13:20-14:50 PLENARY SESSION

101 "Crucial Issues and Development of Science and Technology"

Chair:
Yoshikawa, Hiroyuki, President, National Institute of Advanced Industrial Science and Technology (AIST), JP

Speakers:
- **Bréchignac**, Catherine, President, French National Center for Scientific Research (CNRS); President-Elect, International Council of Science (ICSU), FR
- **Gaidar**, Yegor, Director, The Institute for the Economy in Transition (IET), RU
- **Johnson**, Ray, Senior Vice President and Chief Technology Officer, Lockheed Martin Corporation, US
- **Ogata**, Sadako, President, Japan International Cooperation Agency (JICA), JP

- **Okamoto**, Kazuo, Vice Chairman and Representative Director, Toyota Motor Corporation, JP
- **Rahman**, Atta-ur-, Federal Minister and Chairman of the Higher Education Commission (HEC), Government of Pakistan, PK
- **Zehnder**, Alexander, Scientific Director, Alberta Water Research Institute; former President of the ETH Board, Swiss Federal Institute of Technology (ETH) Zurich, CH

Hiroyuki Yoshikawa said the STS *forum* brings together people from different countries, disciplines and backgrounds to talk about problems facing the world. Discussions and the development of science and technology are needed to halt climate change, reduce poverty and disease, and find new energy resources. Uncertain security, local disputes and financial instability cause problems. There is no "wonder drug" to solve such problems. Discussions are needed between different groups so ideas can be exchanged, leading to solutions.

Atta-ur-Rahman said that Pakistan has a population of 160 million of which 54% are young. The higher education system is focused on quality, access and relevance to both national and international demands. Pakistan has launched a number of exciting initiatives: 3,000 of the brightest students are sent abroad for PhD level studies; the world's largest Fulbright scholarship program has been launched; the typical pay of a professor has been increased to about five times that of a government minister; students and institutions have free access to over 23,000 academic journals and 45,000 textbooks. Pakistan hopes to leapfrog old problems to compete in modern international research.

Sadako Ogata said that the investment of human resources in science and technology has significant impact on both accelerating and sustaining development. With development a key goal for African countries, African leaders and the Japan International Cooperation Agency (JICA) are looking toward Asia to create their own version of the Asian economic miracle. JICA has many technical cooperation projects (concerning science and technology development) in Asia, the Middle East and Africa. As rapid growth sometimes leads to a rise in inequality, programs have to be made that benefit the country as a whole.

Yegor Gaidar discussed Russian science and technology development since the end of the Soviet Union. Russia wants to become an economy based more on knowledge and innovations rather than energy commodities. The Soviet Union featured world-class schools, which Russia now hopes to harness for making useful technology. To invigorate the system, younger workers, especially graduates, are entering the workforce. More and more Russian students are staying in Russia than going overseas.

Catherine Bréchignac said systematic development is the biggest problem that faces the world today. The increase in urbanization and climate change will put a massive strain on available resources. We must go beyond the Kyoto Protocol, and work to continue to adapt and develop technology. Solutions will come through networking at all levels.

Alexander Zehnder said while world population is growing, the quantity of water is constant. Water consumption has increased six-fold over the last century and current use of resources is leading to scarcity. Climate change is likely to cause further water shortages in areas of high population density. Only a few countries can expect risk-free water supplies, and to avoid political abuse of these imbalances, we need the UN Millennium Goals and for governments to guarantee a free market for food products.

Ray Johnson highlighted ubiquitous global communication, the genomics revolution, global talent development, and nanotechnology as four important technology trends and discussed their impact on a global society. The Internet is creating a human terrain that is replacing geographic terrain, genomic-based developments promise cures for diseases as well as having positive impacts on food production, science and math education on a global scale is creating opportunities for both developed and developing nations, and nanotechnology is enabling incredible new materials. The convergence of technologies offers opportunities for invention and innovation that hold the promise of bringing solutions to the world's most challenging problems.

Kazuo Okamoto discussed the future of the automobile industry in light of climate change and rising oil prices. While petroleum facilitated the growth of the automobile industry in the 20th century, we need alternatives if we are to continue our automobile-based lifestyle. Currently, no single alternative energy source is viable. Hybrid engines, which offer greater efficiency and re-use energy by combining different power sources, may be one solution.

14:50-15:50 PLENARY SESSION

102 "How is ICT Affecting Humankind?"

Chair:
Thomson, Robert, Managing Editor, The Wall Street Journal; Editor-in-Chief, Dow Jones & Company, AU

Speakers:
- **Gopalakrishnan**, S. Kris, CEO and Managing Director, Infosys Technologies Limited, IN
- **Hanazawa**, Takashi, Director and Senior Vice President, Director of Research and Development Planning Department, Nippon Telegraph and Telephone Corporation (NTT), JP
- **Kleiber**, Michał, President, Polish Academy of Sciences, PL
- **Sasaki**, Hajime, Chairman of the Board, NEC Corporation, JP
- **Swope**, William, Vice President and General Manager, Corporate Affairs Group, Intel Corporation, US

Robert Thomson opened with an overview of the current serious state of the U.S. financial system and the global situation in general. What he called the greatest upheaval in eight decades is detrimental to investment in science and technology in particular, and societies in general. Two modern trends, digitization and globalization, may be simultaneously contributors and solutions to the crisis. As the democratization of information expands worldwide, he asked, how can it be sustained, what are the social costs, and are current goals too idealistic or not idealistic enough?

S. Kris Gopalakrishnan explained that computers have developed ever-higher levels of complexity, miniaturization and performance, allowing current models to perform tasks and complex calculations at tremendous speeds. The Internet also facilitates a system of interconnectedness and collaboration among people across borders, spurring the creation of new companies like Amazon and providing many other opportunities. In India, 94% of the public has access to mobile technology, which has empowered many by creating or sustaining employment in sectors such as farming and fishing. Communication has resulted in improved productivity and work redistribution. Tasks are also getting redistributed around the world at lower costs, which helps developing economies like India.

Hajime Sasaki reflected on the 30 years following the start of the convergence of Computing and Communications (C&C), during which the speed of communications and power of computers have increased enormously. Advanced computer simulations like those projecting climate change can profoundly affect humankind. New sensing systems are also improving the lives of patients, senior citizens, and others. He raised the issue of the rise in cyber attacks, particularly bot-infected computers, saying that dependable ICT systems should combat such threats. He concluded that C&C will contribute to creating a society in which ICT satisfies people's needs and coexists with humans.

Michał Kleiber stated that virtually every country faces a sense of urgency in meeting the economic challenges of the 20th century, brought about by globalization and technology. He mentioned areas in which IT has made a significant impact, including security and educational inclusion. He said that much like electricity, not only does ICT enable us to do sophisticated things, but its applicability extends into many other areas such as health, cross-border communication and education. The future will usher in new and improved access to more sophisticated network systems and content-rich mobile intelligent devices.

William Swope focused on the positive contributions of ICT to society in the areas of education, healthcare, and the environment. He stated that he is committed to making ICT a positive force in society. He noted that computing power (in particular processor efficiency) has grown exponentially, that connectivity is reaching more people than ever, and that computer prices have decreased substantially. He commented that ICT can make anything more efficient and expressed the hope that wider acceptance of ICT will be able to positively influence government policy.

Takashi Hanazawa presented a vision of the future of communication services based on recent advances. The Internet is now an indispensable part of our daily lives. Personal business and social activities, digital networks, the growth of blogs and video posting all indicate a new era dominated by ICT. He said that this has created an ubiquitous world; a new world order. Security mechanisms, legal regulation and education related to standards, local customs must be put in place to ensure maximum benefit from ICT.

16:30-18:30 FIRST SERIES OF CONCURRENT SESSIONS

103-A1 "Climate Change: Socioeconomic and Security Impacts"

Chair:
McBean, Gordon, Chair of Board and CEO, Canadian Foundation for Climate and Atmospheric Sciences, CA

Speakers:
- **Adachi**, Toshio, Representative Director and Executive Vice President, Sharp Corporation, JP
- **Bernard**, Rob, Chief Environmental Strategist, Microsoft Corporation, US
- **Da Silva**, Wilson, Editor-in-Chief, Cosmos Magazine, AU
- **Kennel**, Charles, Professor, Scripps Institution of Oceanography, University of California, San Diego (UCSD), US
- **Masuda**, Yukio, Corporate Advisor, Mitsubishi Corporation, JP
- **von Deessen**, Ulrich, Climate Protection Officer and President, Competence Center Environment, Health and Safety, BASF SE, DE

Today, climate change has become an issue that impacts the security of mankind. It is said that by 2050 there will be 9 billion people in the world and due to climate change even scarcer resources. Up to half the world's population will be at risk of being impacted. How can we reduce the human impact on the climate system and reduce the impact of the climate on human beings?

We now realize that we cannot only think about mitigating climate change but must adapt to it as well. We need to recognize the interaction between natural disasters and climate change. We also urgently need an international framework for assessing the impact of regional climate change in order to raise awareness among individuals and local decision-makers.

Impacts of climate change on the third world must be addressed. For example, agriculture and fishing communities will be strongly affected by temperature rises, melting ice packs and drought. We must create improved scientific models to help us drive policies and new scientific tools like genetically modified plants that better utilize water. New schemes would also help, such as a pricing structure for carbon sequestration that encourages countries to save their rainforests or the use of mandatory targets for emissions with carbon credits allocated based on population, favoring nations like China and India.

Climate change mitigation by individuals, governments and companies was one theme of the discussion. Global warming is a complicated issue and the notion of emission trading as a practical solution needs to be carefully examined. It is noted that a carbon credit scheme for individuals would allow you to trade your carbon credits through a carbon credit bank. We should reduce unnecessary air conditioning or heating use, improve insulation and take other small steps.

The public knows that global warming is real and caused by human activity but they are paralyzed by the enormity of the problem. People need to know that by making small changes in their lives and houses they can reduce energy consumption drastically. If we use existing technology to reduce energy waste and improve energy storage we can cut energy consumption by half by 2020. Buildings are a source of 40% of emissions, so energy-efficient new buildings must be complemented by building renovation. Another idea is a system in which you can download electrons for your car and then plug back in to a grid to return unused energy in a local, mobile and bidirectional system.

Many corporations are cutting CO_2 reductions through energy use reduction and waste reduction. A careful examination of production processes and product portfolios is needed. It is important to implement existing technologies, such as teleconferencing, to reduce transport-related emissions, as well as innovate with more efficient rechargeable batteries and alternative energy sources. And since one-third of the energy produced in the world is lost in transport and storage, companies need to focus on ways to reduce this kind of carbon leakage.

Incremental change cannot achieve what is needed, however, so our industrial structure must change as well. This will involve such things as new urban design, a complete switch from fossil fuels, carbon catch and sequestration, and the use of biomass to extract CO_2 from the atmosphere. The implementation of such schemes will determine whether the temperature rises by a terrible but manageable 2 degrees or a disastrous 5 degrees, which would transform our world completely.

It was noted that many of the participants discussed ways to reduce emissions, increase energy efficiency and distribute benefits more equitably between developing and developed nations. What is needed is a global social network so we can identify others around the world with the solutions to our environmental problems.

Many companies are investing in environmental technologies, but we need more predictability in terms of governmental law and regulations. We need leadership and an understanding of what climate change means to us as individuals, so we can make the right decisions.

103-B1 "Infectious Diseases"

Chair:
Yeo, Philip, Senior Science and Technology Advisor, Ministry of Trade and Industry, SG

Speakers:
- **Hacker**, Jörg, President, Robert Koch-Institut, DE
- **Herrling**, Paul, Head of Corporate Research, Novartis International AG, CH
- **Imura**, Hiroo, President, Foundation for Biomedical Research and Innovation (FBRI), JP
- **Matano**, Tetsuro, Professor, Division of Microbial Infection, Institute of Medical Science, International Research Center for Infectious Diseases, The University of Tokyo, JP
- **Poovorawan**, Yong, Professor, Department of Pediatrics, Faculty of Medicine, Chulalongkorn University, TH
- **Sun**, Xiaodong, Director, Office of Public Health Emergency Response & Preparedness, Shanghai Municipal Center for Disease Control & Prevention, CN

Rapporteur:
Karpati, Melinda, CEO and Chairman, AmVac AG, CH

This panel session centered on discussion of the global threat that infectious diseases pose. Highly contagious diseases such as avian flu and SARS have spread to several countries throughout the world and have been the cause of fatalities, raising concerns about worldwide pandemics. Infectious diseases both threaten life and place a strain on the resources of any society.

Several emerging diseases in the 21st century have crossed from animals to humans, including encephalitis, HIV and avian influenza (H5N1). The outbreaks can be prevented through worldwide collaboration and monitoring. It is necessary to develop networks of investigation for diseases such as SARS. There is also a need to improve diagnostic methods to help control and prevent diseases. In developing as well as developed nations, the incidence rate of infectious disease can be greatly reduced if modern disease prevention and universal Internet-based hospital surveillance systems are implemented.

Close international collaboration is indispensible for controlling both endemics and epidemics. The United States-Japan Cooperative Medical Science Program has helped address specific infectious diseases and meets twice a year to review its activities and discuss future directions of research. Meanwhile, Japan's development of counterpart research centers in partner Asian and African countries is an example of effective multilateral cooperation. High levels of international collaboration are important for combating infectious diseases.

The rate of death from infectious disease is approximately 30%, but with diseases such as malaria there is a stark contrast in fatality rates between developed and developing countries. HIV and other diseases, however, are problems in both developed and developing countries.

New technologies allow the analysis of the genomes of infectious agents, gene mutations and protein modification, but it takes a significant amount of time to produce drugs and vaccines based on such technologies. Diagnostics using these technologies are also necessary and effective methods for detecting new pathogens.

There is a necessity to share these technologies worldwide and provide education for implementing new techniques and surveillance systems in both developed and developing countries.

The importance of AIDS vaccine development is evident from the increasing number of infected individuals. A pandemic increases the risk of the appearance of drug resistant viruses and a global strategy for prevention is required. A first-generation prophylactic AIDS vaccine would inhibit further transmission to infected individuals while second-generation vaccines would help prevent AIDS progression. New concepts are necessary for effective disease control.

The creation of institutes to target neglected diseases such as tuberculosis and malaria are necessary for infectious disease research. 95% of all pharmaceuticals come from commercial organizations, so huge sums of money with no guarantee of returns cannot be invested into these diseases. Big foundations should form Public-Private Partnerships (PPPs) to promote research in these areas.

Since both pharmaceutical and biotechnology companies cannot invest funds when no return is expected or there is a high rate of failure, a cost-effective approach is necessary to promote such pipelines. Funds should be pooled from both developed and developing countries specifically for R&D. These dedicated monies would then be allocated by an international group of scientific and medical experts to research projects showing promising results.

Improving the success rate in drug development does not seem probable but there is room for improvement in regards to intellectual property. While intellectual property rights are important for encouraging innovation, disease vaccines should be made available to everyone. Sample sharing is necessary to help set up good control systems.

Extending patent rights seems to have been an effective model for giving incentives for research into neglected diseases in the United States, but these same models have shown to be ineffective in the European market. Meanwhile, socio-political agendas can block the sharing of information between countries, as has occurred in the cases of HIV and other diseases.

103-C1 "New Materials – What Can They Do for a Sustainable Society?"

Chair:
Kitazawa, Koichi, President, Japan Science and Technology Agency (JST), JP

Speakers:

- **Brandstetter**, Franz, Senior Technology Consultant, former President, Polymer Research, BASF SE, DE
- **Eastham**, Tony, Acting Vice President for Research and Development, Hong Kong University of Science and Technology (HKUST), CA
- **Hosono**, Hideo, Professor, Materials and Structures Laboratory, Tokyo Institute of Technology, JP
- **Schlapbach**, Louis, CEO, Swiss Federal Laboratories for Materials Testing and Research (EMPA), CH
- **Yasui**, Itaru, Vice Rector Emeritus, United Nations University, JP

Materials research is essential for the development of new technologies, especially those related to the production and use of energy. Such research will help address environmental problems related to climate change and sustainability. There was broad consensus that one challenge for the field to overcome is that research often takes decades to go from concept to market.

Materials research can directly address issues of the energy efficiency of buildings, vehicles and devices. CO_2 emissions can be reduced greatly by adding advanced materials to existing materials. For example, the amount of water used to make concrete is much more than is required for the chemical reaction. The extra water needed can be drastically reduced by adding just a small amount of a polymeric material.

The thermal properties of buildings can be improved to lower the energy requirements for their heating or cooling. Important materials for this task include polystyrene, concrete, phase-change materials, and glass combined with advanced coatings. Also, if all current air conditioning units were changed to heat-pump types, energy consumption would be cut by two-thirds. Although cooling of buildings remains energy intensive, heat loss from buildings can be overcome by the use of insulation. The challenge is to convince the homeowner, for whom it may take years to recoup installation costs. Many types of new materials are needed in order to achieve the doubling of a building's energy efficiency, necessary for reducing CO_2 emissions.

We need to use the wind and the massive amount of exhaust heat that we produce to make our electricity. Solar energy and photovoltaics were promoted as possibilities for generating clean energy. The limitation of the requirement for local daylight could possibly be alleviated by connecting power grids over long distances using superconducting cables. In recent years, the number of potential materials for fabricating superconductors has increased dramatically and the frontiers of basic research in this area have also expanded greatly. There was consensus on the importance of superconductivity, but its viability was debated.

One participant suggested that nanotechnology has broad consumer applications, but whether they make a contribution to power efficiency or sustainability was debated. We should also turn our attention to reusable and recyclable materials. Participants repeatedly mentioned consumption and renewability as areas of importance; in our rush to develop and commercialize new materials, we must not forget the environment.
Efficient rail transport needs to be promoted, but improved efficiency for cars is vital. Either a breakthrough in electricity storage or a viable means of using hydrogen for fuel will likely be necessary. One view of the future was hybrid cars with exchangeable batteries. However, electric cars will likely require more electricity than we produce and there was concern over hazardous waste.

It was lamented that energy policy is driven by political considerations and by public acceptance of specific energy technologies. Advancements in ICT will require breakthroughs in materials for computing and communications hardware. Medical applications of materials, such as replacements for organic materials and research on designing microbe-resistant surfaces, were briefly discussed.

The panelists discussed fuel cells, which are not yet commercially viable, but may eventually have application. Steel production volume and scrap was also touched upon

- it could be possible to source nearly all of Japan's steel production from scrap.

While there are wonderful materials discoveries to be made, not many industries will support long-term research. It is particularly difficult for young researchers to produce results on short time scales in order to receive funding. It is important for institutions to identify talented researchers and support them over longer timeframes, although panelists agreed that this remains a challenge.

103-D1 "Science and Engineering Education"

Chair:
Peacock, Jim, Fellow, Commonwealth Scientific and Industrial Research Organisation (CSIRO); former Chief Scientist, Department of Education, Science and Training (DEST), Australian Government, AU

Speakers:
- **Cox**, Stephen, Executive Secretary, The Royal Society of U.K., UK
- **Ding**, Lei, President, Shanghai General Motors Corporation Limited, CN
- **Krieger**, Eduardo, Head, Hypertension Unit, InCor - Heart Institute/USP; former President, Brazilian Academy of Sciences, BR
- **Mazur**, Eric, Balkanski Professor, Harvard University, US
- **Ponting**, Arlene, CEO, Science Alberta Foundation, CA
- **Schaal**, Barbara, Vice President, National Academy of Sciences (NAS), US

Getting more people interested in science, technology and engineering is a goal for educators worldwide. While it is obviously important to get more university students to enroll in technical courses and thus increase the number of science and engineering graduates, the panel agreed that a lot of interest in science must be stimulated at primary/K-12 educational levels. Various initiatives and methods for this were discussed, and new developments in technology which may benefit education were mentioned.

Many of the panel members discussed programs implemented in their home countries which aim to get people in the sciences and in industry to go into schools and work with children. These schemes create partnerships between teachers and professionals. The panelists cited some encouraging results and all agreed that the schemes were beneficial. Although facilitating some of these programs might be difficult in terms of finding time and incentives for professionals, the consensus was that this was worth working towards. It was suggested that this kind of activity gives children an idea of real-life applications, answering their need to know why they should learn about science.

The discussion moved onto methods of pedagogy. Many speakers said that interactive learning is a far more effective method than just lecturing. While lecturing was described as 'only transfer of information,' interactive learning was suggested to foster superior cognitive and social skills and give students a chance for input and involvement in their own studies. Several speakers reported on achieving improved results and a more positive atmosphere for learning.

Many participants noted advances in technology which are being used in education, especially involving the Internet. Now that information is readily available to children, students and researchers alike the skill to develop is how to find important information, rather than remembering it. This fed into the discussion on interactive learning, where such skills form an integral part of the learning process. However, with the availability of so much course material and resources on the Internet, some asked whether qualifications might become more widely available throughout the world. This led to the point that, especially in science, the skills learned through the interactive and social experience with other people cannot yet be replaced by Internet technologies. However, current popular web technologies, such as social networking, games and so on, were praised as ways to encourage children to learn and to aid the educational process.

While much of the initial talk was about getting children interested in science and the role of universities, many speakers reiterated the importance of making the public scientifically literate. This was a key point of the session. One example given was the critical role that parents play in shaping their children's opinions: if parents are not interested in science, children are likely to be discouraged. Although it was pointed out that this does work two ways and children can encourage interest from their parents, the consensus was that bringing more science to the public is necessary. In furthering this goal, methods of interactive learning and group work were said to have had the best results in generating understanding of science among the general public. Such methods have also been tremendously effective at closing the gender gap, which was raised as another issue that must be addressed to increase understanding of science. That teachers are critical in all of this, and must never be neglected, was the final and overriding message of the session.

103-E1 "International Collaboration in Science and Technology"

Chair:
Aymar, Robert, Director General, European Organization for Nuclear Research (CERN), FR

Speakers:
- **Ikeda**, Kaname, Director General, International Fusion Energy Organization (ITER), JP
- **Klocke**, Fritz, President, International Academy for Production Engineering (CIRP), DE
- **Talwani**, Manik, President and CEO, Integrated Ocean Drilling Program Management International (IODP-MI), US
- **Taylor**, Martin, President and CEO, Ocean Networks Canada (ONC), CA

Three possible models might be helpful for facilitating international collaboration in physics and also possibly applied sciences. The first involves individual interests stimulating research collaboration between institutes and laboratories. Issues such as staffing and material costs would need to be worked out. In a second model, different groups conceive and develop products. While this would allow some scope for dealing with problems that partners face, issues related to intellectual property rights and investment details would need to be addressed. Another model is equipartition involving long-tem participation on a global scale with each partner sharing the responsibilities and benefits. Sometimes investments are grant-based, so some arrangements would need to be formalized in treaties and intellectual property rights protected.

Europe's long-term vision helps to strengthen international collaboration, as seen in projects like the International Fusion Energy project with seven partners: Japan, the European Union, Russia, the United States, India, China and South Korea. The project requires substantial resources, which further reinforces the need for each partner to bring their own expertise.

Each partner in a collaborative venture should assume an important role in the project. Plans to establish facilities such as nuclear power plants must be carefully thought out with strict adherence to safety standards. Also, in order to ensure the continuity of these projects they must attract young people from the community.

Another speaker spoke about the importance of production engineering in dealing with the strategic issue of energy sustainability. He said that companies have to examine local markets and community needs before attempting to work out global solutions. He suggested different models to run research projects, namely, cooperation based on individual interests and joint projects, involving collaboration among industries that share research interests. The speaker suggested that a bottom-up approach that depends on the impact of individual partners is a useful approach to collaboration.

Another participant wondered why some strategic orientation leads to collaboration and some does not. For example, oceanography should be a field with a lot of international collaboration, but unfortunately, this is not the case. He identified certain factors such as funding and national identity issues that affect international collaboration.

There is a large international collaborative effort in ocean drilling among 20 EU countries, China, India, Australia, New Zealand and possibly Russia. The project's high cost, large societal benefits and broad scientific curiosity were all reasons for the international collaboration. Two other impressive examples of international collaboration, according to one participant, are CERN in Europe and the Venus project. The latter aids understanding of the biological, chemical and physical parameters of the ocean and has encouraged the development of what he called "transformative technology."

Seven imperatives were listed: considered to be fundamental to any collaborative effort.

1. Excellence: the need to maintain high professional standards of operation
2. Intellectual capital, involving the best minds
3. Economic imperative
4. Infrastructure imperative
5. Analytical imperative
6. Educational imperative: Opportunities for highly qualified people. Making sure that the information that results from the collaboration is important to the future of science
7. Global imperative

Building research communities is a huge challenge. It is not easy to get organizations to share their intellectual property, or to get agencies to be proactive or to overcome national rules which impede development, but it is essential to successful collaboration.

One participant said that governments need to play a role in collaboration at the operational level. He said that some issues never reach the government level, which leads to difficulties in winning political support. He inquired: "How we can actually begin the process of putting together international networks that lead to success in joint technology platforms and bringing participants together on issues such as mobile technology communications, small enterprises and Internet security?"

Finally, participants also discussed alternative energies and ways of providing developing countries with crucial technologies.

103-F1 "Collaboration among Universities/ Research Institutes/ Industries"

Chair:
Wince-Smith, Deborah, President, Council on Competitiveness, US

Speakers:
- **Feczko**, Joseph, Senior Vice President and Chief Medical Officer, Pfizer Inc, US
- **Gomez Restrepo**, Hernando, President, Council of Competitiveness, CO
- **Lau**, Lawrence, Vice Chancellor and President, Chinese University of Hong Kong (CUHK), HK
- **Matsushige**, Kazumi, Professor, Kyoto University, JP
- **Profumo**, Francesco, Rector, Polytechnic University of Torino, IT
- **Rietschel**, Ernst, President, Leibniz Association (WGL), DE
- **Russell**, Alan, Chairman and Director, McGowan Institute for Regenerative Medicine, University of Pittsburgh, UK
- **Tan**, Chorh Chuan, Acting President, National University of Singapore, SG

Finding the perfect formula for collaboration among universities, research institutes and industries is a very important issue for technological development. The panel explained different ways that this partnership can be developed to be beneficial to all the parties involved. If these collaborations are effective, it can speed up the time taken from the initial scientific breakthrough to the final product.

The main idea was for the creation of a three-way partnership among government, universities and industry. The key may be allowing everyone in the partnership to keep working to their strengths, and to improve the interface between the groups. This way, the core purpose of the institutions can be maintained, but the diffusion of knowledge and ideas can be improved. An example is the cluster model, where universities formulate a research idea that will attract the best scientists and the government and industries interested in the idea fund the project. Some of the research that results would be donated to the cluster, improving the flow of ideas. Such an approach would bring scientists and industries together in a situation where spin-off projects could make money and advance research. Another model involves bringing companies from different areas of interest together with a university to form a group, so that ideas can be shared between all parties without conflict and the university can provide the research that the companies really need.

Almost all models suggest that the government is very important in this process of formulating policies that promote research and development. If a government can provide funding for an idea to be formalized, then industry will be in a position to take it further. For this to work effectively, governments need to release any claim to the intellectual property, making the further development of a product more enticing to industry. This chain of funding will increase the money available at a basic level, so a country is in a position to attract and retain scientific talent.

The issue is different in developing countries; where companies often look outside their own country for research partnerships. This results in low productivity and countries do not effectively use their resources. To encourage these partnerships, governments need to organize research fairs, where companies can meet universities and find out what their own country has to offer. An improvement in research investment means more money stays in the economy and improves the level of research talent in the country.

Though there are many ideas for improvement, one problem was that of ownership of intellectual property rights for research discoveries, which determines who will benefit most from the research. If you clearly define at the start of the collaboration who will own what, problems may not arise later, but this can be more difficult when working on a multinational level.

Many problems stem from a lack of communication, which results in a lack of trust. A solution is to bring universities closer to industry. Methods to promote this include sending scientists out into industry, where they are often very successful, which develops stronger ties between universities and companies. Another successful solution is bringing companies onto the university campus. This blends public and private research, increases a university's capacity for research and provides money and an exchange of ideas to promote research. In the end, personal relations matter; if people like each other, they will work better together. To create a partnership that allows people to grow, you need to get the right people together.

In these collaborations, "value is created at the interfaces." If roles in a partnership are clearly defined and all parties know what they are expected to put in and what they can expect to get out, this will help people work together. Formation of effective partnerships can help scientific developments move into society and benefit everyone.

103-G1 "Business Innovation through ICT – How ICT Affects Business"

Chair:
Higashi, Tetsuro, Chairman and CEO, Tokyo Electron Limited, JP

Speakers:
- **Balasubramanian**, Bharat, Vice President, Group Research and Advanced Engineering, E/E, IT & Processes, Daimler AG, DE
- **Chami**, Ahmed, Minister of Industry, Trade and New Technologies, MA
- **Ito**, Chiaki, Member of the Board and Vice Chairman, Fujitsu Limited, JP
- **Ito**, Joichi, CEO, Creative Commons, JP
- **Sahin**, Kenan, President, TIAX LLC, US

Rapporteur:
Saracco, Roberto, Director, Future Centre and Scientific Communications, Telecom Italia SpA, IT

The discussion began with examples of the advantages of ICT. Rapid urbanization of population leads to poverty, crime, environmental destruction and prevents efficient use of energy. ICT distributes jobs geographically and by doing so eases the pressures of urbanization, such as its burden on the environment, and increases standards of living.

Within the field of ICT, the semiconductor industry has fused with the nanotech and biotech industries to bring improvements in medicine, education, and to the environment. Industries, such as the automobile sector and energy generation, for example, have also benefited from ICT. Although the ICT industry is responsible for 2 percent of carbon emissions, it can have an overall positive effect by reducing emissions in the remaining 98 percent of non-ICT industries. Specifically, ICT reduces the need for buildings and physical facilities which account for 40 percent of CO_2 emissions. ICT can also reduce environmental problems by changing business models and promoting smarter management of supply and demand.

ICT has fostered new kinds of innovation. Traditionally, innovation has come from large companies and governments with heavy amounts of R&D funding. In contrast, the ICT sector features many small firms with low overheads. Transaction costs are low because the Internet allows efficient competition, and the cost of failure is low.

ICT does have problems, though, including a lack of quality standards, since speed-to market is prioritized over quality. Databases exist but don't interoperate. Eighty percent of information is spam. There is no way to validate who is sending information under what name, and identity theft is not being addressed effectively, partially due to the complex nature of the problem and the number of computers involved.

Another problem mentioned was that of the quality of Internet content. We are transitioning from a world of peer-reviewed papers to one where information is free-for-all but often unverified. Often the quality of information on the web cannot be trusted. Institutions such as newspapers and academic journals that hire experts might be put out of business by bloggers. The Internet is building isolated micro-cultures. People only look at information that supports their preconceived beliefs, and consequently democracy is being threatened. On the bright side, some bloggers are gaining a sense of responsibility.

Societies depend on the Internet despite its chaotic structure. There needs to be some government control, and this will be a major issue in the future. However, it is difficult to control such a complex system. This point led to concerns being raised about privacy. Democracy is endangered when governments and corporations become tempted to use and gain control over data.

The session concluded with a statement that IT and communication allows many players to participate and therefore promotes rapid development. Governments will have to play some kind of role in getting all the people involved to behave responsibly. If car manufacturers were completely ethical, they would not build cars that can be driven faster than 30 kph. However, there is pressure to sell cars, so investment is made in making cars safer for people who are not using them safely. Similarly, ICT is not related to ethics or sustainability per se, but is an independent, uncoordinated effort.

19:30-21:00 OFFICIAL DINNER

104 "Lights and Shadows of Science and Technology"

Moderator:
Hayashi, Yasuo, Chairman and CEO, Japan External Trade Organization (JETRO), JP

Speakers:
- **Her Royal Highness, Princess Sumaya El-Hassan**, President, Royal Scientific Society of Jordan (RSS), JO
- **Holliday Jr.**, Charles, Chairman and CEO, DuPont (E.I. du Pont de Nemours and Company), US

Yasuo Hayashi welcomed participants by stating that when discussing issues such as climate change, energy conservation, health, diseases and food problems a long-term vision is required. For the world to achieve sustainable economic growth we must address these issues, and the role played by science and technology is increasingly important. Water will be another increasingly critical issue, and he identified Japanese water practices in the Edo period, 200 years ago, as a model for modern practice. For the ancient Japanese the principles of reduce, reuse and recycle were in force and they did not waste a drop of water. Water is closely related to hygiene and disease control, and it is very meaningful that the STS *forum* is devoting an entire session to this topic. He next discussed mobile telephones, one ICT development that has made it possible to work from any spot on the Earth. He expressed concern that future developments in ICT may further widen the gap between developed and developing countries. Making ICT equipment more eco-friendly is also a challenge.

Charles Holliday Jr. shared his thoughts on current critical issues viewed through the lens of DuPont's corporate experiences. DuPont believes that there is a "new reality;" a realization that the Earth has limited resources. Everything we remove from the planet is at a higher price level than it was 18 months ago, he said. This places demands on science and also means that everyone needs to act differently. He suggested that vehicles like the one-person Segway may in the future become automobiles for the entire family, as long as the government takes the necessary steps. He predicted that the banking system would recover in less than two years. Science, he insisted, can be a big piece of the answer to our current problems.

Princess Sumaya El-Hassan said that Jordan and the Middle East are in a "terrible new reality" for which everyone must take responsibility. Those in science, commerce and politics need to recognize the need to globalize care and invest in knowledge that is committed to understanding local experience. There is considerable untapped human potential in this part of the world – we must extend our efforts to ensure better lives than we currently endure. Individuals must be directly involved in their own development, she added. The Princess explained that in the Middle East the desert is a major source of alternative energy and commerce. There needs to be transparency, trust and cooperation across borders to meet community, cultural and environmental needs, or the region will drift towards chaos and war. She identified non-governmental organizations (NGOs) as being key to bringing real change, and she noted that genuine interest to make the world a better place exists in places like the STS *forum*. Industry and academia are also engines of change, teaching students how to be more entrepreneurial.

Monday, October 6, 2008

08:30-09:50 PLENARY SESSION

200 "Science and Technology in the Service of Health"

Chair:
Yamada, Tadataka, President, Global Health Program, Bill & Melinda Gates Foundation, US

Speaker:
- **Brennan**, David, CEO, AstraZeneca Plc, UK
- **Hasegawa**, Yasuchika, President, Takeda Pharmaceutical Company Limited, JP
- **Kosgei**, Sally, Minister of Higher Education, Science and Technology, KE
- **Lim**, Chuan Poh, Chairman, Agency for Science, Technology and Research, (A*STAR), SG
- **von Eschenbach**, Andrew, Commissioner, U.S. Food and Drug Administration (FDA), US

Tadataka Yamada said that the purpose of the STS *forum* was not for scientists to talk about science for the sake of science but to seek ways for science to serve society. He considers the inequity in healthcare between developed and developing countries to be a moral tragedy and a cause of economic and political instability. He quoted Bill Gates as saying that "humanity's greatest advances are not in its discoveries but in how they are applied to reduce inequity." Collaboration between private and public sectors is necessary to bring money and ideas to solve these problems.

David Brennan alluded to the lights turned on by science and technology and the shadows cast by industry. There is a rise in the incidence of diabetes and obesity along with a number of unmet medical needs, including cancer, stroke, dementia and HIV. Only large corporations can release the potential of medicine to improve peoples' lives. The average citizen's life span has increased from 45 to 60 years due to improvements in diet, living conditions and medicine. Successful partnerships in Japan, France and throughout the world to fight disease will also spark new innovations.

Yasuchika Hasegawa said that many diseases in developing countries are treatable by available drugs, and that infection can be reduced by clean water, sanitation and education. Poverty and starvation hamper efforts to invest in infrastructure and education and provide drugs that are needed. Research institutes focusing on tropical diseases should leverage the experience and knowledge of pharmaceutical companies. Encouraging the worldwide use of vouchers encourages development of medicines for diseases in developing countries. A tiered drug pricing system can be used to provide affordable drugs to countries according to their means. We need to empower developing countries to ensure human dignity and better quality of life for all.

Lim Chuan Poh described his government's success in providing high quality and affordable healthcare through scientific and technological innovation and policy. Singapore tripled its number of researchers and has achieved great growth in a short time. The government introduced an integrated approach to R&D at the highest administrative level by creating a small committee of responsive ministers with control of a budget. Increased collaboration between researchers and technicians resulted in unpredicted benefits such as applications for rehabilitation of stroke patients. He stressed the importance of investigative research and maintaining a balance between top-down governmental and bottom-up researcher-based approaches.

Andrew von Eschenbach said general, macroscopic medicine is being replaced by personalized, predictive, preventive and participatory medicine based on a genetic and molecular understanding of health and disease. Regulatory agencies must create a new regulatory framework to become a bridge, instead of a barrier, for transferring the benefits of medicine to people. These agencies should not focus on national interests but should integrate with other countries. The Federal Drug Administration will soon adopt a "beyond borders initiative" to strengthen confidentiality agreements with other countries. He added that regulatory agencies need to communicate their motives to the public to reduce their fear of biotechnology.

Sally Kosgei stated, "If you are hungry, any opportunistic disease can affect you." Poverty and health issues decrease life expectancy and productivity as the gap between rich and poor increases. Research, science and technology are powerful tools for enabling a long, healthy life and are necessary for achieving the three health-related Millennium Development Goals. The World Health Organization estimates that annually, 600,000 women die from problems related to pregnancy and childbirth. The organization helps save lives by increasing access to healthcare for African women. It is necessary for North-South and South-South partnerships to be formed in research, science and technology to bring important changes to the lives of African people.

10:20-12:20 SECOND SERIES OF CONCURRENT SESSIONS

201-A2 "Harmony with Nature – Nuclear Energy Alternative"

Chair:
Orbach, Raymond, Under Secretary for Science, U.S. Department of Energy (DOE), US

Speakers
- **Arima**, Akito, Chairman, Japan Science Foundation, JP
- **Batterham**, Robin, President, Australian Academy of Technological Sciences and Engineering (ATSE), AU
- **Debreuille**, Marie-Françoise, Vice President, Research and Innovation, AREVA Group, FR
- **Gottfried**, Kurt, Co-founder and Chair, Union of Concerned Scientists (UCS), US
- **Laval**, Guy, Foreign Secretary, Academy of Sciences of France, FR
- **Maekawa**, Osamu, Chief Technology Executive, Toshiba Corporation Power Systems Company, JP
- **Muto**, Sakae, Managing Director, The Tokyo Electric Power Company Inc., JP
- **Otheguy**, Héctor, CEO, INVAP, AR

Table Rapporteur
Pradel, Philippe, Director, Nuclear Energy Division, French Atomic Energy Commission (CEA), FR

We are on the cusp of a transformation in the way we produce and consume energy. The world is addicted to cheap energy but with fossil fuel prices spiraling upwards and worries about global climate change, energy has become a front-page concern. This is a good time for a reexamination of the promise and perils of nuclear energy, along with such issues as its sustainability, spent fuel reprocessing, plant safety and nonproliferation.

Most of the participants agreed that nuclear power will be an indispensable part of a nation's energy portfolio for at least the next few decades, until new, non-carbon or low-carbon-based energy sources like nuclear fusion come on-line. Nuclear energy is cost competitive with most other alternatives, even when a lifecycle comparison is considered, and it is virtually emission-free. The experience of nuclear plants in Japan, which experienced little damage from last year's strong earthquake, demonstrated the improved safety of modern plant design. Uranium supplies are stable for many decades and less subject to price swings than fossil fuels.

There was broad support expressed for rapid expansion of nuclear plants as a means of mitigating climate change, and some disappointment that nuclear energy was not included in the Kyoto Protocol mechanisms. Standardized licensing process across countries and greater cooperation with and funding for the International Atomic Energy Authority (IAEA) will help the nuclear industry expand cost-effectively and safely.

Promising new technologies such as sodium-powered fast reactors, new reprocessing techniques and deep storage technologies are now being developed. Nuclear fusion is a very promising energy source that is thought to be cleaner, safer and more sustainable than current nuclear fuels, but it suffers from a long timeline from development to implementation.

Until now most nuclear plants have been located in the top 16 industrialized nations, but developing nations like China and India are rapidly investing in new plants. Nations like Brazil and Mexico have shown that developing nations can safely operate nuclear plants. Countries acceding to the non-proliferation treaty agree to nuclear safeguards in exchange for receiving help in developing their own nuclear energy. New technologies can monitor and control applications of this technology.

Some participants raised very real concerns about nuclear energy, including the issues of the stability of uranium supplies, nuclear safety, waste management, public acceptance, aging facilities and workforce. Containment of nuclear materials must be successful in the event of plant damage from accidents, whether natural, accidental or manmade. The safety culture of the nuclear industry must be good enough, even for older plants.

Public understanding and support must be gained, and the industry can learn from others in public awareness campaigns. Although environmentalists and labor leaders are more sympathetic to nuclear energy these days, the industry must still do more to engage with the public and not be defensive. The public doesn't believe what is told to them about nuclear power, and only 30 percent have the scientific education required to understand the main issues. Radioactivity creates fear, and many think there is no solution to nuclear waste problems. They should know, for example, that reprocessing can potentially recover up to 95% of the remaining uranium and plutonium in spent nuclear fuel.

Nuclear non-proliferation was a major concern. Nuclear terrorism poses great threat, but governments have not shown the political will to deal with the threat with the urgency required. Stopping proliferation often takes second place to other interests even though we know of secret stockpiles and attempted purchases of plutonium from former Soviet stockpiles. Weapons-grade uranium can be made using civilian output as feedstock. We need to take a long view of nuclear dangers – nuclear facilities will be with us for a long time, and nuclear know-how will spread.

201-B2 "New Development in the Genome Era"

Chair:
Hayashizaki, Yoshihide, Director, Omics Sciences Center, RIKEN, JP

Speakers:
- **Colwell**, Rita, Distinguished University Professor, Center for Bioinformatics and Computational Biology, University of Maryland and Johns Hopkins University, US
- **Conde**, Jorge, President and CEO, Knome Inc., US
- **Landis**, Story, Director, National Institute of Neurological Disorders and Stroke, National Institutes of Health (NIH), US
- **Lindpaintner**, Klaus, Head, Roche Genetics, Molecular Medicine Laboratories, F. Hoffmann-La Roche Ltd., AT
- **Ugrumov**, Mikhail, Counselor of the Presidium of the Russian Academy of Sciences on Foreign Affairs, Russian Academy of Sciences, RU
- **Winter**, Alan, President and CEO, Genome British Columbia, CA

This session analyzed the impact of next-generation genome sequencing technology on modern science and healthcare. The recent increases in sequencer throughput have resulted in a significant drop in the price and time required to sequence a genome. This promises to change research, healthcare and other aspects of science.

Society has great expectations for next-generation sequencing technology. The possibility of DNA as a predictor for diseases such as Alzheimer's, certain behavioral patterns, the production of replacement organs and the determination of risk for certain diseases is promising. The answers to problems related to aging, food, pandemics and bio-fuels will come from a molecular-level of biology. While genomics allows us to understand biology at a fundamental level, the human genome itself does not reveal everything.

The ethical and legal aspects must be faced. Controversies surrounding stem cell research, establishing a standard of care, regulating procedures and how to deal with privacy and confidentiality are all issues that need to be tackled. As genetic information can reveal private information and have a psychological impact, fair methods of dealing with genome sequencing must be developed.

The movement of technology has resulted in cheap and efficient methods of sequencing the genome, having rapidly fallen from millions to thousands of dollars. When the cost of sequencing a genome falls to a certain level, consumers will become increasingly interested in genetic technology for personal use. Some companies have begun to offer sequencing services to individuals and this development brings up many issues. Customers want to know about indications of preventable diseases that may show up in their gene information while some wish to remain uninformed about the possibility of developing certain incurable illnesses. However, dangers lurk in the possibility of the misuse of genetic information in employment, selective healthcare and other areas.

Concerns that it is too early to properly interpret the instances of rare variance found during genetic sequencing were raised. Using epidemiology to find phenotypic expressions of rare variance takes time and requires extremely large sample numbers. Expectations must be managed appropriately. Nothing specific can be drawn from genetic information besides risk factors. Creating tested products for gene analysis that deliver true value will take time.

Application of these technologies can be used to improve the diagnosis of neurodegenerative diseases which are characterized by the appearance of symptoms some 20-30 years after the sporadic degeneration of certain neurons. Advancing sequencing technologies could be used to look at gene mutations associated with neurodegenerative disease such as Parkinson's disease.

Current genomics can already study private mutations or copy number variations that may exist in individuals by utilizing amazing sequencing capacities. Yet, as a caution, as the speed of sequencing increases and its cost decreases, accuracy will need to be assured. Understanding why genetic defects cause disease involves complicated biology and creating therapeutics is difficult despite the availability of genetic information.

Sequencing can provide a powerful and immediate tool for identifying pathogenic viruses. The current method of diagnosis for pathogens takes a very long time but it is desirable for physicians to be able to determine the type of infection you have as soon as possible. There are a lot of scientific surprises resulting from the ability to identify pathogens such as cholera, small pox and anthrax. It will take time to analyze bacterial genomes as there are many existing mutations but this information is a valuable tool for treating infectious diseases more rapidly and effectively.

The drastic fall in sequencing prices will result in new promising applications for gene sequencing technologies. However, unreasonable public expectations that widespread personal applications of genomics are available must be avoided. Curiosity is the biggest driving factor for those who are interested in these technologies for personal use and diagnosis. As the complexity of the genome goes beyond a one-gene one-enzyme connection, efforts should be made to inform the public about genomics by educating science writers.

201-C2 "What Can ICT do for Education?"

Chair:
Bregman, Mark, Executive Vice President and Chief Technical Officer, Symantec Corporation, US

Speakers:
- **Adly**, Noha, Director, Information and Communication Technology Department and International School of Information Science (ISIS), Bibliotheca Alexandrina, EG
- **Kulikov**, Gregory, Executive Vice President, TransTeleCom, RU
- **Leslie**, Ian, Pro-Vice Chancellor (Research), University of Cambridge, UK
- **Martin**, David, Executive Chairman, SMART Technologies, CA
- **Murai**, Jun, Vice President, Keio University, JP
- **Schoenberger**, Chana, Associate Editor, Forbes Magazine, US
- **Siriruchatapong**, Pansak, Executive Director, National Electronics and Computer Technology Center (NECTEC), TH

The participants expressed overwhelming support for applying technology to education and research. Many examples of possibilities were given, especially as a tool to benefit and complement existing frameworks. One concern was the education of teachers, especially those who are not technology natives. A recent phenomenon is students knowing how to use the technology before learning about it in school. Students often know more about technology before their teachers. Access to technology can be a source of frustration to students in the developed world, when they realize that they have better access to technology in their own homes than in their schools.

However, this is not true in the developing world, where technology access is clustered at institutions. Current education centers could become technology deployment centers. Technology is changing the teaching environment and teachers are moving away from being lecturers and toward being facilitators. New methods of teaching must be developed to accompany new technology, such as real-time evaluation of students, in which students perform activities while teachers provide feedback on how the students are responding. Other examples include changing from lecturing to interactively exploring material with students.

Teachers must be better trained to foster "learning to learn," and allow each individual to progress at their own pace. Technology has enabled take-home textbook content to become take-home multimedia content, which can complement classroom technology. Search technology should likewise be a complement to libraries and traditional sources.

Many existing and innovative solutions were offered for addressing the wide technology gap between the developed and developing worlds. The biggest differences are the educational divides between cities, schools and areas.

A popular application of ICT is distance learning, especially for rural schools. However, a high bandwidth connection is required for video broadcast, which is prohibitively expensive for many countries. For schools that don't have reliable broadband access, there could be systems which can run on- or off-line. Wimax is a possible solution for getting 90% of information online for 5% of the cost. To set up an IT system in a remote area, one could run it like a business - identifying the local educational process and understanding the customers.

Benefits of ICT use include students developing connections and friendships outside of their hometowns and helping teachers communicate with parents. Access to scientific journals, currently impossible, could become a reality.
Education is an important part of the process of creating innovation and fostering international competitiveness. In the coming years in India, there may be wage parity with IT workers in the US. Many organizations are looking to the next

markets and worker resource areas, such as Africa.

Not only accessing, but internalizing knowledge remains important, and the new "cut-and-paste" culture is becoming a major barrier to learning. Also at the university level, not enough young researchers are practicing true research that doesn't just feed on accessed information.

In years past, there was standard coursework on library navigation, which should be extended to technological information. Not all references can come from Wikipedia, which was debated as an educational tool. Children should be taught about ethical issues surrounding the use of technology. To combat plagiarism, there are technological solutions, such as a term-paper database service to check against existing papers.

Obstacles to the increased use of technological information are language barriers, resistance to change, and copyright. English is the language of choice, and machine translation is not yet practical. We all need to work on overcoming these hurdles. The issue of copyright is also a major challenge. The existing educational use exception does allow for online materials, so new frameworks and perhaps new laws are needed to allow educational collaboration in the online space. Finally, new methods must be cheap, effective and sustainable.

201-D2 "Role of Universities – What is Needed of Universities in the 21st Century?"

Chair:
Anzai, Yuichiro, President, Keio University, JP

Speakers:
- **Eichler**, Ralph, President, Swiss Federal Institute of Technology (ETH) Zurich, CH
- **Ghubash**, Rafia, President, Arabian Gulf University (AGU), AE
- **Kovačević**, Branko, Rector, University of Belgrade, RS
- **Lenzen**, Dieter, President, Free University of Berlin, DE
- **Seabra Santos**, Fernando, Rector, University of Coimbra (UC), PT
- **Suh**, Nam Pyo, President, Korea Advanced Institute of Science and Technology (KAIST), KR

Table Rapporteur
Minami, Masago, Senior Writer, Yomiuri Shimbun, JP

The discussion recognized that universities play a key role in helping address global issues such as climate change, health, security and poverty. Globalization and the market for research expanding across national borders were noted as pivotal changes for modern universities. The social responsibility of universities to supply government and industry with knowledge was underlined, as was the need for interdisciplinary teaching and conducting research for solutions to modern problems. However, it was generally agreed that traditional disciplines of education must not be abandoned - the need for students to have broad, relevant, skill-based educations was also emphasized.

The difficulty of balancing interdisciplinary research with the acquisition of knowledge necessary to understand technical subjects came up throughout the session. Working with different fields may be the only way to innovate and successfully tackle today's emerging problems, but faculty heads should not eliminate the boundaries of core subjects. Some universities are now choosing to implement much more radical programs - the push by Massachusetts Institute of Technology (MIT) to make research integral to all of its courses, and Melbourne University's move towards more modular education were given as examples.

Also recurrent was the subject of funding for universities and the sources for this funding. As universities have expanded, their position in society has changed. It was agreed that more funding is always good, but more important is the university's autonomy. Therefore, the source of funding should be considered. Most stated that private funding allowed the greatest freedom for university research, but as part of the global marketplace, a combination of funding sources is now standard.

Globalization was seen as a phenomenon in which universities are playing a major role, while also being profoundly affected by it. Universities are accepting more and more migrants as both faculty and students, which has accelerated international cooperation. Industries seeking the best research partners now select top global universities, bypassing national borders.

This led to a discussion about what skills a university of the 21st century should teach. Panelists agreed that teaching was the main responsibility of universities. Graduates should now be viewed as 'global citizens' and need to be able to compete in a global setting. It was suggested that degrees be standardized across the world and that universities work together to make degrees more transferable across borders; the European system was cited as an example. Courses which encourage learning of more of the skills needed for creativity, design or synthesis were said to be desirable now, with such skills being taught as part of courses at all levels. This should give students a wider skill base, which is of benefit to both interdisciplinary academic research and will also produce more employable, skilled individuals for industry.

A discussion of the relationship between universities, industry and wider society was central to this session. It was agreed that an atmosphere where universities can contribute to the wider world should be encouraged. Schemes which encourage competition and provide motivation for academics through practical problems from industry were recommended either through government schemes or from industrial projects. It was suggested that in motivating healthy research, some mix of "fear, greed and aspiration" is optimal.

201-E2 "Research Collaboration between Developed and Developing Countries"

Chair:
Juma, Calestous, Professor, Practice of International Development, Belfer Center for Science and International Affairs, Harvard University, KE

Speakers:
- **El Nazer**, Hani, President, National Research Center (NRC), EG
- **Forssberg**, Hans, Vice President, Karolinska Institutet, SE
- **Fujii**, Nobutaka, Executive Vice President, Kyoto University, JP
- **Hassan**, Mohamed, Executive Director, the Academy of Sciences for the Developing World (TWAS), SD
- **Kojima**, Seiji, Ambassador for Science and Technology Cooperation, Ministry of Foreign Affairs (MOFA), JP
- **Rubinstein**, Ellis, President and CEO, New York Academy of Sciences, US
- **Rwamasirabo**, Emile, Ambassador, Embassy of the Republic of Rwanda, RW
- **Singer**, Peter, Professor of Medicine, University of Toronto, CA

There is a need to enhance the ability of developing countries to be competitive in the global environment. Global competitiveness will help developing countries in tackling persistent problems associated with nutrition, health, education and water. The Hundred Dollar Laptop program was one practical example given of an effort to enhance the ability of developing countries to contribute to the global fund of knowledge.

It was also suggested that software development in developing countries is another way of increasing their capacity to tailor their knowledge base to fit their own developmental agendas.
Participants agreed that science and technology is crucial to any national development effort. Through science and technology, developing countries are better equipped to deal with issues such as global terrorism, natural disasters and diseases. However, for this to happen there must be better infrastructure to build sound partnerships in science and technology. One participant remarked it is the United Nations' responsibility to take the leading role in fostering this kind of scientific collaboration. He proposed the creation of a new UN umbrella organization called the World Science and Technology Organization (WSTO).

One participant said that as there is a strong association between poverty and health, there is a concomitant ethical imperative to place the focus on helping developing countries in dealing with diseases. He proposed that universities in developed and developing countries should be partners in these collaborative efforts. The idea of university twinning was given as one possible starting point.

Another speaker endorsed the idea of inter-university partnerships across the developed and developing world. International science and technology centers have created new patterns of collaboration that benefit developing countries. More advanced developing countries, like China, Brazil and India, should share their expertise with other developing countries.

There was general consensus that science could and should contribute to poverty reduction and economic development. Regarding the economic disparity between developed and developing countries, there is a need for more collaboration at the national agency level in formulating a comprehensive policy which promotes projects that ensure maximum delivery of benefits to people in the developing world.

It was also suggested that there is an obvious problem when aid organizers are not working in partnership with each other. He described an effort called "Scientists without Borders," which brings existing and potential aid organizers together through the web. This is a global alliance, like *Wikipedia*, that puts project leaders and individual organizers from developed and developing countries in contact with each other.

One speaker noted that while the Internet is invaluable in gaining access to information vital to development, several places, like East Africa, do not yet have this access. He mentioned, however, that there are currently initiatives to build better internet network infrastructure in the region.

Another participant gave examples of programs run by the Canadian government to aid development. He highlighted the Development Innovation Fund which finances the development of vaccines that do not need refrigeration.

An attendee said that there needs to be more regional cooperation among countries, so they are better able to respond to common challenges. The website www.iphandbook.com was offered as an online source of practical information on developing science and technology projects. Developing countries need to have specific priorities to organize donors. This needs-driven approach would ensure that resources are channeled into the most critical areas.

Closing remarks centered on integrating scientific research into national development agendas. The development of human capital was said to be the best way to increase developing countries' capacities to contribute to global knowledge. Support for young scientists and research institutions, access to publications and the development of educational infrastructure to train people locally, were some of the practical examples highlighted.

201-F2 "Interface and Dialogue between Humanities and Natural Sciences"

Chair:
Yaari, Menahem, President, Israel Academy of Sciences and Humanities, IL

Speakers:
- **Dutkiewicz**, Rafał, Mayor, City of Wrocław, PO
- **Haiduc**, Ionel, President, Romanian Academy, RO
- **Hasse Ferreira**, Joel, Member, European Parliament, PT
- **Kuroda**, Reiko, Professor, Graduate School of Arts and Sciences, The University of Tokyo, JP
- **Niiniluoto**, Ilkka, Chancellor, University of Helsinki, FI
- **Otieno Malo**, Joseph, President, Kenya National Academy of Sciences (KNAS), KE

In the world today, the need to bridge the gap between natural science and humanities is more apparent than ever. As new information is identified by science, for example relating to climate change, it then falls on the humanities and social sciences to identify the impact that these discoveries will have, and what policies need to be enacted as a result. Without this interface, further scientific developments will be hard to integrate into society.

There are many areas in which the link between natural science, social science and humanities must be improved. In large urban areas, there is general interaction between these three disciplines, but without joint action, the implementation and development of new plans is slow. The environment is another area in which these three groups need to come together; society will be affected by any decision made and must understand what is happening. In order for people to make sacrifices, they have to understand the reasons why.

There are many barriers which impede this interaction. Some of the strongest are built into the education establishment, where specialization forces students to choose an area of study from a young age. Once students have been separated into different areas, it is then very difficult to integrate them. With some notable exceptions, in most areas of humanities or natural science there is no chance to study outside of one's own field. As a result, two scientists may not understand each other's terminology, which means that laymen would always struggle. Scientists need to let in other scientists, and then humanities to improve the flow of information.

In the case of many cutting edge scientific discoveries it can be very difficult to diffuse knowledge into the public domain. The scientist is not necessarily at fault; pressure to publish papers and obtain funding and grants make it very difficult to find time to disseminate findings to a wider community. The job lies with journalists, but journalists without scientific training often unintentionally misrepresent scientific discoveries. It is very important that the people who are moving information into the public domain have a level of scientific training that allows them to understand the scientific discovery. This also applies to politicians – if they have an interest in science, then they can implement scientific policy that they understand and believe in.

Communication is very important for moving science into society. One example given related to science in developing countries, but is equally applicable to many other countries with strong historical or cultural identities. When scientific policies were implemented, many tribes, with different cultures and languages, would immediately reject them as they do not match with cultural beliefs. This happened because there was no explanation and communication between the two groups. In this situation, social scientists and humanitarians need to be involved in projects, so they can explain the benefits and the reason why scientists believe something has to be done. Without this interaction with society, important scientific work will not reach its full potential.

There were a number of possible solutions discussed in this session, one of which was implementing courses at universities relating to science communication. These courses would allow both science students and students with backgrounds in the humanities to learn about different ways of interdisciplinary communication. Such courses could also train those that may not end up in science careers to work to promote greater understanding of science. This would help society have its say in important decisions about the environment, nuclear power, privacy of genetic information and other issues that impact peoples' lives.

201-G2 "Role of Venture Capital in the Developed and Developing World"

Chair:
Hara, George, Group Chairman and CEO, DEFTA Partners; Ambassador, UN ECOSOC, JP

Speakers:
- **Hsu**, Charles, President, eMemory Technology Inc., Chinese Taipei
- **Massingue**, Venâncio, Minister of Science and Technology (MCT), MZ
- **Moon**, Chulso, CEO, Cangen Biotechnologies; Adjunct Professorship of Otolaryngology and Oncology, Johns Hopkins Medical Institute, KR
- **Patel**, Ketan, CEO, Greater Pacific Capital, UK
- **Vargas Guerrero**, Rodolfo, Chief Technology Officer, XVD Technology Holdings (USA) Inc., MX

First, it was stated that the original purpose of venture capital was to sow the seeds of new businesses and industries and to foster their growth. However, this purpose has degenerated into making big money without benefiting the public.

Several stages of development were described through which venture businesses typically progress. For the first few years there is a risk stage in which millions of dollars of investment annually produce zero revenues. After about the fourth year of remaining in this stage, financers tend to write off the company as a failure. However, some of today's most highly successful businesses initially required huge investments while yielding no returns for the first three years.

Examples were given of countries that have successfully used government policy to promote venture businesses. These countries tended to progress through several stages. First, the government stimulated innovation by providing incentives for investors to invest in high-tech ventures together with the government. As these companies began to succeed and make initial public offerings (IPOs), more investors began to invest in the new industries. During this period, the countries experienced great industrial growth and became world leaders in the new industries. However, big companies then began to start business ventures in these new lucrative technologies and became competitors to the small companies. Consequently, the market became saturated and growth declined or ceased in these industries.

The claim that the venture capital market is a failure was addressed. The participants thought that if problems such as global warning are so big, then there must be ways to make a profit by solving them. One reason that it is difficult to fund such ventures is that it is unclear whether there is a market for the products. For example, it is difficult to invest in agricultural biotech ventures in Europe because it is unclear whether a market exists for such ventures. In contrast, there is a very clear roadmap for biofuel development in the US, so there is sure to be funding for it.

Some concern was expressed that start-up companies may become addicted to government funding and learn tricks to get funds without actually creating a successful business. However, examples were given of countries that successfully avoided this problem. For example, an organization in one country received all of its funding from government for a certain allowed period, and then was required to get half of its funding from other sectors, and ultimately ended its dependence on government funding.

A major problem identified by the participants was that fund-managers measure performance of a company by its internal regular returns. Consequently, short-time return plays an important role in venture capital industries even though it is more efficient in the long run to invest a lot of money at the beginning. Technology-based venture companies have to make big investments for future R&D. It is too risky for them to borrow money from banks because they have to return it. Once venture businesses go public, they become investments for activists who demand that capital be distributed as dividends instead of reinvested for R&D. To counteract activists, venture companies should accumulate money internally before having an IPO.

Participants recognized that this is a difficult time for venture capitalists. The whole banking system became risk-averse overnight because of the current economic crisis. This situation makes it even more difficult for venture business to get financing.

Some participants suggested that their governments should provide funding to solve these problems. They thought their countries should provide fiscal incentives and tax breaks to investors who invest in venture businesses. This strategy would encourage investment in the future of the country instead of in money games, such as subprime loans.

12:20-14:05 WORKING LUNCH

202 "Dialogue between Political Leaders and Scientists"

Chair:
Goldin, Daniel, Chairman and CEO, Intellisis Corporation, US

Speakers:
- **Barañao**, Lino, Minister of Science, Technology and Productive Innovation, AR
- **Cohen**, Jay, Under Secretary for Science and Technology, U.S. Department of Homeland Security, US
- **Kumar**, Ashok, Chair, Parliamentary Office of Science and Technology (POST), Houses of Parliament, UK
- **Mlynek**, Jürgen, President, Helmholtz Association of National Research Centres, DE
- **Rowland**, F. Sherwood, Donald Bren Research Professor of Chemistry and Earth System Science, University of California, Irvine (UCI), US (Nobel Laureate in Chemistry 1995)
- **Schiesser**, Fritz, President of the ETH Board, Swiss Federal Institute of Technology (ETH), CH

Daniel Goldin said that his generation has experienced mainly the "light aspects" of science and technology, but his grandchildren will have to deal with the many "shadows." We are living in a time full of potential for significant climactic disaster. Low cost energy is not actually low cost or clean, and while humans can quickly travel around the world, so too can infectious disease. He said that the three shadows in ICT are inadequate security, privacy and reliability. Scientists should work harder to educate political leaders.

Lino Barañao explained that dialogue between scientists and political leaders is a new phenomenon in Argentina. Previously, relationships between scientists and politicians were strained, as science budgets stayed low in both good economic times and bad, but political support is now increasing. All politicians in Argentina today believe that science and technology are required for economic development and state policy, but adequate human resources, technology-based enterprises and new venture capital are missing.

Jay Cohen told the audience that terrorism knows no bounds. Fortunately, solutions to terror threats and other issues also know no bounds. Good ideas come from everywhere, so international engagement and cooperation is critical. The U.S. is an optimistic society. So too is the STS *forum*, which seeks to balance challenges and solutions. The idea of the force of enlightenment is a common thread. Only federal governments have the resources, staying power and wherewithal to facilitate discoveries and the knowledge to change the world and solve problems.

Ashok Kumar described dialogue between the science and technology community and the British parliament as healthy and successful. Exchanges about climate change, fossil fuels, and other scientific topics are occasionally fierce. Politicians speak one language and scientists another. The Parliamentary Office of Science and Technology (POST), where he is employed, tries to bring both sides together.

POST attempts to take difficult, complex subjects and explain them to politicians so they can understand and apply them in their debates. It is an independent advisory body which has gained the respect of all political parties.

Jürgen Mlynek said that when students asked Einstein why he asks the same questions every year, he explained that it was because every year the answers to the questions are different. Mlynek believes it is our duty as scientists to make this clear to the public and to politicians. Innovations come from curiosity-driven research. Politicians are not interested in science, or if they are, it is only if there are political or business gains. It is up to scientists to make science more political and business-oriented.

F. Sherwood Rowland started his session by reminding the audience that this is the 21st anniversary of the Montreal Protocol, which is now often cited as the most successful global environmental treaty ever put into effect. In 1974, the year that Rowland and his partner Mario Molina first published the scientific work for which they later shared the Nobel Prize, they had to decide whether to engage actively with the media and the political world. "We chose to talk to people and become enmeshed in politics and science."

Fritz Schiesser claimed that a dialogue in science and technology is essential to tackle the challenges we are facing. Scientists and politicians are competitive but in different ways. Scientists are competitive in funding, while politicians compete in order to be elected and re-elected. In order to establish a successful dialogue, scientists need to understand politics, without giving up the principles of science. They must also pursue outreach activities to enlighten the public to help them understand how science works. An enlightened public equals enlightened voters.

14:20-16:20 THIRD SERIES OF CONCURRENT SESSIONS

203-A3 "Harmony with Nature – Managing Water Resources"

Chair:
Khoo, Teng Chye, Chief Executive, Public Utilities Board (PUB), SG

Speakers:
- **Braga**, Benedito, Director, Brazilian National Water Agency (ANA), BR
- **Conzelmann**, Claus, Vice President for Safety, Health and Environment, Nestlé S.A., DE
- **Guinot**, François, President, National Academy of Technologies of France (NATF), FR
- **Kada**, Yukiko, Governor, Shiga Prefecture, JP
- **Szöllösi-Nagy**, András, Deputy Assistant Director General, Natural Sciences Sector, UNESCO, HU

Seven hundred million people have no access to safe, affordable water and 2.5 billion lack access to safe sanitation. This global water scarcity crisis was referred to as "global drying" by one participant. Although climate change will have a tremendous impact on water resources, through increased rainfall or droughts, among other effects the greatest driver of the water crisis is population growth. More than three billion people will be added to the current 6.4 billion people in the world in the next 50 years, with most of the population growth occurring in the developing world. Trends like urbanization and migration will make water management even more difficult.

Like oil, water is precious, although, unlike oil, water is considered a renewable resource. This assumption was challenged by one participant, though, as he noted that in many areas water scarcity is causing depletion of deep underground aquifers and that this fossil water is not easily renewed.

Simple, cost-effective, self-sustaining solutions to water problems must be found. Fortunately, many already exist. Participants suggested increasing the number of surface or subterranean reservoirs and groundwater and the expanded use of traditional techniques such as gravity-powered rather than petroleum-powered water pumps. They also spoke of managing demand through pricing policies. Farmers, who are often subsidized for water use, must understand the true economic value of water in order to encourage conservation and reduce waste. Since up to half of all irrigation water is lost, the productivity of water employed in agriculture must be improved.

There has been some progress in securing safe drinking water around the world, but increasing numbers of people lack sanitation. The increase in reservoirs and irrigation has changed the flow conditions of rivers. We have the tools for management but lack trained personnel, so we must invest in education of water professionals.

Cities face unique problems in water management, including limited land for water storage. Some techniques that may be effective are the reuse of water using advanced membrane technology and the desalination of sea water. Public water conservation campaigns and taxes help raise awareness of water conservation.

There was a discussion about whether water should be considered a public good or an economic good. While minimal needs must be met, some participants suggested that pricing water accurately would actually benefit the poor, who already pay dearly for water. To understand the economic value of water we must consider virtual water assessment, in looking at all the water consumed to produce goods. One beef steak, for example, represents 2000 liters of water. For many foods or consumer products, most of the water is used at the production site, far from where final consumption occurs. Large factories use lots of water but are often located in water-scarce areas and use raw materials that have used lots of water, so even reducing water use doesn't affect greater waste in agricultural sectors where raw materials derive. Farmers do not know the true economic or environmental cost of water because of government subsidies for water use.

Consumers need to make the right choices. Carbon labels tell consumers how much CO_2 equivalent is required to make a product, but it was suggested that a virtual water label also be added to products so that they understand how much water was consumed as well.

Some participants suggested that we do have enough water to meet global needs. Accessing that water is both a technological and economic issue, depending on whether an area is largely urban or rural and the country's level of development.

Water problems in the developed world tend to get solved when a crisis arises and political will is felt but this is not true for developing nations. Developing nations need funding and assistance to deal with building the needed infrastructure and management systems they will need in coming years. Funding that will allow developing nations to comply with Millennium development goals must be found.

203-B3 "GMOs for Food, Fiber and Fuel"

Chairs:
- **El-Beltagy**, Adel, Chair, Global Forum on Agricultural Research (GFAR), EG
- **Fedoroff**, Nina, Science and Technology Adviser to the Secretary of State, U.S. Department of State, US

Speakers:
- **Datta**, Asis, Professor of Eminence, National Institute for Plant Genome Research (NIPGR) New Delhi, IN
- **Fischhoff**, David, Vice President, Technology Strategy and Development, Monsanto Company, US
- **Holmgren**, Peter, Director, Environment, Climate Change and Bioenergy Division, Natural Resources Management and Environment Department, Food and Agriculture Organization of the United Nations (FAO), SE
- **Oishi**, Michio, Director, Kazusa DNA Research Institute, JP
- **Van Montagu**, Marc, President, European Federation of Biotechnology (EFB); Chairman, Institute for Plant Biotechnology for Developing Countries (IPBO), BE

Agriculture plays a significant role in most countries. In developing countries it can involve over 50% of the population and successful agriculture programs are necessary for employment and prosperity. The world food crisis and continuing social upheaval will cause poverty and cause us to fall short of our Millennium Development Goals. New scientific tools are needed to tackle increasing problems of poverty and hunger. The use of genomics and genetic engineering could become extremely important in the near future.
Participants in the session believed that while the use of genetically modified organisms (GMOs) is the most prominent solution to food shortage, strong public sentiment is preventing the full exploration of the possibilities, especially outside the United States. Opposition to the production of GMOs leaves scientists with few options. We must allow more access to information about DNA and biotechnology and continue research in this area. There will come a day when GMOs are necessary for the world.

The agriculture and energy sectors are closely intertwined. Bio-fuels (all carriers of energy in biomass) compose 13% of the world's total energy consumption – the energy equivalent of 4 gigatons of oil. 1.9% of this energy comes from liquid bio-fuels, including bio-ethanol and bio-diesel. The possibility of using these fuels as resources is currently a topic of intense debate. Bio-fuel production has both advantages and risks, but a clear picture of its effects on green house emissions and water resources has yet to be developed.

Scientists have to be ready to give more information about the usefulness of GM-crops with viral and bacterial resistance. In the case of corn, over 400 genes contributing resistance have been patented and crops with increased nitrogen fixation abilities are already available. Certain speakers were adamant that blocking the use of GMO technology due to misinformation and lack of funds must be discontinued.

It was agreed that we must create confidence in the use of GM-crops and dispel false beliefs. People say that they want a world free of GMOs and there is a lack of support at the political level. It is urgent that scientists speak up now to bring to the attention of society the benefits of GMOs. Scientists must be prepared to provide information to dispel false claims against GMOs and make the public understand that "the whole world is one big genetic laboratory."

While some countries carefully introduce GM-crops, others block farmers from the choice between the use of GM and non-GM crops. Access to scientific information is too limited. Our politicians don't receive accurate information, and non-governmental organizations (NGOs) raise large amounts of money to counteract the production GM-crops. The public is fascinated by the use of technology in electronic items, but they do not know about its potential in agriculture. A recently released study in Europe has shown that GM-crops are safe, but the EU has not published this report or held any press conference.

It will be a difficult challenge to convince the general public of the safety and benefits of GMOs. In one African nation, a census revealed that printed media reach only 15% of the population – radio media was more widespread, but not used to promote GMOs. Neither the African public nor private sectors are commonly involved in the development of GMO technologies. Most citizens' trust lies with the public policies of the government and there are many obstacles to gaining the public's trust of GMOs. Working in connection with the international community to promote funding for research in these areas would be invaluable to making African countries more receptive to these necessary technologies.

203-C3 "What can ICT do for Health?"

Chair:
Campbell, Donald, Senior Strategy Advisor, Davis LLP, CA

Speakers:
- **Chang**, Morris, Chairman, Taiwan Semiconductor Manufacturing Co. Ltd., US
- **Gage**, John, Partner, Kleiner Perkins Caufield & Byers, US
- **Graydon**, Oliver, Editor-in-Chief, Nature Photonics, UK
- **Harbour**, Malcolm, Member, European Parliament for the West Midlands, UK
- **Hegarty**, John, Provost, University of Dublin, Trinity College, IE

- **Kitano**, Hiroaki, Director, The Systems Biology Institute (SBI), JP
- **Sangin**, Amirzai, Minister of Communications and Information Technology, AF
- **Sutherland**, Garnette, Professor of Neurosurgery, Department of Clinical Neurosciences, University of Calgary, CA

ICT now plays a role in almost all aspects of our daily life, especially healthcare. At the intersection of ICT and health, many great strides have been taken and many possibilities exist for future breakthroughs. It can be said that ICT has contributed to the rising cost of healthcare, but it will likely also be part of an effective healthcare solution.

In developed countries, populations are aging, and as a result, healthcare costs are rising exponentially. An important recent study reported that 20% of persons over 65 are dependents. Technological solutions, such as monitoring systems and assistance devices, will be needed to care for these persons, either at home, which is the cheaper alternative, or in care facilities.

The use of sophisticated imaging and standardized records can help minimize the need for surgery and tissue sample procedures and achieve more targeted treatments for specific subsets of patients. Electronic hospital records also offer improvements in safety, accuracy, convenience and environmental impact. They can speed treatment for critically urgent situations, such as stroke, following imaging and diagnosis.

We can look forward to a much more informed consumer in terms of both ICT and healthcare. One US study reported that 75% of Americans use the Internet for health advice, and Google has become the number two resource for health information. Patients want control and security for their medical information, but need to maintain its availability to family and care-givers when necessary. They also want more accurate information and more effective treatments on ever shorter timeframes.

ICT can be of great help to developing countries where it can make a big difference. Unfortunately, ICT infrastructure is the least developed in these countries. The needs of developing countries can be markedly different from those of developed nations. In remote areas of developed countries, broadband ICT availability can help bring doctors to patients and vice-versa. However, in many developing nations, basic ICT, such as cell phones and slow-speed Internet, remain luxuries. Even this low-tech ICT can be a major contribution to healthcare. Access to electronic books, journals and basic communication makes a major difference to medical research in the developing world. It was noted that the majority of simple problems in rural areas could be treated without transport to a hospital if communication technology were available. However, electrical power generation alone remains a large obstacle in many remote areas.

Numerous technological advances were discussed, including optical sensors, higher-speed networks, mass data storage, and better communication between healthcare workers, including first-responders and those involved in subsequent treatment. Likewise, in high-tech healthcare, advances have been made against malaria and other diseases, and breakthroughs have even been made in stem cell research. Panelists discussed one cutting-edge area of drug research, synergistic effects of combinations of drugs, which has produced several useful drugs; some drugs unrelated to certain diseases are effective against those diseases when used in combination. Computational science was suggested as a future technology for predicting possibilities and reducing the risks and difficulty of exploratory clinical trials.

ICT is of great importance for securing acceptance and motivation for action on health issues. Attendees expressed concern that the most successful products are not always the most technologically advanced, but often the cheapest ones. The STS forum could be influential in speaking out against barriers to ICT advancement.

Overall, there was a general consensus that ICT has a great role to play in both the developed and developing world, in terms of medical progress.

203-D3 "Proposals from Young Scientists"

Chair:
Schürer, Wolfgang, Chairman, Foundation Lindau Nobelprizewinners Meetings at Lake Constance, CH

The overriding themes of this session were how to create an environment where young scientists can work on problems which particularly concern them and what are the opportunities for getting more young people positions in science. General issues such as social responsibility, increased funding for "blue sky" research and encouraging innovation from young scientists were raised. Additionally, reforming academia to further motivate scientists was suggested. It was agreed that quality of research should be fostered in young scientists, rather than purely encouraging a high quantity of publications.

The session was divided into the following five sub-topics:

Fostering young researchers
This starts with communities and schools and children should be exposed to science early. However, science does not stop when people leave school. Meanwhile, scientists from developing countries should have more facilities, infrastructure and recognition to continue research when they return from institutions overseas. This creates more local role-models in science and sets science up as a viable career path. Government commitment is needed for this, along with a greater number of scientists in government - in both developed and developing countries.

Schemes to develop the creative ideas of young researchers
The crucial idea discussed was creating a positive environment for young researchers. The ideas discussed had much in common with the previous topic, as it was pointed out that such an environment is necessary for both fostering young researchers and developing their ideas. It is extremely desirable for young scientists to be able to concentrate on their research, rather than worry about their career and job

security. This environment should be sustainable and feature evaluation methods and criteria for research projects which allow for interdisciplinary work.

Establishing networks among young researchers

Now that we have very good, ubiquitous networks, how can we use these to aid research and help young scientists? Participation with Internet-based collaboration tends to be more active and lacks some passive elements of face-to-face networks. Encouraging the use of the Internet is usually easy among young scientists, but using it across generations presents more of a challenge. Technologies also afford much faster publication of research results and this generates extreme competition. An environment with healthy competition where young scientists feel free to share new ideas is something worth pursuing and will require more trust between young scientists.

Mutual and international exchange between academic, industrial and governmental sectors

Technology licensing is now an issue that is international and encompasses both developed and developing nations. Public outreach is necessary and more groundwork is needed in schools, governments, banks and the wider scope of society. The issue of retaining good researchers in academia, as much talent is lost to the private sector, and the specific case of developing countries being unable to keep talent were discussed. Some examples given were universities from developed countries building branches in developing countries. This kind of local distribution of institutions can lead to research specific to regions.

Next great challenges for Science and Technology

A profound issue raised in this talk was that of risk assessment. In the past century, many new technologies were developed for very worthy causes, but had unexpected side-effects. The development of chlorofluorocarbons (CFCs) was cited as one such example. Meanwhile, the recent financial crisis was described as possibly a case where innovation had overtaken risk assessment and balanced thinking. With the proportion of old people now outweighing that of young people in many countries, it was asked if young scientists might be "endangered." Points raised earlier in other topics came up again, clarifying the opinion that inspiration for young scientists needs to be introduced early.

203-E3 "Brain Drain, Brain Gain and Brain Circulation"

Chair:
Zhang, Jie, President, Shanghai JiaoTong University, CN

Speakers:

- **Bououny**, Lazhar, Minister of Higher Education, Scientific Research and Technology, TN
- **El-Hassan**, Princess Sumaya, President, Royal Scientific Society of Jordan (RSS), JO
- **Kabganian,** Mansour, Deputy Minister, Ministry of Science, Research and Technology, IR
- **Omer**, Ibrahim, Minister of Science and Technology, SD
- **Winnacker**, Ernst-Ludwig, Secretary General, European Research Council (ERC), DE
- **Wintermantel**, Margret, President, German Rectors' Conference, DE

The session examined ways in which "brain drain" affects developing countries. One negative impact that was highlighted is that brain drain decreases the capacity of a developing country to meet its own local needs and makes it difficult for it to compete on a global scale.

The push and pull factors that lead to migration and brain drain were also discussed. Low income, poor social conditions and ethnic problems were identified as important push factors. Developed countries, on the other hand, are attractive for exactly the opposite reasons. Additionally, one participant spoke about the policy of some European Union countries to actively recruit highly skilled scientists from the developing world and from other European countries. This is seen as a necessary step in maintaining a competitive edge in the global economy. It was reported that Europe aims to become the most competitive and dynamic knowledge-based economy by 2010. The success of this goal will depend on an influx of highly trained migrants. Some participants further argued that in a globalized world, the concept of brain drain is inappropriate. They suggested that the term "brain circulation" better describes the flow of talent between sending and receiving countries.

On the transition from brain drain to brain gain, it was reported that Chinese universities have begun putting programs in place to repatriate scientists who have gone abroad to pursue their studies. These scientists are considered to have added value and a government initiative has been set up to recruit them and utilize their knowledge in addressing the local needs of their home country. Thus countries facing brain drain will need to develop strategies to cope with the loss of their skilled people while at the same time finding ways to integrate them into the development efforts in their home country.

One such strategy that was suggested is for developing countries to take steps to prioritize their resources in such a way that education is not disproportionately underfunded. Lack of responsible resource allocation is identified as a prevalent problem in a number of developing countries. Some of these counties expend a huge portion of their national budgets on militarization while neglecting critical areas like health and education. One example that was given was those developing countries which still have not fully committed themselves to educating their women and harnessing their potential to play a significant role in the development of their economies.

One participant argued that efforts by developing countries to prevent brain drain might be futile. Instead, it was suggested that they should concentrate their energies on developing alternatives that can attract private investment.

Some countries like Japan suffer from a phenomenon that one participant called "brain stagnation" in which young people are not interested in pursuing their studies abroad and as result lose out on the new perspectives and skills that they could gain from other countries. This has the potential to reduce the capacity of the Japanese workforce to compete globally.

It was concluded that a borderless world makes it easy for people to migrate to other countries. However, international collaboration can help to lessen the impact of brain drain on vulnerable economies. One way in which collaboration could do this is by setting up national or regional diaspora organizations that encourage scientists to play an active role in the development of their home countries.

203-F3 "Role of Media in Science and Technology"

Chair:
Kurokawa, Kiyoshi, Special Advisor to the Cabinet; Professor, National Graduate Institute for Policy Studies, JP

Speakers:
- **Jain**, Jinendra K., Chairman, Jain TV Group, IN
- **Jasny**, Barbara, Deputy Editor for Commentary, Science, American Association for the Advancement of Science (AAAS), US
- **Kamanga**, Daniel, Director of Communications and Public Acceptance, Africa Harvest Biotech Foundation International (AHBFI), KE
- **Osterwalder**, Konrad, Rector, United Nations University; Under-Secretary-General of the United Nations, CH
- **Park**, Penny, Supervising Producer Discovery Specials, Discovery Channel Canada, CA
- **Power**, Christopher, Assistant Managing Editor – International, BusinessWeek, US

Table Rapporteur:
Bergman, Catherine, Author and Journalist, CA

While the general public does not need to have a deep knowledge of every area of current research, it needs to have some understanding of the science behind the issues that face the world today. This session focused on how the media could be used to diffuse this important knowledge to the public.

It can be difficult for a journalist to write an accurate science article. With great pressure to meet deadlines, it can be difficult to do sufficient background reading and check all facts and sources. An editor is looking for a story that will sell, if the science article is not sensationalist, it is unlikely to be approved. This pressure means that a story about a scientific discovery is less likely to be written. With this situation, it is a struggle for scientific research to make it into the public domain.

Misinformation is a big problem with the scientific articles that do appear in the main stream media. Scientists often feel the meaning of their research is distorted, a recent example being the Large Hadron Collider, where one person with a sensationalist viewpoint managed to make it into the press with views that did not match those of the scientific community. Press coverage like this spreads a false view of scientific work, and also breeds fear and mistrust within the scientific community. It is imperative that accurate information can be given to the public to reverse this trend.

An important first step for science, when using the media to broadcast findings, is careful selection of the correct choice of medium. This choice will depend on the country you are in and the audience you want to reach. The media is market-orientated; it has to provide the stories people want, which puts the onus on the scientist to present not just their findings, but also a story that will interest the public. Programs following scientific endeavors can present findings and humanize the research process, helping the public understand what scientists are doing.

A different approach has to be taken in developing countries, where there are higher levels of illiteracy and in many areas people do not own televisions. For these people, knowledge about agriculture and having general access to educational materials is very important. Radio is one means to provide this; in Africa most people will listen to the radio everyday, providing a medium for scientific knowledge to be dispersed.

The media cannot be expected to give science more coverage; as businesses they have the right to choose the material they cover. They need to satisfy their market and if the market does not crave scientific knowledge, they should not be obliged to provide it. It instead falls to the government, through education policies, and scientists, through finding ways to sell their science as a story, to create a culture of science. Once a culture of science has been created, the market will then be there for the media to satisfy, leading to increased science coverage.

Science and journalism are two very different cultures, and a way to provide a bridge between the two is needed. Centers like the Science Media Centre in the UK can provide this bridge. They provide weekly briefings for editors, a contact point for journalists when they have to write a science story; and experts that can explain the science to the journalist. This way, scientific ideas can be presented as journalistic stories, without technical jargon, allowing an accurate article to be made. Another bridge could come through training for scientists to communicate with journalists, making communication easier. This greater communication can be turned into personal bonds, massively improving relationships, resulting in science being brought into mainstream media.

203-G3 "International Reconciliation of IPR"

Chair:
Yu, Geoffrey, Senior Specialist Advisor, Ministry of Foreign Affairs, SG

Speakers:
- **Akimoto**, Hiroshi, Counsel of Intellectual Property, Japan Pharmaceutical Manufacturers Association (JPMA), JP
- **Hennessey**, William, Professor of Law, Franklin Pierce Law Center, US
- **Koezuka**, Masahiro, former Commissioner, Japan Patent Office; Advisor, Mitsui Sumitomo Insurance Co. Ltd., JP
- **Li**, Yonghong, Director General, Electricity Examination Department, State Intellectual Property Office of P.R. China, CN
- **Oosterlinck**, René, Director, Galileo Programme and Navigation related activities, European Space Agency (ESA), BE
- **Stein**, Christian, CEO, Ascenion GmbH, DE
- **Takagi**, Yo, Executive Director, Office of Strategic Planning and Policy Development and the WIPO Worldwide Academy (WWA), World Intellectual Property Organization (WIPO), JP

The session opened with a statement that political and ideological differences have distracted attention from important issues, such as the discrepancy between developed and developing countries. The purpose of the session was to bring back substantive rather than political-ideological debate, because IPR is based on necessary cooperation between states.

Patent offices need to harmonize national IP systems to catch up with the increased workload caused by increased filings, and to reduce redundancy of applications in multiple countries. This harmonization can be achieved by collaboration between patent offices of various countries to function as one "virtual global patent office." Patent offices need to respond to the differences between innovation modes in areas such as IT and pharmaceuticals. Patent offices also need to address global disputes and assess the negative impacts of opportunistic activities by improving predictability in the acquisition and utilization of IPR. Clear and transparent rules combined with effective use of IT and the facilitation of IPR transfer and licensing are required. Finally, a pro-innovation global IP infrastructure needs to be established.

It was noted that only a small percentage of patents are owned in developing countries. Consequently, such countries are skeptical about the IP system, because they don't understand how it could benefit them. Their skepticism must be eliminated and they must be encouraged to protect their own patents. Also, developing countries don't know which IP model to follow as there is no established model among developed countries.

Participants discussed the significance of free and open source software (FOSS) for IPR. The old industrial model was based on the concept of individual or company ownership of property, but the basis of IT innovation is sharing. Pressure from the IT collaborative model has caused phenomena such as patent pools and collective trademarks. The question was posed as to whether FOSS would work as well for other industries as well as it has for IT. India was cited as an example of a country that has applied the FOSS model to the pharmaceuticals industry. Participants discussed whether FOSS would work as well in the pharmaceuticals industries as it has in IT, and concluded that there are some important differences between the two fields. IT products combine many technologies, but pharmaceutical products are single substances. Therefore, open source innovation would be difficult to apply to the pharmaceutical field. However, open source innovation could be useful for basic research tools used in pharmaceutical fields.

Concern was expressed about the harmful effects of patent "trolls," who opportunistically enforce their patents against alleged infringers. An example of a successful solution to an IP problem was offered: A US law changed the term of patents from seventeen years after its grant date to twenty years after its filing date. This law reduced the number of "submarine patents," those which were granted long after the application date and remain unknown to the public during that period.

An infrastructure is necessary to foster cooperation and technology transfer between academia and industry. Universities must be allowed to participate in the commercial successes of their products. A line needs to be drawn between competitive and precompetitive research, so that the latter can be pooled. Since the role of universities and researchers is to disseminate information, they should not use "blocking patents," which prevent patentees from using their inventions without licenses from another patent. Grace periods should also be introduced.

Linguistic issues were mentioned as examples of the effects of globalization on IPR. Disclosures are required to be written in English, but applicants from some countries think they should be translated into their languages. The importance of IPR for startup companies was also mentioned. Innovation can be promoted by prioritizing startup companies over large companies for grants of revenue.

16:50 – 18:00 PLENARY SESSION

204 "Biofuels and their Potential Effect on Food Production and the Environment"

Chair:
Serageldin, Ismail, Director, Library of Alexandria, EG

Speakers:
- **Desmarescaux**, Philippe, Chairman, Scientific Foundation of Lyon, FR
- **Riisgaard**, Steen, President and CEO, Novozymes A/S; Chairman, EuropaBio, DK
- **Rosegrant**, Mark, Director, Environment and Production Technology Division, International Food Policy Research Institute (IFPRI), US
- **Taha**, Elzubair, Minister of Agriculture, SD
- **Wambugu**, Florence, CEO, Africa Harvest Biotech Foundation International, KE

Ismail Serageldin described carbon emissions, volatile markets and competition against food production as issues to overcome if biofuels are to be truly viable. Subsidies have been enacted in a number of countries and in the U.S., one-quarter of the corn crop now goes to produce ethanol. However, with population increase and economic growth leading to much greater demand for food, there may not be room for biofuel production. With rising food prices leading to riots in some areas, the decision to cultivate biofuels is not simple. "It is wrong to burn the food of the poor to fuel the cars of the rich." he suggested, especially when many alternatives may be explored.

Mark Rosegrant explained that although biofuels have triggered high food prices, many other factors contribute to the price rises. Low rainfall, export bans and increases in demand are greater factors and, as an estimate, biofuels have only accounted for around 30% of these price rises. He recommended that ethanol blending and similar policies should be removed. Also, with high and rising gasoline prices, biofuels are comparatively economical. Even after the current problems of food and oil are solved, biofuels will be part of the long-term equation. Production of second generation biomass also creates competition for land, so there are no easy solutions.

Elzubair Taha stated that food security is paramount. Arguments over the details and causes of food price rises are causing many rifts in the world. These problems are shared between us and are likely to get worse. Sudan has much fertile land and can support massive crop production, and is opting for harvesting food rather than producing car fuel. This choice is like a 'tug of war,' but new agribusinesses may promote cooperation. As the problems are common, we must identify who, rather than what, is the villain.

Steen Riisgaard said the next generation of cellulose-based biofuels will be developed on an industrial scale within two years. The confluence of expensive energy and improved technology, along with funding from the U.S. Department of Energy, has made this possible. The new biofuels will be produced in China, which has been providing first-generation biofuels on the local level, in Brazil, a pioneer in sugar cane-based biofuels with a developed market, and in the U.S., where new automotive fuel standards mandate biofuel use. Europe will lag 5-10 years behind, due to a lack of political will. Unwavering political leadership and a road map are what are needed to convince companies to invest with confidence.

Florence Wambugu explained that early this year food prices rose by more than 50 percent for all commodities, while energy prices also spiked, leading to dire suffering for many. Also behind the food crisis, she said, was an increase in meat consumption, a growing population, and biofuel production. Yet placing blame on biofuels would be counterproductive. Biofuels have potential benefits for African communities, she said, citing examples of fuel conversion of indigenous plants, like Jatropha, that grow well in semi-arid conditions. She urged Africans to turn a perfect storm of events into a perfect opportunity for fostering a green revolution in Africa.

Philippe Desmarescaux said that we need to consider global and environmental impacts of our behavior. We must change our lifestyle and eating habits, accepting that livestock farming requires more land and cereal than is sustainable. We must balance our use of arable land with needs for food, fuel, fiber and feed, and preserve the environment for the benefit of all. Science and technology can help us do this by improving energy yields and developing new plant varieties that need little water or are able to use more arable land in saline or drought areas.

Tuesday, October 7, 2008

08:30 – 09:25 PLENARY SESSION

300 "Summaries from Concurrent Sessions"

Chair:
Helal, Hany, Minister of Higher Education and Scientific Research, EG

Speakers:
- [A] **Schellnhuber**, Hans, Director, Potsdam Institute for Climate Impact Research (PIK), DE
- [B] **Bhumiratana**, Sakarindr, President, National Science and Technology Development Agency (NSTDA), TH
- [C] **Carty**, Arthur, Executive Director, University of Waterloo Institute for Nanotechnology, CA
- [D] **Shirai**, Katsuhiko, President, Waseda University, JP
- [E] **Córdova**, France, President, Purdue University, US
- [F] **Lee**, Yuan Tseh, President Emeritus, Distinguished Research Fellow, Academia Sinica, Chinese Taipei (Nobel Laureate in Chemistry 1986)
- [G] **Brown**, Gavin, Inaugural Director, Royal Institution of Australia, AU

Hany Helal introduced the speakers, who each summarized the proceedings of one of the seven tracks of concurrent sessions. He later concluded the session by calling upon the audience to think globally, act locally, network among scientists and other stakeholders, simplify science and promote public education, save energy, and improve connectivity and access to information for developing nations.

Hans Schellnhuber described the three sessions of the A track. The first session looked at socioeconomic and security aspects of climate change. Global warming might generate violent conflicts and cause widespread human dislocations, and the necessary cuts in CO_2 emissions require system change as well as individual behavioral change. The participants warned that strong political leadership is needed to achieve a satisfactory outcome for Copenhagen next year. He concluded that even under ideal circumstances, we can only limit global warming to about 2 degrees, so we will need far-reaching adaptation measures. He thus suggested that next year's meeting deal with integrated regional assessments.

The second session covered nuclear energy. It was felt that nuclear fission should be part of a country's energy portfolio under certain conditions like good governance but there remain crucial problems with proliferation and public acceptance. We need international control regimes and dialogue about the risks related to society. If nuclear succeeds it must do so by economically competing with other no-carbon energies.

The final session concerned the global water crisis, which threatens natural and social security. We need incentives to conserve water and appropriate pricing and incentives for innovation in water management. Early warning systems for storms and membrane technology for water filtration are important, while improved agricultural efficiency is imperative. He warned that a large-scale water disaster is looming, due to climate-change-generated glaciers melting on the Tibetan plateau and shifting monsoon patterns that may ultimately disrupt the lives of up to 2 billion.

Sakarindr Bhumiratana said that the continuing worldwide problems of infectious disease require a timely, appropriate and coordinated global response, including detection and notification of new pathogens and drug resistance. Engineering new drugs and vaccines are important parts of the solution but generally take time to develop. Prevention worldwide will require the consolidation of efforts like research, doctor training and technology transfer to areas of greatest need. Prevention and treatment of polio in particular remains a major challenge. Governmental and private assistance is still needed in areas that offer little opportunity for profit. Additionally, worldwide coordination and consideration of intellectual property regulations are recommended.

He noted progress in genome science, with recent rapid acceleration especially in sequencing, and predicted continuing progress and falling costs. The challenge will be to convert the research to the clinical regime as there remains a gap between the promise and the realization. Important applications include diagnostics and prevention of neurological disease. Genetic techniques will be very important for public health, and there have been significant contributions made by the private sector.

GMOs are the most prominent method for expanding food production, but strong public opposition is preventing widespread use outside the U.S. This leaves scientists with few options for addressing world food problems. We must improve the education of the public and create confidence in the use of GM crops. Biofuels, with their recent rapid increase, are an area of ongoing discussion in light of world food needs.

Arthur Carty explained that ICT has strong influences on materials science, education and healthcare. Materials are the building blocks of our society: bronze, steel, plastics, and now nano materials have brought about innovation and have great promise in the future. Materials science will in particular drive the development of innovative technologies including areas such as photovoltaics, high-speed communications and computing, and polymer and composite materials. Also, applications in high temperature superconductivity remain a long-sought future goal, with many new possibilities. The use of ICT in teaching and learning includes the role of teachers, parents, and students. New learning formats, the use of computers, and online communication and communities must cater to the needs of students who are today's "digital natives." Teachers are becoming facilitators and parents are being incorporated in the learning process. Students must become more active participants in their education.

The use of broadband can be a vital link for rural areas, especially in the developing world, and even narrowband connections can be important. Connections can, for example, link high school students with universities and their students. International links can be especially fruitful, though some barriers remain, such as language, with a universal language such as English not widespread in remote areas. In healthcare, aging populations are a major concern, and ICT can help drive improvements to healthcare, including that for the elderly. New technologies include advanced medical imaging, electronic records, robotic surgery and more rapid treatments. Developing countries also face difficulties which can be addressed by ICT, providing medical care to remote areas, and access to medicine, research, knowledge and assistance to developing nations.

Katsuhiko Shirai discussed Track D. He spoke of the necessity to interest more people in science and provide opportunities for study for the young, citing examples of bringing researchers into the schools and forming partnerships between teachers and professionals. Interactive education can be an effective way to disseminate science.

The next session covered the role of universities. Universities are key sources of ideas and markets for research. To carry out their social responsibility to supply society with knowledge, universities should promote interdisciplinary education while not abandoning the strengths of a traditional education. Universities are increasingly globalized, and so they must enable their graduates to compete in the global marketplace. International standardization of degrees would be one positive step.

The third session featured ten promising young researchers, who presented meaningful proposals for improving the scientific environment around the world. Mr. Helal called one of the ten young scientists to the stage to share the findings of these promising young researchers in their session. The researcher reemphasized the importance of networking and mentoring, supporting research in developing nations, and building a science-friendly society and schools. He added that young scientists need the chance and the funding to take risks and generate paradigm-shifting ideas. The other young scientists then joined him on the stage for an introduction to the audience.

France Córdova discussed Track E on international scientific collaboration. In the first session, participants shared differing models for international partnership and identified some common features, such as the promise of revolutionary results, the need for powerful new tools such as platforms in space and robust analytical tools, the potential for societal benefit, agreed upon models for sharing research and, most importantly, visionary leadership.

The second session covered research collaboration between developed and developing nations. Developing countries need to build capabilities and infrastructure, enhanced by funding from both governments and private investment. Open courseware and the Internet can help facilitate this kind of collaboration and identify new opportunities for government, universities and research centers to work together.

The problems of brain-drain and brain-gain were the topic of the third session. With globalization leading to increased human migration, developing nations must implement creative solutions to retain and draw home their promising talent. More investment in research and science facilities and government-private sector collaboration was advised. Emigrants would benefit from links with their global diasporas.

Lee Yuan Tseh explained that the key to partnerships between universities, research institutes and industry was to allow each partner to work to their strengths and maintain interaction. He said that it was agreed that government must provide support and leadership, and efforts must be coordinated between institutions within countries, especially in developed countries with more resources. On the other hand, developing countries often look outside their borders for support and more forums for fostering collaboration within their own countries are needed.

The area of intellectual property and giving proper credit for ideas is still lacking clear solutions. Contributions of the humanities to science issues and cooperation among the disciplines are very important for both the sciences and the humanities. Adequate funding for collaboration continues to be an area that must be stressed. He said that in particular, more focus should be given to providing scientists a broader view of science in society. The media has an important influence in science as it disseminates information quickly, but deadline culture and research culture are often at odds; journalists often find it difficult to sufficiently research background on a story in a short period of time, and scientists cannot always communicate their findings in a compelling fashion.

In the developing world, literacy is low, and dissemination methods are fewer. Tools such as radio are useful for spreading science information. Media and science are very different, and a bridge is needed to make experts available to journalists and training for scientists to communicate effectively to non-specialists. Improved science education is also important to ensure that correct and formal science education is compelling and pervasive.

Gavin Brown said that there was overwhelming optimism among participants for applications of ICT in business. Numerous advances have been made, such as remote collaborations, safety in the auto industry and crash prevention and mitigation. Today even remote farmers are often ICT enabled. The Internet especially has experienced many innovative advances, such as open source development, collaboration of technologies, and security mechanisms. He noted concerns such as dependence on the Internet and the massive impact of a failure, as well as the difficulty of organizing and retrieving universally accurate information.

Venture capital can make important contributions to nations' development, but we need to do more in financing emerging small businesses. Green innovation is especially important.

Lastly, he said that internationalization of an IP regime is a critical need. We need simple and consistent rules and an end to the current glut of patent filings. To improve IPR, he recommended more collaboration, grace periods and use-it-or-lose-it clauses. In short, institutions should behave more ethically.

10:45 – 11:45 PLENARY SESSION

302 "Role of Science and Technology in the 21st Century"

Chair:
Komiyama, Hiroshi, President, The University of Tokyo, JP

Speakers:

- **Bement Jr.**, Arden, Director, National Science Foundation (NSF), US
- **Hwang**, Chang-Gyu, President, Corporate CTO, Samsung Electronics Co. Ltd., KR
- **Markides**, Karin, President, Chalmers University of Technology, SE
- **Noyori**, Ryoji, President, RIKEN, JP (Nobel Laureate in Chemistry 2001)
- **Sibal**, Kapil, Minister of Science, Technology and Earth Sciences, IN
- **Thumann**, Jürgen, President, Federation of German Industries (BDI), DE

Hiroshi Komiyama, citing the learning from the first G8 University Summit held earlier this year, mentioned that it is no longer adequate for universities to generate and then feed knowledge into society; they need to play a more active role by acting as a driving engine for shaping society and by developing university campuses as a model for a sustainable society. In order to achieve their new roles, universities need to take the lead in establishing the "Network of Networks", connecting existing networks on a global scale.

Ryoji Noyori spoke about what needs to be done for future generations. Despite warnings as early as 1985 about the societal implications of the population explosion, no great improvements have been made. The promotion of economic growth has brought about deterioration in society. A flaw in the way quality in life is measured has brought about a focus on the materialistic, instead of the spiritual. This imbalance must be readdressed. A return to humanity is essential to battle the limitless greed of modern society.

Arden Bement Jr. said three vital national and international needs can benefit from scientific progress: energy, environment, and economy. The understanding of each of these individual systems has improved, but the inherent complexity of their interaction complicates efforts to build sound policies for the three in combination. Advances in information and communication tools are critical to improved analysis of complex coupled systems, which in turn will lead to advances in forecasting, better response strategies, and enhanced tools for science-informed decision making. These are grand challenges worthy of the global scientific enterprise.

Kapil Sibal said we are being threatened with formidable and unprecedented global challenges in health, food, energy, security and the environment. Science can provide solutions, but we need to better understand the innate value of nature and people living together in a global village. Cooperation between different sectors such as genomics, ICT, nanotechnology and synthetic biology can bring new hope. Solutions must be simple and affordable to be of practical benefit to the poor people of the world.

Jürgen Thumann explained that to tackle global challenges like climate change and meeting the needs of energy, food and water supply as well as education and healthcare, we need innovation and technology. The Federation of German Industry (BDI) has presented a strategy for future growth and employment. This BDI Manifesto supports the government's efforts to boost 17 different areas of technology and recommends among other things to create education markets and expand research markets. Thumann emphasized that the BDI is dedicated to promoting cooperation between science and industry on an international level and strongly advocates the development of a global roadmap. It is through international conferences like the STS *forum* that we can face the challenges of the 21st century together.

Chang-Gyu Hwang said that we should develop a more futuristic approach to scientific research by devising a mechanism for creating opportunities for future generations of scientists. Consumer and global products define the IT industry and as such future lifestyles should embrace three main concepts: customized entertainment, intelligent living and shared feelings. Companies cannot work alone and so in addition to support from academia and governments, they must have a global outlook that embraces different people, technologies and industries.

Karin Markides stated that developing countries could strengthen their own economies if they build technology now with help from clusters of universities, research institutes, the public sector, and industry. However, funding stakeholders are needed and action must be taken now as the gap between the "haves" and "have-nots" widens. If tests and pilot schemes, developed through an understanding of local needs, can be implemented in developing countries, then greener, safer, more robust and more efficient transport systems of the future can be created, improving the economic capacity of the developing world.

11:45– 12:30 CLOSING PLENARY SESSION

303 "Returning to Harmony with Nature – What Can We Do?"

Chair:
McKinnell, Henry, Chairman, Accordia Global Health Foundation, US

Speakers:
- **His Imperial Highness, The Crown Prince of Japan**
- **Friedman**, Jerome, Institute Professor and Professor of Physics Emeritus, Physics Department, Massachusetts Institute of Technology (MIT), US (Nobel Laureate in Physics 1990)
- **Omi**, Koji, Member, House of Representatives; Chairman and Founder, STS *forum*, JP
- **Schavan**, Annette, Federal Minister of Education and Research, DE
- **Swaminathan**, Monkombu, Chairman of the Board of Trustees, M. S. Swaminathan Research Foundation, IN

His Imperial Highness, The Crown Prince expressed his appreciation of the animated discussions that took place during the STS *forum*. While humankind has benefitted greatly from the remarkable developments in life science, communication technology and other fields, questions are raised as to whether development is in harmony with the laws of nature. Moreover, we should ask if the fruits of these innovations are equally shared. It is not easy to give clear-cut answers, but the cost of not seeking these answers is too high. Humankind should mobilize its utmost wisdom to ensure that science and technology can provide a bright future for planet Earth.

Henry McKinnell began by describing the beauty of Kyoto as a city built by skilled artisans, architects and designers hundreds of years ago. However, will the legacy of current generations be appreciated in the future? We may be the first generation to leave the world in a worse state than we found it in. Nonetheless, if we improve people's understanding of science, we can get the support necessary to redress this. He ended by asking how can we ensure that ten years from now we can look back at STS *forum* and say that it made change for the better.

Annette Schavan said that science derives its strength from the diversity of scientists and their approaches. We should work together closely in order to find viable scientific answers to the challenges of the 21st century. While industrial nations often use energy recklessly and live in excessive affluence, people in other parts of the world have neither access to energy nor a decent healthcare system. There is need for a continuous dialogue of the entire international communities and sustainable solutions. Our golden rule ought to be that our actions remain compatible with the permanence of human life.

Jerome Friedman warns that we must seal global pacts to reach our environmental goals and prevent the devastating consequences of global warming. It is forecasted that atmospheric levels of CO_2 could reach 550 ppm by mid-century. If this increase is allowed to continue, climatologists warn that we will cross a point of no return, resulting in reduced crop yields in many parts of the world; reduced supplies of drinking water; more severe storms; droughts and forest fires of increasing intensity; an increase of infectious diseases; lethal heat waves; coastal flooding and large scale species extinction. Industrialized nations, most responsible for the amount of greenhouse gases in the atmosphere, must bear the biggest responsibility for leadership. The world's nations must replace the Kyoto protocol in 2009, establishing long term goals as well as interim goals that would require prompt investment in reducing greenhouse gases.

Monkombu Swaminathan asked what we can do for the Earth at a local level. Sustainable development should become the new human ethic and to build a good common future, we need a better common present. Education is essential to this, but a 'nature deficit disorder' is hindering our progress. We need children to understand and experience their natural environment. Integrated use of technology is already aiding human life, but now we need integrated and sustainable use of nature and technology. As a final thought, he quoted Gandhi: "How can we be non-violent to nature, if we are violent to each other?"

Koji Omi said that the opinions and profound insights offered highlight the significance of holding the STS *forum*. We have agreed that rapid progress in energy efficiency and clean energy, nuclear power under strict safety and non-proliferation, international standards for privacy protection and the development of a new international framework to replace the Kyoto protocol are necessary. This forum has deepened our ties of friendship and expanded our human network. Developing countries and developed countries must utilize all their knowledge and resources. Joint activities should be encouraged in order to mobilize the human resources of developing countries. The STS *forum* is not a mere conference, but a movement of world leaders to ensure the future of mankind.

The Science and Technology in Society (STS) *forum*, inaugurated in November 2004, holds an annual meeting starting on the first Sunday of October every year, in Kyoto, Japan. The meeting is aimed at creating a global human network based on trust and providing a framework for open discussions regarding the further progress of science and technology for the benefit of humankind, while controlling ethical, safety and environmental issues resulting from their application: "The Lights and Shadows of Science and Technology." In seeking to ensure further progress in science and technology throughout the 21st century, it is necessary to keep possible risks under proper control based on shared values, and to establish a common base for promoting science and technology.

Because international efforts as well as concerted efforts between different areas to address these problems are essential, the forum gathers top leaders from different constituencies: policymakers, business executives, scientists and researchers, media - from all over the world.

HIH The Crown Prince of Japan Naruhito

Picture from STS forum

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As of October 09, 2008

STS *forum* Fifth Annual Meeting
Oct 5-7, 2008, Kyoto, Japan
Confirmed Participants

(**Last name**, first name, title in organization, organization, country)

Adachi, Toshio, Representative Director and Executive Vice President, Sharp Corporation, JP

Adly, Noha, Director, Bibliotheca Alexandrina, EG

Aizawa, Masuo, Executive Member, Cabinet Office, Government of Japan, JP

Akimoto, Hiroshi, Counsel of Intellectual Property, Japan Pharmaceutical Manufacturers Association (JPMA), JP

Alabastro, Estrella, Minister, Ministry of Science and Technology (DOST), PH

Albagdadi, Abdalgader, Minister, Ministry of Education, LY

Aldea, Alexandru, Vice President, National Authority for Scientific Research, Ministry of Education and Research, RO

Al-Soufi, Mohamed, President, Taiz University, YE

Amaya de López, Rosa Maria, Secretary, National Secretariat of Science and Technology of Guatemala (SENACYT), GT

Amorim, Joakim, Head of Operation, Swedish Foundation for Strategic Research, SE

Anzai, Yuichiro, President, Keio University, JP

Aoki, Kiyoshi, Chairman, Chief Executive Officer, Haruna Group, Haruna Beverage Corp., JP

Arata, Manuela, Technology Transfer Officer, National Research Council (CNR), IT

Arima, Akito, Chairman, Japan Science Foundation, JP

Arimoto, Tateo, Director-General, Research Institute of Science and Technology for Society, Japan Science and Technology Agency, JP

Armand, Jean-Louis, Science and Technology Counsellor, French Embassy in Japan, JP

Arrighi, William, Senior Vice President, Chubb & Son, US

Aymar, Robert, Director General, CERN (European Organization for Nuclear Research), CH

Badran, Ibrahim, Chairman, Egyptian National Committee of the World Health Organization (WHO), EG

Balasubramanian, Bharat, Vice President Group Research and Advanced Engineering, Daimler AG, DE

Barañao, Jose Lino, Minister, Ministry of Science, Technology and Productive Innovation, AR

Batterham, Robin, President, Australian Academy of Technological Sciences and Engineering (ATSE), AU

Beja, Fatos, Minister, Ministry of Education and Sciences, AL

Bement, Jr., Arden, Director, National Science Foundation (NSF), US

Bergman, Catherine, Book Author, CA

Bernard, Rob, Chief Environmental Strategist, Microsoft Corporation, JP

Bethke, Siegfried, Member of the Board of Directors, Max Planck Institute for Physics, DE

Bhumiratana, Sakarindr, President, National Science and Technology Development Agency (NSTDA), TH

Bibby, David, Pro Vice-Chancellor, Victoria University of Wellington, NZ

Birt, Michael, Director, National Bureau of Asian Research (NBR), US

Bishop, Robert, Founder and Chairman, BBWORLD Consulting Services Sarl, CH

Boright, John, Executive Director, National Academy of Sciences (NAS), US

Bououny, Lazhar, Minister, Ministry of Higher Education, Scientific Research and Technology, TN

Braga, Benedito, Director, Brazilian National Water Agency (ANA), BR

Brandstetter, Franz, Head, BASF Aktiengesellschaft, DE

Bréchignac, Catherine, President, French National Center for Scientific Research (CNRS), FR

Bregman, Mark, Executive Vice President and Chief Technical Officer, Symantec Corporation, US

Brennan, David, Chief Executive Officer, AstraZeneca Plc, UK

Brown, Gavin, Director, Royal Institution of Australia, AU

In alphabetical order of individual names
The indicated country code corresponds to the country where the Organization H.Q. is located and not the individual's nationality

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As of October 09, 2008

Buasai, Silaporn, Deputy Director, Thailand Research Fund (TRF), TH
Campbell, Donald, Senior Strategy Advisor, Davis LLP, CA
Carty, Arthur, Executive Director, University of Waterloo Institute for Nanotechnology, CA
Casanovas, Josep, Vice-Rector of University Policy, Polytechnic University of Cataluña (UPC), ES
Casselton, Lorna, Foreign Secretary and Vice President, The Royal Society of U.K., UK
Cebeci, Omer, Vice President, Scientific and Technical Research Council of Turkey (TÜBITAK), TR
Chaisang, Wutipong, Minister, Ministry of Science and Technology (MOST), TH
Chami, Ahmed, Minister, Ministry of Industry, Commerce and New Technologies, MA
Chand, Ganesh, Director, Fiji Institute of Technology (FIT), FJ
Chang, Morris, Chairman, Taiwan Semiconductor Manufacturing Co., Ltd., Chinese Taipei
Chapin, J. Thomas, Director for Research & Development, Underwriters Laboratories Incorporated, US
Cheng, Huiqiang, Dean, Institute of Recycling Economy, Beijing University of Technology, CN
Chi, Youngsuk, Vice Chairman, Elsevier, US
Chryssolouris, George, Director, University of Patras, GR
Chung, Ik Kyo, Professor, Pusan National University, KR
Chung, Yoon, President, Korea Foundation for the Advancement of Science and Creativity (KOFAC), KR
Cohen, Jay, Under Secretary for Science and Technology, U.S. Department of Homeland Security, US
Coloe, Peter, Pro Vice-Chancellor, Royal Melbourne Institute of Technology (RMIT) University, AU
Colwell, Rita, Distinguished University Professor, University of Maryland and Johns Hopkins University, US
Conde, Jorge, President and Chief Executive Officer, Knome, Inc., US
Conzelmann, Claus, Vice President, Nestlé S.A., CH
Cope, David, Director, United Kingdom Parliament, UK
Córdova, France, President, Purdue University, US
Cox, Stephen, Executive Secretary, The Royal Society of U.K., UK
Cui, Jian, Vice President, Baoshan Iron & Steel Co., Ltd., CN
Da Silva, Wilson, Editor-in-Chief, *Cosmos Magazine*, AU
Dai, Tiejun, Vice Director, Institute of Recycling Economy, Beijing University of Technology, CN
Datta, Asis, Director, National Institute for Plant Genome Research (NIPGR) New Delhi, IN
De Goes, Paulo, Head of the Office of International Affairs, Brazilian Academy of Sciences, BR
De Mendoza, Diego, Director, Institute of Molecular and Cell Biology of Rosario, AR
Debreuille, Marie-Françoise, Vice President, Research and Innovation, AREVA Group, FR
Degett, Jens, Executive Director, European Action on Global Life Sciences (EAGLES), ES
Dell'Ambrogio, Mauro, State Secretary for Education and Research, State Secretariat for Education and Research (SER), CH
Desmarescaux, Philippe, Chairman, Scientific Foundation of Lyon, FR
Diderichsen, Børge, Vice President, Novo Nordisk A/S, DK
Ding, Lei, President, Shanghai General Motors Corporation Limited, CN
Doi, Norihisa, Professor, Department of Information and System Engineering, Chuo University, JP
Duhart, Jean Jacques, Under-Secretary of Economy, Development and Reconstruction, Ministry of Economy, CL
Durant, Graham, Director, Questacon - National Science and Technology Center, AU
Durongkaveroj, Pichet, Executive Director, Knowledge Network Institute of Thailand, TH
Dutkiewicz, Rafał, Mayor, City of Wrocław, PL
Eastham, Tony, Acting Vice President for Research and Development, Hong Kong University of Science and Technology (HKUST), HK
Eichler, Ralph, President, Swiss Federal Institute of Technology (ETH) Zurich, CH
El Nazer, Hany, President, National Research Center (NRC), EG
El Sherbini, Ahmed, Director, National Telecommunications Institute, EG
Elahi, Yed, President, Bangladesh Employers' Federation (BEF), BD
El-Beltagy, Adel, Chair, Global Forum on Agricultural Research (GFAR), EG

In alphabetical order of individual names
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Watters, Jack, Vice President, External Medical Affairs, Pfizer Inc, US
Whisstock, James, Professor, Monash University, AU
Wince-Smith, Deborah, President, Council on Competitiveness, US
Winnacker, Ernst-Ludwig, Secretary-General, European Research Council (ERC), BE
Winter, Alan, President, Genome British Columbia, CA
Wintermantel, Margret, President, German Rectors' Conference, DE
Wong, Peter, Chairman, MK Corporation Ltd., HK
Wu, Jyh-Yang, President, National Chung Cheng University (CCU), Chinese Taipei
Wu, Kenneth, President, National Health Research Institutes, Chinese Taipei
Xerri, Christophe, Managing Director, Marketing & Industrial Strategy, Areva Japan Co., Limited, JP
Xu, Meihua, Secretary-General, Science and Technology Commission of Shanghai Municipality, CN
Yaari, Menahem, President, Israel Academy of Sciences and Humanities, IL
Yakushiji, Taizo, Executive Member, Cabinet Office, Government of Japan, JP
Yamada, Eiichi, Project Manager, Toyota Motor Corporation, JP
Yamada, Keiji, Governor, Kyoto Prefectural Government, JP
Yamada, Tadataka, President, Bill & Melinda Gates Foundation, US
Yasui, Itaru, Vice Rector Emeritus, United Nations University, JP
Yeh, Gong Ping, Senior Physicist, Fermi National Accelerator Laboratory, US
Yeo, Philip, Senior Science and Technology Advisor, Ministry of Trade and Industry, SG
Yoshida, Tamio, Director, Shimadzu Corporation, JP
Yoshikawa, Hiroyuki, President, National Institute of Advanced Industrial Science and Technology (AIST), JP
Yu, Geoffrey, Senior Specialist Advisor to the Ministry of Law, Ministry of Foreign Affairs and Ministry of Law, SG
Yusof, Fadilah, Deputy Minister, Ministry of Science, Technology and Innovation, Malaysia, MY
Zatz, Mayana, Dean of Research, University of Sao Paulo (USP), BR
Zehnder, Alexander, Former President of the ETH Board, Swiss Federal Institute of Technology (ETH); Scientific Director, Alberta Water Research Institute, CH

In alphabetical order of individual names
The indicated country code corresponds to the country where the Organization H.Q. is located and not the individual's nationality

STS *forum* – Science and Technology in Society *forum*

As of October 09, 2008

Zhang, Jie, President, Shanghai Jiao Tong University, CN

Zhu, Jianwei, Director, International Academic Exchange Section, Anshan Iron and Steel Group Corporation, CN

(461 participants from 80 countries and regions and from 8 International Organizations)

In alphabetical order of individual names
The indicated country code corresponds to the country where the Organization H.Q. is located and not the individual's nationality

Picture from STS forum

Picture from STS forum

Final Version

10/07/2008

Science and Technology in Society *forum*
5th Annual Meeting
October 7, 2008 (Embargo until 12:30)
Kyoto, Japan

STATEMENT

1. The 5th Annual Meeting of the Science and Technology in Society *forum* was held from October 5 to 7. Over 750 leading scientists, policymakers, business executives and media leaders gathered from 91 countries, regions and international organizations. This year's STS *forum* discussed science and technology under the main theme "Harmony with Nature." We agreed upon the following.

2. Harmony with nature is the most important challenge for humankind. We have been discussing global environmental problems every year at the STS *forum* and stressed the need to establish a new international post-Kyoto framework in which all countries, including the United States, China and India, will participate. We welcomed the G8 leaders' shared view of seeking to adopt a global target for reducing emissions of greenhouse gases. The time has come to enact an action plan to solve this problem.

3. Given the growing global demand for energy, rapid progress in energy efficiency, conservation and clean alternative energy development are indispensable. Among these, we agreed that nuclear power is crucially important. We recognized that we should increase the implementation of fission power, under strict conditions of nuclear safeguards, safety and security. The development of nuclear fusion power is also essential for the future.

4. Biofuels have been developed as alternatives to fossil fuels, but we should recognize their potentially adverse effects on global food and environmental problems. Therefore, research and development in technologies for non-subsidized second-generation biofuels from non-food sources should be promoted.

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5. Given the growing number of the hungry and the unstable food supply, we believe expansion of food production is an urgent priority, particularly in the developing world. Therefore, both GMO and non-GMO research should be promoted by paying attention to safety while continuing to make efforts to gain public acceptance.

6. In line with the significant progress made in genome research, we agreed that personalized medicine should be emphasized and international standards for privacy protection are needed. We also expect that the rate of advancement in preventive medicine will be accelerated.

7. We reached consensus that ICT should be used extensively to enable solutions to problems of the global environment, education and health, and to contribute to business innovation. The digital divide must be addressed. We should also pursue enhanced efficiency in ICT applications while ensuring that public concerns over the security, privacy and use of personal data are met.

8. Keeping in mind that the intellectual property (IP) system is essential for innovation, we should pursue a comprehensive strategic approach for the establishment of a worldwide pro-innovation IP infrastructure to drive the advancement of science and technology for global socio-economic development.

9. It is important to encourage joint research in developing countries with the participation of researchers and scientists from developed countries. We recommend collaboration with developed nations, in addition to using Official Development Assistance (ODA), for joint research to mobilize and empower the human potential of developing countries. In this regard, we welcome the adoption of a new initiative of science and technology diplomacy by the Japanese government.

10. In addition to meetings of science and technology ministers and university presidents, the program included for the first time this year a meeting of academy presidents and a session of young scientists and engineers. We believe that the STS *forum* has been evolving and is becoming more influential in decision-making for the future of humankind.

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11. Realizing that the development of science and technology now has an important impact on society, we concluded that there should be more direct dialogue between political leaders and scientists, and that scientists should be involved in policy formulation. As part of this process, policymakers should bring the needs of society to the attention of scientists and properly reflect accumulated scientific knowledge in their policies. Scientists should actively propose policy recommendations based on their scientific knowledge. The general public needs to understand and support science and technology, and the media will have an increasingly important role to play in this exchange.

12. We consider the *forum* to be an important venue for learning about and discussing the latest developments in science and technology, and how they affect human society. Recognizing that both the lights and the shadows of science and technology have a great impact on humankind, and that we share a common destiny on Earth, it is important for people of all backgrounds, regardless of race, nationality or gender, to consider these issues as their own. We agreed that we should try our utmost to accumulate knowledge and understanding, and use them wisely, in order to survive and prosper.

13. We agreed to hold the 6th Annual Meeting of the STS *forum* in Kyoto from October 4 to 6, 2009. We look forward to meeting here again to contribute to building a better future for humankind in harmony with nature.

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