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PANEL SESSION: SOUTHEAST EUROPE AND REGIONAL ELECTRICITY MARKET---CONFIGURING THE POWER SYSTEM[#]

IEEE 2003 General Power Meeting, Sheraton Centre Toronto Hotel, Toronto, Canada, Thursday, July 17, 2003, Sheraton/Conference Room B, 9:00 a.m.

EXTENDED FULL LENGTH PAPERS

Chair: Tom Hammons, Chair, International Practices for Energy Development and Power Generation, University of Glasgow, Scotland, UK; E-mail: T.Hammons@ieee.org with Peter Donalek, Montgomery Harza (MWH) Global, Chicago, USA, E-mail: peter.j.donalec@us.mwhglobal.com

INTRODUCTION

The Panel Session discussed Southeast Europe and Regional Electricity Market---Configuring the Power System.

Panelists focused on several of the more significant aspects of recent regional power system developments in Southeast Europe. The countries in the Region are in the process of reconstructing portions of several national systems, upgrading (to improve system and market performances), creating a regional tele-information network among national dispatch centers, developing transmission interconnections, and planning for regional power sales. The developments in Southeast Europe are taking place within the context of unbundling national power systems, standardizing system-operating capabilities, preparing technical and commercial grid codes, evaluating a possible regional electricity market, and configuring for ultimate operation as part of the European Union. International specialists from the region discussed developments that are taking place.

Principal contributors included:

1. T. Cerepnalkovski, Electric Power Company of Macedonia: Southeast European Power Systems Aspects Overview
2. S. Mijailović, Electricity Coordinating Center, Yugoslavia: Review of Electricity Supply and Demand in South East Europe
3. D. Bajs, Energy Institute—Croatia: South-East Europe Transmission System Planning Project
4. S. Virmani, Electrotek Concepts, USA: Tele-Information System in South East Europe to Enhance Coordinated Operation and Support the Regional Market
5. P. Donalek, Montgomery Watson Harza, USA: Role and Value of Hydro and Pumped Storage Generation in a Proposed Regional Electricity Market in Southeast Europe
6. V. Koritarov and T. Veselka, Argonne National Laboratory, USA: Modeling the Regional Electricity

[#] This document has been prepared and edited by Tom Hammons, Chair of International Practices for Energy Development and Power Generation, University of Glasgow, 11C Winton Drive, Glasgow G12 0PZ, UK.

Network in Southeast Europe,

7. B. Pavlov, Natsionaina Elektricheska Kompania EAD, Bulgaria: The Electric Power System of Bulgaria: On its Way to UCTE
8. J. Constantinescu, Transelectrica, Romania: Romanian Electricity Sector Reform, Market Opening and Challenges.

Each Panelist spoke for approximately 20 minutes. Each presentation was discussed immediately following the respective presentation. There was a further opportunity for discussion of the presentations following the final presentation.

The Panel Session was organized by Tom Hammons, Chair of International Practices for Energy Development and Power Generation, University of Glasgow, UK; and Peter Donalek, Montgomery Watson Harza, USA

It was moderated by Tom Hammons and Peter Donalek..

The first presentation was entitled: Southeast European Power Systems Aspects Overview. It was given by Trajce Cerepnalkovski, Assistant General Manager, and Head of the Development and Investment Department and SECI Projects Coordinator, Electric Power Company of Macedonia.

The European Commission project "Balkan Energy Interconnection Task Force" was established in 1997. It was aimed at making an inventory of potential energy interconnection projects in Southeastern Europe (SEE) (Balkans). This Task Force produced a Report that is one of the background documents for further work on new interconnections development and different related initiatives under the Southeast Europe Cooperation Initiative (SECI).

In the framework of the overall Southeast Europe Cooperation Initiative, the SECI Project Group for improving cooperation of Power Systems in the region was established in 1998. This initiative performed very good activities and developed a high level of cooperation. Joint work on projects of common interest to Power Systems in the region was initiated. These projects were summarized by Trajce Cerepnalkovski. They were elaborated in the seven subsequent presentations.

Trajce Cerepnalkovski graduated in Electrical Engineering at the University of Skopje, Macedonia. He has been affiliated with the Macedonian Power Company (ESM) for 23 years, as Transmission Planner, IT Manager, and as Development and Investment Director. Currently, he is Assistant General Manager and Head of the Development and Investment Department and SECI Projects Coordinator.

The second presentation was a Review of Electricity Supply and Demand in South East Europe. It was made by Snežana Mijailović, Electricity Coordinating Center, Belgrade, Yugoslavia

After the political situation in South-East Europe calmed down, better cooperation between countries in the region was initiated. The power sector is extremely important for the development of every country in the Region. Also, numerous organizational and structural changes impact on bulk power systems all over the world. According to new issues, there is a need for better cooperation in electrical power matters and in the interconnection between countries in the region. This presentation presented electricity supply and demand in South East European countries in the past ten years. In order to understand problems concerned with necessary future investments and operational requirements, focus was given on regional balance for the year 2001.

Snežana Mijailović graduated in 1990 in Electrical Engineering at the University of Belgrade, Yugoslavia. She worked first at the Nikola Tesla Institute in Belgrade. Starting from 1997, she has been employed in the Electricity Coordinating Center, first as Head of the Study and Consulting Department, and from 2002 as Deputy General Manager

The third presentation discussed the South-East Europe Transmission System Planning Project. Davor Bajs, Energy Institute “Hrvoje Pozar”, Zagreb, Croatia made it.

After the political situation in the region calmed down, better cooperation conditions were initiated between countries in the region. The power sector is extremely important for development of every single country. Also, numerous organizational and structural changes make impact on bulk power systems all over the world. According to new issues, there is a need to make better cooperation and interconnection between countries in the region. The Regional Transmission System Planning Project was launched by USAID. This presentation discussed some of the activities that are being performed within this project.

Davor Bajs graduated in Electrical Engineering at the University of Zagreb, Croatia in 1994. He received his M.Sc. degree in 2000 from the same Faculty. His area of interest is Transmission Network Planning and Analysis. He has been with the Energy Institute ‘Hrvoje Pozar’ since 1995.

The fourth presentation was on a tele-information system in South East Europe (SEE) to enhance coordinated operation and to support the regional electricity market. Sudhir Virmani, Christopher O’Reilly, and Savu Savulescu of Electrotec Concepts, Cupertino, California, USA prepared it. Sudhir Virmani made the presentation.

In early 2000, the United States Agency for International Development initiated a project under the SECI umbrella to develop an architecture and basic design for a tele-information system that would enable all the National Dispatch Centers in the region to exchange data with each other. This was followed by a second project begun in late 2001 to look at specific communication links needed to complete the network as well as to address the related issue of regional telecommunication network management. This was completed early in 2003. This presentation addressed the requirements and architecture of the system. The tele-information system proposed will play a crucial role in the reconnection of the UCTE and in development of the regional electricity market. It is planned to have it fully implemented by 2005. New transmission network interconnectors will be equipped with fiber optic ground wires thereby making the cross-border communication easier. This was also discussed.

Sudhir Virmani obtained his B.Tech. (Hons.) degree from the Indian Institute of Technology, Kharagpur, India and his M.S. and Ph.D. degrees from the University of Wisconsin at Madison WI, USA, all in Electrical Engineering. He has worked at American Electric Power and System Control Inc. and, as a co-founder, at Stagg Systems and EPIC Engineering. Currently, he is General Manager, Power System Planning and Operation at Electrotek Concepts Inc.

Savu C. Savulescu is with Electrotek Concepts Inc., USA He graduated from the Polytechnic Institute of Bucharest, Romania and received the *Docteur en Sciences Appliquées* (Ph.D.) degree from the Polytechnic School of Mons, Belgium. Prior to this, he worked at Kema Consulting and Stagg Systems. He was a Professor at Pratt Institute, New York and the University of Sao Paulo, Brazil.

Christopher O’Reilley obtained his B.E.E from Villanova University, Villanova, PA. and his M.Eng degree in Engineering Science from Pennsylvania State University in 1992. He has worked at GE Aerospace (now Lockheed Martin). Currently, he is a Senior Telecommunications Engineer at Electrotek Concepts Inc.

The fifth presentation was given by Peter Donalek, Montgomery Watson Harza, Chicago, USA. It was entitled: Role and Value of Hydro and Pumped Storage Generation in a Proposed Regional Electricity Market in Southeast Europe.

Hydro generation and Pumped Storage Hydro can play a unique role in the operation of modern power systems. As part of the introduction of a regional electricity market for the Balkans region, a study was made to identify the role of hydro and pumped storage in a market based regional electricity market. The study included an analysis of the hydrologic conditions in individual countries as well as for the region. The results of the hydrologic analysis determined that the region could be simulated for three hydrologic conditions; wet, normal and dry. A power system simulation was made for year 2005 and the results were used to quantify the value of hydro. The results of the analysis were summarized.

Peter Donalek gained a BSEE degree from the University of Illinois in 1961, a Master of Science degree in Electrical Engineering from Moore School, University of Pennsylvania in 1970, and a Masters Degree in Mathematics from the University of Toledo in 1973. Donalek has been a Power System Engineer and a Project Manager on operational and transmission expansion planning studies of national and regional power systems in: South Korea, Central America, South Asia, Africa, Central Asia, and Southeast Europe. .He has carried out power system studies in over 20 countries. He was principal investigator for the EPRI study TR-105542, *Application of Adjustable-Speed Machines in Conventional and Pumped-Storage Hydro Projects*, 1995

The Sixth presentation was entitled: Modeling the Regional Electricity Network in Southeast Europe. Vladimir Koritarov and T. Veselka, Argonne National Laboratory, Argonne, IL, USA presented it.

The objective of the analysis was to investigate potential benefits of a regional electricity market in Southeast Europe in 2005. The study modeled the operation of electric power systems of seven countries. Four typical weeks in different seasons of 2005 were simulated. To capture the variability of hydro inflows and their influence on hydro generation, the analysis was performed for three hydrological conditions: wet, average, and dry. In analysis of the regional electricity market scenario, hourly values of location marginal prices for all nodes of the regional network were calculated and used to optimize power transactions among the utility systems. The presenter showed that a comparison of operating costs obtained for the two scenarios indicated that a regional electricity market provides significant benefits and cost savings compared to the operation of individual utility systems. He explained how substantial savings in costs are achieved in all analyzed periods and under all hydrological conditions.

Vladimir S. Koritarov graduated from the School of Electrical Engineering, University of Belgrade, Yugoslavia. In 1991 he joined Argonne National Laboratory, U.S.A., where he is presently an Energy Systems Engineer in the Center for Energy, Environmental & Economic Systems Analysis. He specializes in the analysis of power system development options, modeling of hydroelectric and irrigation systems, hydrothermal coordination, reliability and production cost analysis, marginal cost calculation, risk analysis, and electric sector deregulation and privatization issues.

Thomas D. Veselka is an Energy Systems Engineer in the National and International Studies Section at Argonne National Laboratory. He builds optimization and simulation tools and is currently a member of a multi-disciplinary team that is writing an agent-based modeling system that simulates the complex adaptive behavior of participants in a deregulated electricity market.

The penultimate presentation was entitled: The Electric Power System of Bulgaria: On its Way to UCTE. It was presented by Bozhidar Pavlov, Head of the Transmission Planning Department, National Dispatching Center, Sofia, Bulgaria.

The Bulgarian Electrical Power System was interconnected to the Second UCTE Synchronous Zone in 1996. Parallel operation significantly improved performance of the whole interconnection, resulting in higher quality of frequency control, a higher stability and reliability level, and increase of the network transmission capacity. The National Electric Company expressed its intention for joining the UCTE. A program for Bulgarian Electrical Power System modernization was initiated to satisfy UCTE recommendations and requirements.

This presentation summarized the basic data for the Bulgarian Power System at the end of 2002, the important steps to be taken in the process of interconnection to UCTE, investment projects, power system on-line control, primary control reserve, measures against swings and low-frequency oscillations, tests and results, and energy accounting.

Bozhidar Pavlov has a M.Sc. degree in Electrical Engineering from Sofia Technical University, Bulgaria. Since graduation, he has been with the Bulgarian National Electric Company. He became a Transmission Planning Engineer and currently is Head of Transmission Planning and System Analysis. His international activities include Member of the UCTE Operation and Security WG, and Acting Secretary of the Technical Committee UCTE/Romania-Bulgaria.

The final presentation was on Romanian Electricity Sector Reform, Market Opening and Challenges**.** Jean Constantinescu, Director General, Transelectrica, Romania prepared it. Mrs. Rodica Balaurescu, Project Director, presented it.

Transformation of the Romanian Power Sector from a monopoly of a vertical integrated structure to a competitive electric market has progressed gradually since August 2000. A relative long transition has occurred considering the initial structure of the sector, the lack of market experience, the impact of these deep changes on the market participants, and the economy.

In July 1998, the first step in implementation of the power sector reform program was initiated. Further to this CONEL was set up, a joint stock company including three legal subsidiaries: Termelectrica, Hidro-Electrica (generators), and Electrica (distributor and supplier). Nuclear-Electrica was also set up as a separate generating company. Setting up of this joint stock company was summarized.

The process was further developed in the second half of 2002. Eight legal supply and distribution subsidiaries were established within Electrica, while Termo-electrica was divided into six legal subsidiaries. Meanwhile, a number of forty independent electric private suppliers have emerged.

At present, the privatization of generating and supply/distribution companies is under final preparation. Trans-Electrica will remain wholly state-owned, at least within the mid run.

Jean Constantine reviewed the regulatory framework, generation, transmission and system operation, distribution, and electric market structure. He demonstrated that power sector unbundling and market tools improve efficiency and reliability of electricity service, even in the early stages.

Jean Constantinescu has been Director General of the National Power Grid Company since August 2000. Before that he was President of the Romanian Electricity and Heat Regulatory Authority (ANRE). He joined the Romanian Electricity Authority (RENEL) in May 1997, as Coordinator of the Strategy and Reform Committee. He was also Director General and Director of the R & D Center with the Energy Research and Modernizing Institute (ICEMENERG) and head of the Power System Department with the National Power Control Operational Unit.

Dr. Constantinescu is a member of the EURELECTRIC Board of Directors and Chairman of the EURELECTRIC Romanian National Committee.

The 8 presentations are summarized below:

1. SOUTHEAST EUROPEAN POWER SYSTEMS ASPECTS OVERVIEW

Trajce Cerepnalkovski, Electric Power Company of Macedonia, Skopje, Republic of Macedonia

1. Introduction

South East Europe (SEE) or Balkans region includes: Albania, Bosnia & Herzegovina, Bulgaria, Croatia, Greece, Republic of Macedonia, Romania, Turkey, Yugoslavia (Serbia and Monte Negro) and in some projects includes Slovenia and Hungary as well. The region parameters: population more than 130 millions; GDP ranging from \$1000 up to the \$12.000; total electricity consumption approximately 326 TWh (all data for 2001).

During the last 12 years most of the region faced dramatic changes and different political and economic challenges. Transition from the previous political and economical systems for many of the countries in the region was followed with war activities that, unfortunately, lasted several years. Today there is a new political and economic picture in the region. This transition has affected power systems in the region as well. But, generally, power systems in the region in the very turbulent period proved their robustness and ability, apart from the big problems that jeopardized them, of providing a secure supply of electricity to the customers. All SEE counties declared their clear intention for integration with the European Union. Power Systems. Not yet members of the UCTE (European Interconnected Power System), intend to become a member of UCTE.

2. Power Systems Status and Interconnections

Power Systems of the SEE countries have a different status concerning UCTE membership: most of them are members of the UCTE (Slovenia, Croatia, B&H, Federal Republic of Yugoslavia, Republic of Macedonia and Greece); Bulgaria and Romania are in the final stages of the long process for full UCTE membership, and they are undertaking a large effort and technical and investment activities to satisfy UCTE operational rules. Turkey has submitted an application and UCTE opened the procedure for evaluating the possibility for synchronous interconnection of Turkey to UCTE. Hungary, through the independent process performed in the CENTREL (Poland, Czech Republic, Slovakia and Hungary) has become a full member of UCTE.

As a result of the war activities in ex-Yugoslavia, very important elements of the high voltage network of the region were damaged and have been out of operation for many years. The damaged facilities are: Mostar (B&H) Substation 400 kV with connected lines that caused the interruption of the Adriatic line; and Ernestinovo (Croatia) Substation 400 kV with connected lines that caused interruption of the North ex-Yugoslavian power corridor. As a result, the southeast UCTE wing was separated from the main European interconnected grid since 1991. The reconnection of the SEE UCTE wing, so called 2nd UCTE synchronous zone, is expected to occur at the end of 2003 or beginning of 2004. In the mean time, UCTE members from the southeast electrical island (Greece, Macedonia, Serbia, Monte Negro and part of B&H) were interconnected and operate in parallel synchronous operation mode. Albania was interconnected to this block even though it is not a member of UCTE. As the Power Systems of Romania and Bulgaria expressed their interest to becoming members and to adapt their power systems according the UCTE criteria, first Romania in 1994 and later Bulgaria in 1996 joined the synchronous interconnection of the 2nd UCTE zone. At the moment there are two interconnection lines between Bulgaria and Turkey and they are being used for exchange of power, in an island mode operation only. The new 400 kV interconnection line between Greece and Turkey is under preparation for construction and it will strengthen the interface between the huge Turkish Power System and Balkans.

3. Related Initiatives in the Region

The European Commission (EC) project “Balkan Energy Interconnection Task Force” was established in 1997, aimed at making an inventory of potential energy interconnection projects in the SEE (Balkan) and to try to make a first prioritization effort. This document is one of the background documents for further work on new interconnections development and different related initiatives, SECI included.

The Stability Pact Program for the SEE region was established to develop coordinated policy for regional development and many power infrastructure studies and potential investments were identified and funds pledged.

Figure 1. Southeast Europe Cooperation Initiative 400 kV Interconnections in 2005

In the framework of the overall Southeast Europe Cooperation Initiative (SECI) the SECI Project Group for improving cooperation of Power Systems in the region was established in 1998. This initiative performed very good activities and developed a high level of cooperation and joint work on the projects of common interest to Power Systems in the region. The activities were focused on some technical aspects and needs to support to some extent regional electricity market development and investment priorities in the Stability pact process. The particular projects for regional telecommunication system and data exchange between NDC's (future TSO's) regional transmission planning and identification of the role of Hydro Power in the future regional electricity market environment are projects that are still the focus of interest. These projects will be elaborated in separate papers.

Southeast Europe Cooperation Initiative 400 kV Interconnections planned for 2005 is indicated in Figure 1.

4. *Regional Electricity Market (REM)*

The Study for a Regional Electricity Market (REM) was initiated in 1999, under EC sponsorship. Based on this Study, two Memorandums were signed by Energy Ministers in the region for REM development.

In year 2002, the European Commission established a new very ambitious process for SEE REM development and preparation for integration to the EU internal electricity market. The process is based on the experience of development of the EU internal electricity market, strong commitments of most of the countries in the region for intention to join the EU and to implement EU Electricity Directive 92/96, and proposal for new amendments on the 92/96 Directive. The new proposal was confirmed with a MoU signed by relevant ministers from the countries in SEE and EC (15 November 2002). The new proposal has strong commitments for opening the electricity market in the region for all non-residential customers up to 2005. That is a very big challenge for the region that is undergoing different degrees of structural and functional change in a political and economical environment. On the other side in many parts of the region the electric power sector is undergoing restructuring, unbundling and privatization while others still remain vertically integrated.

The new committed REM process required: hard work on reform implementation in all counties, even though part of them are in the advanced process; higher level of cooperation for implementation of regional functions and harmonization of the approach in the internal market solutions; implementing unbundling; implementing independent TSO's; and necessary legal framework and coordination of the implementation programs. Southeast European Electricity Regulatory Forum was established on six month bases, and Ministerial meetings on yearly bases to direct and confirm the process. The TSO's and regional regulators association, observed by the European ones, will develop the proposals for the Forum. And the very important task of reconnection of the 2nd UCTE zone to the main network, new interconnection of Turkey to UCTE, integration to UCTE Electronic Highway development and operational issues dedicated naturally to UCTE and SUDEL as sub regional UCTE organization.

To achieve the goals, apart from the very big effort required from countries, the region has received commitment for strong support from the EU, International Donor Community, and the IFI's to solve a lot of current gaps and problems and to ensure development toward EU internal electricity market integration and SEE REM.

5. Biograhy

Trajce Cerepnalkovski, born in 1953, graduated at University of Skopje, Republic of Macedonia, Faculty of Electrical Engineering. Affiliated with Macedonian Power Company (ESM) for 23 years, as Transmission planner, IT manager, Development and Investment Director. Current position with ESM is Assistant General Manager and Head of the Development and Investment Department and SECI Projects Coordinator. E-Mail: *trajce@esmak.com.mk*

2. REVIEW OF ELECTRICITY SUPPLY AND DEMAND IN SOUTH EAST EUROPE

Snežana Mijailović, Electricity Coordinating Center, Belgrade, Yugoslavia

Abstract-- After political situation in South-East Europe calmed down, better cooperation conditions are initiated between countries in the region. Power sector is extremely important for development of every single country. Also, numerous organizational and structural changes make impact to bulk power systems all over the world. According to new issues, there is a need to make a better cooperation and interconnection between countries in the region. This paper presents the electricity supply and demand in past ten years in South-East European countries. In order to understand problems concerning necessary future investments and operational constrains focus is given on regional balance for the year 2001.

Index Terms-- Power transmission planning, bulk power systems, electricity supply, electricity demand.

1. Introduction

This main objective of this paper is to present the development of electricity consumption, production, as well as electricity balance over the next ten years in South East European countries and also identify opportunities and the main barriers for expanding trade in the region.

The South Eastern European (SEE) countries, (very often called "Balkan"), that once encompassed the former Yugoslavia [Bosnia and Herzegovina, Croatia, The Former Yugoslav Republic of Macedonia (FYROM), Slovenia, and the current Federal Republic of Yugoslavia (Serbia and Montenegro)], as well as Albania, Bulgaria and Romania, are in the focus (except Slovenia). Bosnia and Herzegovina consists of two autonomous entities: the Federation of Bosnia and Herzegovina (FBiH) and the Republika Srpska (RS). Hereinafter, the Former Yugoslav Republic of Macedonia (FYROM) will be referred to as simply "Macedonia".

The electricity supply influence and demand status in Greece and Turkey are important from regional point of view. For this reason, the present status in these two countries is taken into account.

Present development and economy status of SEE region countries is quite different. Prior to its dissolution, former Yugoslavia had an energy infrastructure and general level of economic development comparable to that of other east-block states such as former Czechoslovakia and Hungary, but there was considerable diversity within the former Yugoslavia, with Slovenia being the most advanced and the Kosovo, as part of Serbia, being the least developed. With the exception of Slovenia, the warfare and political instability that has occurred since 1991 has damaged the economic, and specifically, the energy infrastructures of all the constituent republics of former Yugoslavia.

Albania, prior to the demise of its isolationist communist regime in 1991, was far less developed economically than any part of former Yugoslavia, and was the poorest country in Europe. Since that time, the Albanian economy has been facing the progress, but it is still among the least developed countries in Europe.

In the past, Romania and Bulgaria were part of the so called East block but at present, they prepare themselves to join the European Union (EU) in the future.

The total population of former Yugoslavia plus Albania is approximately 26.2 million, slightly less than the total population of Bulgaria and Romania. Total population of the whole investigated region is about 55.7 million, similar to Ukraine or a little smaller then France.

Many differences exist among national power systems of the region in terms of size, production and load composition, and level of investment. As a result of different economic conditions, there are different levels of projects relating development of the power systems in each country.

The former Yugoslavia had a single electricity grid and was a member of the Union for the Coordination of the Transmission of Electricity (UCTE) network, i.e., it was part of the Western European power grid. Destruction of the transmission network in BiH and Croatia resulted in only Croatia, Slovenia and part of BiH being connected to the UCTE. Electric power systems of Yugoslavia, Macedonia, part of BiH (Republika Srpska), Albania and Greece built, the so-called, Second UCTE zone. Electric power systems of Romania and Bulgaria joined this interconnection in 1994 and 1996, respectively.

At present, the power systems of Albania, Romania, Bulgaria, former Yugoslav Republic of Macedonia, Greece, Republic Srpska (part of Bosnia and Herzegovina) and Federal Republic of Yugoslavia operate synchronously, in full accordance with the UCTE rules. Reconnection of this part of the UCTE network to the main UCTE interconnection is expected by the end of 2003 or beginning of 2004. From February 1st 2002 till January 31st 2003, electric power systems of Romania and Bulgaria are in one-year interconnection test with other UCTE members from SEE countries in order to achieve membership in UCTE.

The electricity sector development in SEE countries is based mostly on autonomous expansion plans for each country. These plans neither take advantage of, nor consider the collaboration opportunities that exist in the region, with the exception of periodic and on the spot power exchanges. After introducing electric power companies of Romania and Bulgaria into UCTE interconnection, and reconnection of the SEE countries grid to the European transmission grid and extension of the electricity market from the European Union to other countries in Europe, prerequisites for Balkan regional coordination and cooperation will be fulfilled.

In June 2001, energy ministers from Albania, Bosnia and Herzegovina, Bulgaria, Greece, Macedonia, and Romania, and in 2002 energy ministers of Croatia and Yugoslavia, signed a memorandum regarding creation of a competitive energy market in the Balkans. The Regional Association of Energy Regulators (ERRA) was established in December 2000 in order to create a common power market in South Eastern Europe and in former Soviet Union. The co-establishing countries of ERRA are Albania, Armenia, Bulgaria, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Poland, Romania, Russia and Ukraine. Some of SEE countries are members of the Black Sea Regional Energy Center (BSREC), an organization for cooperation within the energy field, comprising Albania, Armenia, Azerbaijan, Bulgaria, Georgia, Greece, Moldova, Romania, Russia, Macedonia, Turkey and Ukraine. Programs concern promotion of energy policy development, energy supply diversification and energy interconnections development.

In June 2002, the first South East European Electricity Forum was organized in Greece. The task of the forum was to improve collaboration between SEE countries in electricity sector and prepare them for establishing SEE electricity market. Also, establishment of competitive SEE regional market conditions in the electric power sector can be the missing ingredient for effective support to the economic development of the region. Final organization of regional electricity market is expected during the year 2005.

The reconnection of the UCTE members in the Balkans and network extension towards Bulgaria and Romania will provide new opportunities for better utilization of existing interconnections and will improve feasibility of common interest transmission interconnection projects.

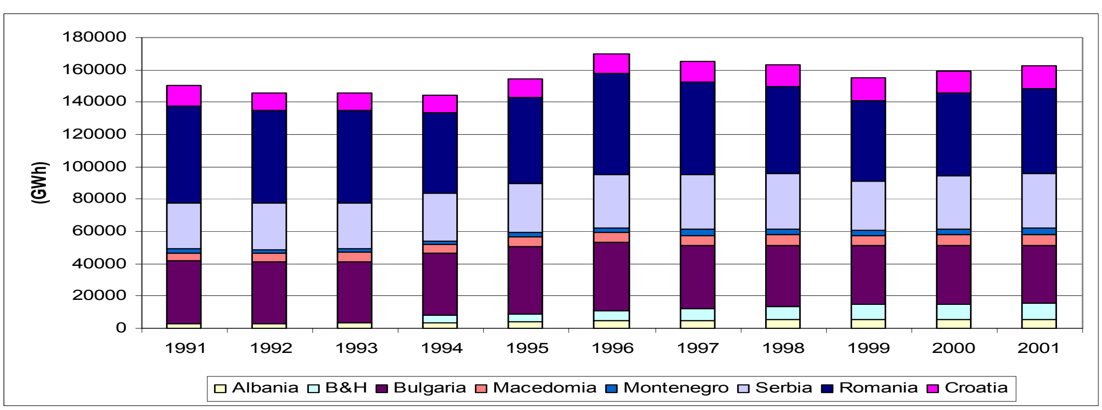
2. Regional Electricity Supply and Demand in the Previous Decade

Regional electricity demand for the period 1991-2001 is presented in Figure 1, considering the electricity demand of all SEE countries in the past ten years.

Average regional annual growth rate of gross electricity demand in the past ten years in South East Europe was 0.88% and in period 1994-2001 (including Bosnia and Herzegovina) it was 1.82%**.** Romania and Bulgaria had a negative electricity demand growth rate, while other countries registered positive trend in the period 1991-2001. The highest trend was registered in Bosnia and Herzegovina (12.31%), Albania (6.94%) and Montenegro (5.6%). During the last ten years, electricity demand for the whole region varied between 145 and 160 TWh. Average growth rate in period 2000-2001 was 2.1%. The main reason for the electricity demand increase in the region was the increase of electricity consumption in Romania (2.58% in the period 2000/2001). Regional electricity demand in 2000 was 159 TWh and in 2001 163 TWh (increasing by 2.1%).

Bulgaria, Romania and Serbia had the highest influence on electricity consumption. The SEE power systems can be divided into two groups according to their overall size: Bulgaria, Serbia and Romania would belong to the group of relatively large power systems (more than 30 TWh), while Albania, Macedonia, Bosnia and Herzegovina, Montenegro and Croatia would belong to the group of relatively small power systems (less than 15 TWh). The electricity consumption share of the electric power systems of Romania, Bulgaria and Serbia in total electricity demand in the region has a decreasing trend. At the beginning of 1994, they participated with about 81% and in 2001, their share was 75%.

Electricity consumption of Albania, Bosnia and Herzegovina, Macedonia, Croatia and Montenegro (40.1 TWh) was by about 10% higher than the electricity consumption in Bulgaria (36.2 TWh), or by about 20% higher than the consumption of Serbia (33.8 TWh). Total production of Albania, Macedonia and Montenegro in 2001 is at the same level as production of Bosnia and Herzegovina.



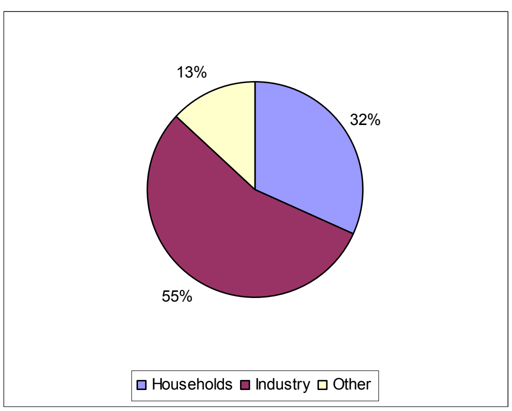
* Electricity demand in B&H is not included for period 1991-1993

Figure 1. Regional Electricity Demand in Period 1991-2001

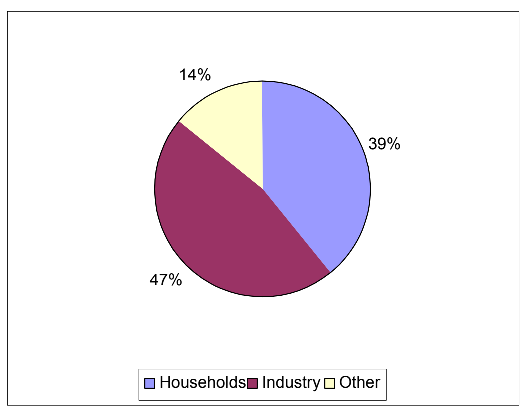
National electricity consumption as well as the maximum registered monthly consumption show that all electric power systems of the SEE countries had an increase of electricity consumption in 2001, except Macedonia, Albania and Bulgaria. Annual growth rate of Albania in 2000/2001 had negative value as a result of the load shedding recently introduced due to heavy droughts. The long-lasting droughts were also the reason for the electricity demand decrease in Macedonia. The decrease in Bulgaria was caused by initial steps of implementing energy efficiency measures. The least increase was recorded in Romania (2.58%). Total electricity consumption in all SEE countries, including Greece and Turkey had an increase of 2.42% in 2001 compared with the amount in 2000.

Peak load for the region was calculated as a sum of peak loads of all countries. It must be emphasized that peak loads of the countries do not appear at the same time and that the real amount of the regional peak load is therefore lower than the value presented. Since it is impossible to estimate the real values, since not all of these countries are in parallel operation, the presented value will be considered, which is on the safe side. For example, the peak load in 2001 for part of the region consisting of countries whose power systems operate within the Second UCTE Synchronous Zone, excluding Greece and Bulgaria, was 18.9 GW in 2001. If peak loads of the same countries are summed, regardless of the difference in dates of appearance, the amount 19.3 GW is obtained, which is by 2.5% higher than the exact or real value (based on the Electricity coordinating center (EKC) operational database [1]). Here, it is important that the peak load in all investigated countries appears during the winter months.

All SEE countries recorded peak load growth over the past decade. However, the growth was not uniform in every country. Comparing peak values of the years 2001 and 1991 for different countries, it can be concluded that the highest increase was in Albania (from 580 MW to 1210 MW, or 109%) and in Montenegro (from 278 MW to 714 MW, or 157%), while Romania had a decrease of its peak load (from 9723 MW to 9247 MW, or -5%). The installed capacities of some countries could not meet consumption and peak demand, so load shedding had to be imposed in Serbia, Montenegro and Albania. Regional peak load in year 2001 (calculated as previously described) was 31.4 GW while in 1991 it was 25.5 GW (increase of 23%). Average annual growth rate of the peak load for the past ten years was 2.2%. Regional peak load decreased in period 2000-2001 by 1.8%. Peak load appears during winter months in all countries. Only Greece has peak load that appears during summer months.



1991, 146.9 TWh, 2172.0 kWh/cap.

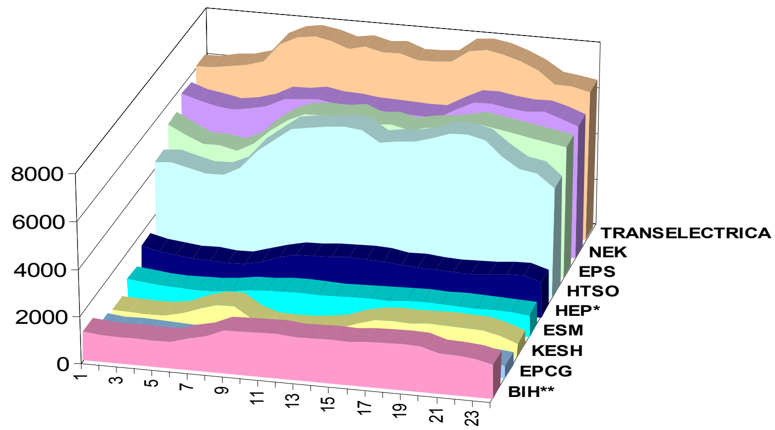


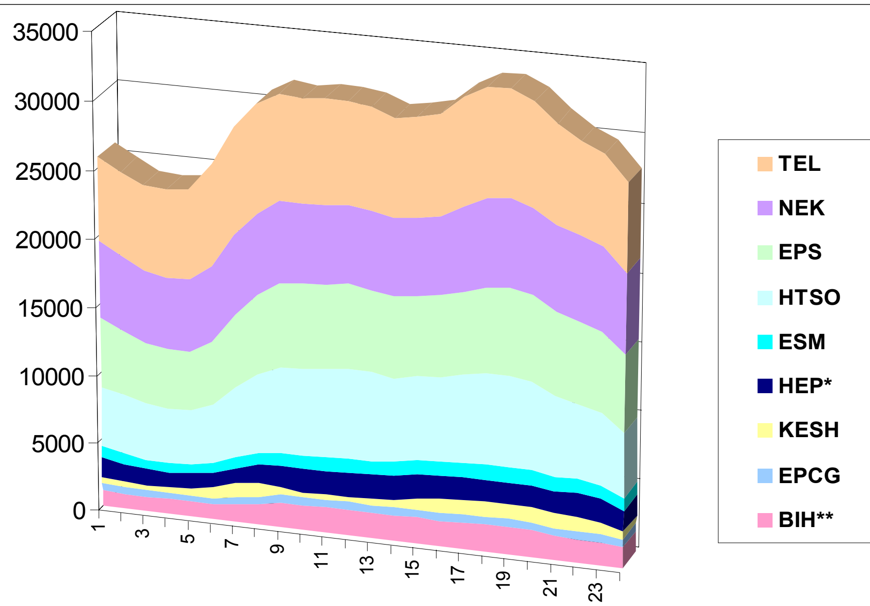
2001, 162.7 TWh , 2192.0 kWh/cap.

Figure 2. Consumption by Categories

Figure 3 shows load diagrams for January 17th, 2001 (these were typical days according to the UCTE standards - the third Wednesdays of January). Beside load curves of the investigated countries, load diagrams also include the load diagrams of Greece, because the electric power system of this country operated synchronously within the Second UCTE Synchronous Zone during 2001. Load diagram for January 17th also presents the peak in the evening hours, which amounted 33593 MWh/h (including Greece).

17.01.2001



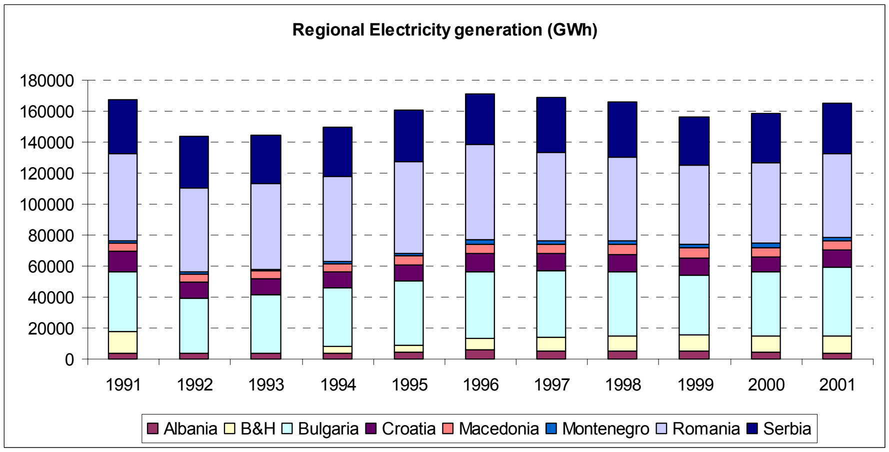


* First UCTE Zone

**First UCTE Zone - EPBiH, EPHZHB

Figure 3. Load Diagrams (values in MWh/h)

Figure 4 presents the amounts of regional electricity production for period 1991-2001 considering the electricity production of all countries in SEE for the past ten years.



* Electricity production in BiH is not included in the period 1991-1993

Figure 4. Regional Electricity Production in Period 1991-2001

Average annual regional growth rate of electricity production for the past ten years in South East Europe was 0.05% (the growth rate of consumption 0.88%). The highest average growth rate of electricity production was in Bosnia and Herzegovina (13.41%), in Montenegro (6.6%) and in Bulgaria (1.39%). Within the last ten years electricity production of the whole region varied between 140 TWh and 170 TWh. In 2000, regional electricity production was 158 TWh and in 2001 165 TWh. During the period 2000/2001, negative trend of electricity production was recorded in Albania (-22.1%), Macedonia (-8.1%) and Montenegro (-4.53%). The highest increase was recorded in Croatia (14.93%), Bosnia and Herzegovina (13.84%) and Bulgaria (7.35%). The highest production within the past decade was recorded in Bulgaria, Romania and Serbia. The participation of these countries in total annual electricity production of the region was from 75% to 85% during the previous decade. Figure 5 illustrates participations of all electric power utilities in total production in 2001.

3. *Current Production and Structure*

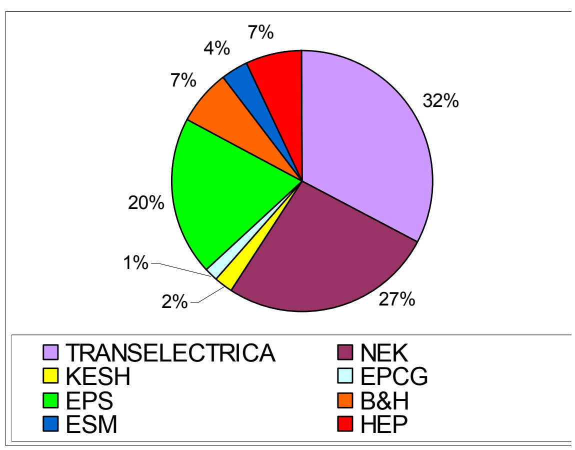
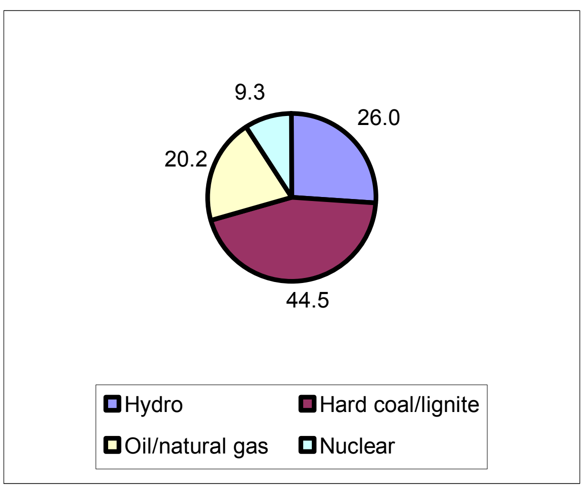


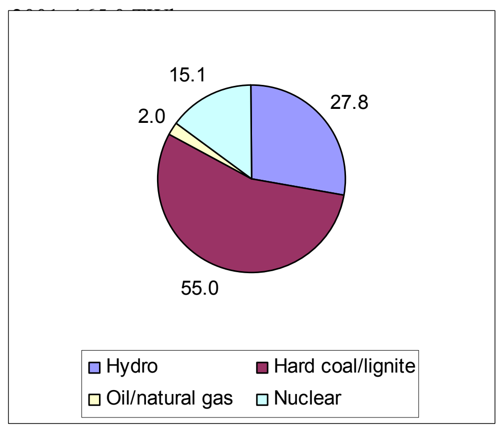
Figure 5. Electricity Production in 2001

As illustrated in Figure 6, most of the electricity is produced in thermal or nuclear power plants. Very high share of oil and natural gas in the electricity production, which existed at the beginning of the observed period, was almost completely substituted by the hard coal and lignite. In 1991, the share of electricity produced in oil or natural gas thermal power plants amounted 20% and until 2001 it has fallen to only 2%. At the same time, electricity production in power plants using conventional fuel increased from 44% to the level of 55%. One of the main reasons for substitution of gas power plants in electricity production was inability of bringing up gas to Romania. The electricity production in nuclear power plants increased during the previous decade from 9% in 1991 to the level of 15% in 2001. This increase is mainly influenced by commissioning of a second unit in NPP Cerna Voda in Romania. The participation of the hydro production remained unchanged over the past years (about 23% to 34% depending on hydrology).

Comparing to the year 2000, Montenegro, Macedonia, Albania and Greece had decrease of production (the highest decrease of production was in Albania whose production in 2001 was by about 22% lower than electricity production in 2000) because electricity production in these countries is strongly dependent on hydro generation. Therefore, the decrease in production was caused by a dry season.

The region (including Greece) had an increase of power production by 3.23% in 2001 in comparison to 2000. In the structure of production for complete interconnection, the highest increase was in thermal conventional production for about 6.62 TWh, while there was a decrease in hydro production because of dry hydrological conditions (1.44 TWh less than hydro production in 2000). The highest increase of electricity production was recorded in Bulgaria, 7.35%, mostly due to increase of export (5584 GWh in 2000 and 8017 GWh in 2001).





1991, 167.4 TWh

Figure 6. Structure of Electricity Production

Figure 7 presents monthly productions in hydro and thermal power plants for all utilities in SEE in 2001. All countries had the highest value of production during the winter months, except for Greece that had peak consumption, as well as production, during the summer period. The greatest production in hydro power plants is in Romania and Serbia. Taking into account the installed capacity in hydro power plants and their production in 2001, it will be seen that the Bulgarian power system uses them only for balance covering, while primary sources of electricity for both domestic consumption and exports are thermal power plants and nuclear power plant Kozloduy. Having in mind the production of the Bulgarian hydro power plants, which amounted to 5% to 8% of the total production in the last ten years, there is a question of their status and efficiency, as well as availability of their large potentials not only for Bulgaria but also for all countries in the region. Increased hydro production in Romania and Greece during summer months indicates the characteristics of number and types of hydro capacities, i.e., run-of-river hydro plants and reservoirs (in Greece the installed capacities of the run-of-river plants is 19.8 MW, while 3071.2 MW of plant is installed using reservoirs).

Comparing electricity consumption and production realized in 2000 and 2001, it is clear that production within the existing generation capacities was not always in position to meet the electricity demand, and that sometimes it was necessary to import electricity from countries that do not belong to the observed region. During 1990s, there were no investments in the power plants of regional importance. The main reason was political and economy crisis that marked the previous decade in this part of Europe. It should be noted that construction of NPP Cernavoda in Romania (800 MW) and pumped storage HPP Chaira in Bulgaria (864 MW generation and 788 MW pump mode) were the only investments realized in the course of the previous decade.

The installed capacity of the observed countries was 49.3 GW (peak load was 31.4 GW) in the year 2001. The largest share of installed capacity in the region also belongs to the Electric Power Utilities of Romania (37%) and Bulgaria (22%). Analyzed interconnection has mostly thermal characteristics (41% of installed capacity belongs to conventional thermal power plants, 13% to oil and 9% to nuclear power plants). The utilization factor of the coal/lignite fired units in most participating countries is relatively low. In addition, capacity of oil and natural gas fired units gives leverage for the enhanced control of intermediate loads, while the hydropower generations secures peak load of the region. The electricity production of the countries with prevailing hydro capacities is strongly dependent on hydrology conditions, causing the problems with load covering during the droughts.

The structure of the installed capacities varies from the countries with mainly hydro installed capacities (Albania, Montenegro) to countries whose electricity generation is based on thermal units (Bulgaria, Romania).

The ratio between peak load and installed capacity has different values throughout the region. In 2001, the peak load in Bulgaria was 7.4 GW, or 67% of the installed capacities, which amounted 11.0 GW. In the same year, the installed capacities in Serbia amounted 8.4 GW, while the peak load was 6.8 GW (81%). The lowest values of peak loads compared to the installed capacities had Bosnia and Herzegovina (51%) and Romania (50%), while the most inconvenient ratios were in Montenegro (82%) and Macedonia (87%). Taking into account the status of certain production capacities and relative participation of hydro and thermo production (i.e. Albania and Montenegro), there is a question of providing sufficient reserve margin, and even covering peak load in some SEE countries.

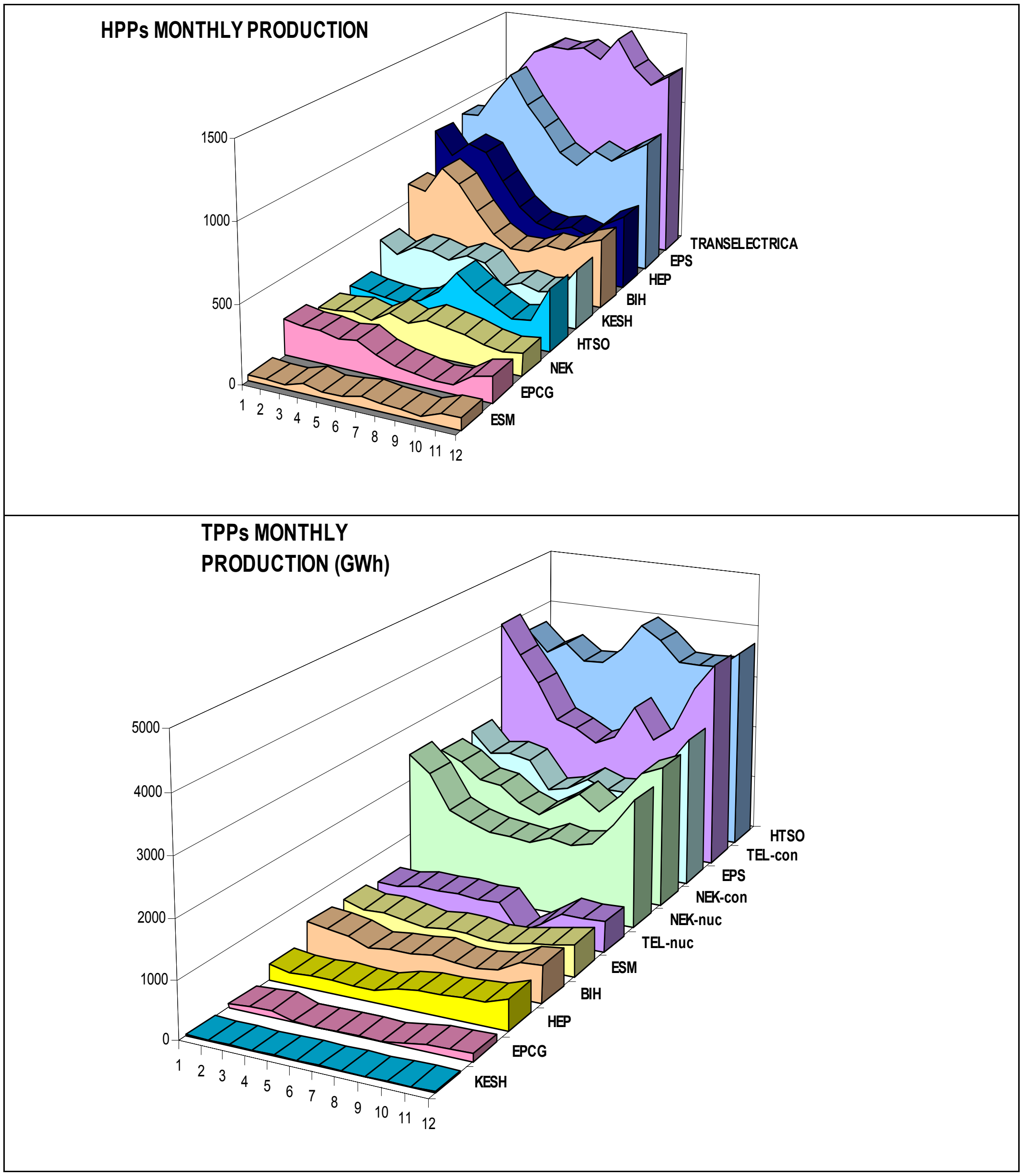


Figure 7. Monthly Production

The analyses of regional consumption, production and the installed capacities for the year 2001 did not include the influence of two very important countries in the region, Greece and Turkey. Electricity consumption in Turkey was 118.5 TWh and in Greece 44.7 TWh, or 37% and 14% of the total SEE regional electricity consumption in 2001, respectively. These two countries together participated with more than 50% of the electricity consumed by the region in 2001. Turkey and Greece participate with 36% and 14% in the overall electricity production in 2001, respectively. It means that half of the regional electric energy was produced in these two countries. Considering the production structure by type, the share of thermal and nuclear generation in 2001 was 66% and 8%, respectively. Concerning the installed capacities, Turkey participates with 26% and Greece with 12%.

Turkey is the largest electricity consumer and producer in southeast Europe and all conclusions concerning energy on the regional level must be drawn as a result of considerations of two scenarios, the region with and without Turkey. This fact will be of great importance in connecting the Turkish power system to the interconnection of UCTE, which is expected in 2006, at earliest. Until then, it will be necessary to perform detailed analysis of the electricity supply and demand in the region considering the influence of the Turkish power system.

Electric power systems of Albania, Bulgaria, Romania, Macedonia, Montenegro, Serbia, and part of Bosnia and Herzegovina – Republic Srpska, together with Greece operate in synchronous parallel operation (the Second UCTE Zone). Some of the utilities exchange electric energy with neighboring systems in island operation (for example Serbia and Hungary, Bulgaria and Turkey, Romania and Moldavia). However, this amount is limited due to network restriction. Electric power system of Croatia and another part of Bosnia and Herzegovina are connected to the First UCTE Zone and exchange energy with the European electric power systems.

The exchange between Bosnia and Herzegovina (one of two entities) and Croatia on one side and countries that operate within the Second UCTE Zone is feasible only in island mode of operation. The amounts that were exchanged between the above mentioned countries were very small and therefore neglected in this analysis.

Table 1 presents the annual physical energy exchange between utilities of the SEE countries, which operates in second UCTE synchronous zones. In 2001, Serbia imported the highest amount of electricity energy (6.6 TWh) and the largest exporter was Bulgaria (8.0 TWh). The huge amount of import recorded in Serbia is a result of the long-term contract that exists between Montenegro and Serbia, related to use of HPP Piva. The amount of Serbian export includes 1.6 TWh imported according to this contract. The exchange with “third countries” assumes the electricity exchange with countries whose electric power systems do not operate in parallel operation with countries of the southeast Europe. For example, in 2001, Serbia imported about 1.3 TWh from the direction of Hungary through 400 kV line Subotica (Serbia)-Sandorfalva (Hungary). Similarly, Bulgaria exported 3.8 TWh to Turkey. The total amount of energy exported to third countries was 4.6 TWh, while the total amount of energy imported from third countries was 6.7 TWh. The amount of energy exported, according to long-term contract from Bulgaria to Turkey, is sufficient to cover the import from the third countries in the Second UCTE zone.

Most of the energy exchanged is a result of transactions between Bulgaria and Serbia, and Bulgaria and Greece. In both cases, Bulgaria exports electricity. The important transfer of energy is a result of transactions between Romania and Serbia. The greatest transactions at the annual horizon were made between Bulgaria and Greece (Bulgaria exported 2.4 TWh in Greece), and Republic of Srpska (BiH) and Montenegro (Montenegro imported 2.4 TWh). In 2001, the greatest importer in the region was Croatia (3.2 TWh or 22% of the gross electricity consumption in 2001). The greatest exporter was Bulgaria (6.9 TWh or 16% of the total electricity production in 2001).

At this moment (July 2003), the energy transactions are made between national electric power utilities only, except for the Romanian generation company Termoelectrica and certain Greek large consumers who are allowed to choose supplier and to make cross-border transactions. Though the unbundling process has already started in Bulgaria, the Electric Power Utility of Bulgaria (NEK) is still the only company from Bulgaria that appears in the regional electricity cross-border transactions.

It is seen that in the last few years, Albania had a serious problem with electricity balance, as a result of a long lasting drought. Problem with balance covering is also very serious in Montenegro and Macedonia. There are also problems with balance covering in Serbia. In this country, these problems do not exist during the spring and summer months (March till July). Greece has problems with balance covering during the entire year, especially in summer months characterized by peak consumption.

Romania, Bulgaria and Republic of Srpska in Bosnia and Herzegovina are countries that do not have problems with balance covering and are very important exporters in the region. Croatia is also forced to import electricity over the year in order to cover its demand, while Bosnia and Herzegovina's part, which is in the first UCTE zone, has a certain excess of electricity, that is exported to Croatia and other European countries.

In the year 2001, Albania, Croatia, Macedonia, Montenegro and Serbia were not in a position to cover their national gross electricity consumption from their own generation capacities (Table 1). The largest deficit was in Albania (48%) and Montenegro (72%) related to production. The electric energy deficit in Croatia was 28%, while its amount in Serbia was 3%. Better hydrology conditions would contribute to easier balance covering in Albania, Macedonia and Montenegro, but the general problem of gross consumption covering would be solved for a long term only by increasing the power plants efficiency and installation of new generation capacities.

Generally, the region as a whole, which is now split in two interconnections (UCTE main grid-Croatia and western part of Bosnia and Herzegovina and the Second UCTE synchronous zone), is hardly able to reach balance between electricity consumption and production. The problems with balance covering within the Second UCTE zone that existed in September, October and December 2001 were solved by energy exchange with third countries (Serbia imported electricity from the direction of CENTREL or Hungary), while the balances in Montenegro and Albania were covered by production within the Second Zone (although there was some load-shedding). In the first zone, though Croatia has insufficient electricity production, consumption can be met by importing electricity from western part of Bosnia and Herzegovina. Therefore, these two countries are locally balanced.

Table 1. Annual Physical Energy Exchange between Utilities of Second UCTE Zone

	EPCG	EPS	ERS	ESM	KESH	NEK	PPC	TEL
Total import	4131	6588	2306	1581	1815	1092	3600	748.5
Total export	2429	4472	3671	1147	64.91	8017	1050	2059
Total exchange	-1702	-2116	1365	-434	-1750	6925	-2550	1311

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[4] Memorandum of Understanding for the creation of a Regional Electricity Market in South East Europe, 2002.

5 Biography

Snežana Mijailović, born in 1965, graduated in 1990 at the University of Belgrade, Yugoslavia, Faculty of Electrical Engineering. She was working in Nikola Tesla Institute, Belgrade. Starting from 1997 she is employed in Electricity coordinating Center, first as head of Study and Consulting Department and from 2002 as deputy general manager. stdpt@ekc-ltd.com

3. SOUTH-EAST EUROPE TRANSMISSION SYSTEM PLANNING PROJECT

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Abstract-- After the political situation in South-East Europe calmed down, better cooperation conditions were initiated between countries in the region. The power sector is extremely important for development of every single country. Also, numerous organizational and structural changes make impact to bulk power systems all over the world. According to new issues, there is a need to make better cooperation and interconnection between countries in the region. The Regional Transmission System Planning Project has been launched by USAID. This paper presents the activities performed within this project.

Index Terms-- Power transmission planning, bulk power systems, interconnections**.**

1. Introduction

South-East Europe Cooperative Initiative (SECI) was established in 1996 to improve economical cooperation between South-East European countries. The project group on "Development of Interconnection of Electric Power Systems of SECI Countries for Better Integration into the European System" has identified five projects as regional priorities concerning rehabilitation of existing transmission lines and substations, feasibility and technical study of east-west corridor in the high voltage transmission systems of the South-East European countries including issues related to the interconnection of the region to the Turkish power grid, investigation of economic and technical advantages of the integrated operation of the interconnected Balkan Electric Power Systems, tele-information system for the connection of the dispatching centers of the power systems in the region, and study to define a revitalization methodology for high-voltage lines and transformer substations by identifying priority criteria.

First project, as the most important for the region, has the expected finalization by the end of 2003. Activities comprise rehabilitation of transformer stations 400/110 kV Ernestinovo in Croatia and 400/220/110 kV Mostar in Bosnia and Herzegovina, together with 400 kV lines that are out of operation, or currently in operation at lower voltage levels, due to destruction during the war in the 1990s. After that the region will be re-connected to the UCTE.

Fulfilment of these activities represents the starting point for the Regional Transmission System Planning (TSP) Project, sponsored by USAID, the Energy and Infrastructure Bureau for Europe and Eurasia. Main goal of this project was to analyze the possibilities for competition under the Regional Electric Market (REM), which is under creation by participating South-East European countries and European Commission. Project was led by the CMS, with the following countries (companies) were involved: Albania (KESH), Bosnia and Herzegovina (ZEKC, EPBiH, EPRS, EPHZHB), Bulgaria (NEK), Croatia (HEP), Macedonia (ESM), Greece (PPC/HSTO), Hungary (MVM), Romania (Transelectrica), Turkey (TEAS), Yugoslavia/Serbia (EPC), and Montenegro (EPCG). Regional coordinator was ESM. Two companies were also involved in the project, especially within the regional model construction and analysis: EKC (Electricity Coordinating Centre) Belgrade and EIHP (Energy Institute "Hrvoje Pozar") Zagreb.

As a part of the Project, PSS/E software was delivered to all participating countries. The training on Power Flow and Steady State Analysis, Optimum Power Flow and Dynamic Simulations was organized, and conducted by Power Technologies Inc (PTI) and sponsored by USAID.

Three working groups were formed for following tasks; data conversion and model development, transmission project technical and financial reviews and post-project cooperation on transmission system planning. All activities were coordinated between these three groups, Technical Coordination

Group (TCG) and Steering Committee (SC). Interconnection Study Task Group (ISTG) was formed with experts from EKC, EPBiH, NEK, ESM, and EIHP performing calculations and preparing the final report.

2. Regional Model Construction

The tasks were set to convert data for each power system in the South-East Europe (SEE) into the PSS/E format, and to create the regional transmission system model planned to be used for SEE regional planning studies, and studies performed by the participating countries in SEE. The common regional transmission model (RTM) was based on internal models prepared by experts in the participating countries, which are joined together and tested by EKC.

Currently (end of 2002), the SEE countries have different status in the UCTE. Former Yugoslavian countries (Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Montenegro and Macedonia) are UCTE members, but only Slovenia, Croatia and part of Bosnia and Herzegovina are operated synchronously with the UCTE. Other countries (Serbia, other part of Bosnia and Herzegovina, Montenegro and Macedonia) are synchronized with Albania, Romania, Bulgaria and Greece (2nd UCTE zone). Romania and Bulgaria are in advanced process of getting full UCTE membership, while Turkey submitted the application and started the procedure to join UCTE.

As a result of the war activities in ex-Yugoslavia, very important points in the high voltage network in the region were damaged and have been out of operation for many years. These points are:

(1) Mostar substation 400/220/110 kV with connected lines that caused the interruption of the Adriatic line, and
(2) Ernestinovo substation 400/110 kV with connected lines that caused interruption of the northern ex-Yugoslavian power corridor.

As a consequence, the southeast UCTE island was separated from the main European interconnecting grid. In the meantime, UCTE members from the southeast island (Greece, Macedonia, Serbia, Montenegro and part of B&H) were interconnected and work in parallel synchronous operation mode with Bulgaria, Romania and Albania. Turkey is connected with Bulgaria with one 400 kV line in an island mode operation.

The separated UCTE zones will be reconnected through repaired substations Mostar and Ernestinovo (400 kV Adriatic line and northern Croatia/Serbia corridor), existing interconnecting line Subotica (Yug) – Sandorfalva (Hun) and optionally interconnection of Romania with CENTREL through Burshtin Island (Ukr).

The influence of connection of the very large power system of Turkey on regional power flows and its various effects have been considered and compared, especially taking into account the option that Turkey could be very strongly interconnected with the new line to Greece. UCTE interconnection was modeled with adequate equivalents at the border region of Hungary and Slovenia.

Regional model was created with following assumptions:

- Target year is 2005.
- All SEE countries work synchronously with UCTE (re-connection of 2nd UCTE zone is expected till target year).
- Two base sub scenarios are defined depending whether Turkey works synchronously with the UCTE or not.
- Winter and summer peak conditions are included.
- In the Base Case all countries are balanced including long term electricity exchange contracts.
- The existing and the new interconnections confirmed to be in operation until 2005, approved by TCG, are implemented in the base scenarios (Figure 1).
- Model is intended to be used for steady state analysis.

The regional model deals mostly with the 400 kV, 220 kV and 150 kV networks. Four base case models were created: winter with Turkey, winter without Turkey, summer with Turkey and summer without Turkey. Table 1 shows the size of the "winter with Turkey" model.

3. *Regional Transmission System Planning Study*

The study was performed in order to test the regional transmission system under REM conditions. It was the project goal to see how the system, as it is predicted to exist in 2005, would react to winter and summer peak loads as base cases and then how it would react to the added bulk power transits predicted to occur under REM conditions. Starting scheduled exchanges are shown in Table 2.

Eight scenarios for winter peak and two scenarios for summer peak 2005 were observed within the study. To model these transits injection nodes tables were created and approved by the TCG.

Figure 1. Interconnected Network of SECI Countries (2005)

In addition, the study goals included a detailed look at twelve proposed interconnections between countries to see which of them, if any, would provide the most regional benefit in terms of increasing maximum exchanges, reducing system losses and improving system security.

Table 1. Size of the Regional "Winter with Turkey" Model

Element	Total
Buses	1720
Plants	300
Machines	473
Switched shunts	8
Loads	890
Branches	2595
Transformers (2 winding)	552
DC lines	0
FACTS devices	0

These 12 proposed interconnections are summarized as follows:

1. 203 km of 400kV OHL from Podgorica (Montenegro, Yug) to Elbasan (Albania)
2. 75 km of 400kV OHL from Sremska Mitrovica (Serbia, Yug) to Ugljevik (B&H)
3. 156 km of 400kV OHL from Nis (Serbia, Yug) to Skopje 5 (Macedonia)
4. 80 km of 400kV OHL from Sombor (Serbia, Yug) to Pecs (Hungary)
5. 71 km of 220kV OHL (second circuit) from Prizren (Serbia, Yug) to Fierze (Albania)
6. 230 km of 400kV OHL from Banja Luka (B&H) to Tumbri (Croatia)
7. 85 km of 400kV (double circuit) OHL from Ernestinovo (Croatia) to Pecs (Hungary)
8. 92 km of 400kV Overhead Line from Bekescaba (Hungary) to Oradea (Romania)
9. 160 km of 400kV OHL from Heviz (Hungary) to Cirkovce (Slovenia)
10. 200 km of 400kV OHL from Skopje (Macedonia) to Tirana (Albania)
11. 150 km of 400kV OHL from Chervena Mogila (Bulgaria) to Stip (Macedonia)
12. 257 km of 400 kV OHL from Maritza East 3 (Bulgaria) to Phillipi (Greece).

The study looked at the regional system Base Case for 2005 with only projected 2005 winter and summer peak loads plus long term contracted exchanges, but without any incremental transits and any of the 12 proposed new interconnections installed. Then, the region was modeled by adding each of the 12 proposed new interconnections, one at a time, subjecting it to each of 8 bulk power transit scenarios for winter peak and 2 for summer peak conditions. Data for each scenario was collected to measure the impact of each proposed new line on power flows, losses and the lines ability to increase maximum exchanges (transits) across the region using (n-1) security criteria. Economical criteria were not considered in this project phase.

For examined scheduled power exchanges some limitations within internal networks were determined. Due to these limitations, exchange programs were not possible according to (n-1) criteria. To solve this, decrease of scheduled bulk power transfers is applied by using a 100 MW step. As a result, maximum possible transfers according to security criteria were calculated as shown in Table 2. Maximum power exchanges were decreased in scenarios 1 (600 MW), 2 (700 MW), 3 (1000 MW), 4 (700 MW), 5 (1000 MW) and 7 (1000 MW) for winter regime and scenarios 1 (600 MW) and 5 (1200 MW) for summer regime. Starting scheduled exchange of 1500 MW was achieved only in scenarios 6 and 8 for winter peak.

Table 2 Bulk Power Exchange Scenarios

		Winter Peak	
From	**To**	**Scheduled Exchange (MW)**	**Maximum Exchange (MW)**
1.UCTE	TUR	1500	600
2.TUR, GR	UCTE	1500	700
3.UCTE	BUL, GR, ALB	1200	1000
4.ROM, BUL, GR	UCTE	1500	700
5.CENTR,Burstin Isl.,ROM	TUR,GR	1500	1000
6.TUR,BUG	CENTR	1500	1500
7.CENTR,Burstin Isl.	BUL,GR,ALB	1200	1000
8.ROM,BUL,GR	CENTR	1500	1500
Summer Peak			
1.UCTE	TUR	1500	600
5.CENTR,Bur,ROM	TUR,GR	1500	1200

Because of the limitations in certain internal networks, each new candidate line has a low impact on increase of maximum exchanges. Some lines improve power exchanges in scenarios 3 and 7 for 100 MW only. Limiting internal lines and transformers are located in Turkey (OHL 380 kV Habipler – Unimrdg) and Yugoslavia (transformer 400/220 kV Sremska Mitrovica and OHL 220 kV Pljevlja – Mojkovac). There is also one existing interconnection line that limits power exchanges (scenarios 1 and 4 for winter and scenario 1 for summer regime) and that is OHL 400 kV Redipuglia (ITA) – Divaca (SLO).

The Hungarian power system is modeled by MVM experts. Since 120 kV network is not MVM's property, the Hungarian power system has been modeled by using equivalents. Thus, some transit limitations occurred in Hungarian system in winter exchange scenarios 2, 4, 6 and 8. However, due to a lack of clear understanding of these limitations, they were not taken into account in this study.

Power losses in each power system of South-East Europe were also determined for each power exchange scenario. Losses were calculated with and without each new candidate line. In general, new candidate line influence on total regional active power losses is very limited (less than 1%). But, active power losses in some systems in the region are significantly reduced with a new line in comparison with power losses without a new line. Those systems are neighboring systems connected by new candidate line. Loss reduction in these cases varies from 1% to 22% of active power losses. In some cases active power losses reduction is very high. The most significant is for the line Ernestinovo (Cro) – Pecs (Hun) in scenario 8 where active power losses in the Croatian system are 22% lower than without line, and at the same time loss reduction in Hungarian system is 11%, even though total regional power losses are not significantly reduced (0.9%). In some cases, power losses are reduced or increased in the neighboring systems that are not connected with a new line. The most significant one is the case of the line Heviz (Hun) – Cirkovce (Slo), when power losses in Croatian system are decreased for 16.5% for summer scenario 1. The new line 400kV Podgorica (Yug) – Tirana (Alb) – Elbasan (Alb) has a big influence on active power losses in Albania, Yugoslavia and Macedonia, for two reasons:

1. Upgrade of part of Albanian network on 400 kV level (causes slight decrease of losses in Albanian transmission system up to 3.6%);
2. The line represents an alternative path for energy transfer from East to West, parallel to path over power systems of Serbia and Macedonia.

4. Study Conclusions and Recommendations

This study has shown that the regional electric transmission system, as predicted to exist in the year 2005, fully interconnected to UCTE, with and without Turkey and without any of the 12 proposed interconnections, is robust and capable of serving projected 2005 demand plus all long term contracted exchanges plus an additional 600 – 1500 MW bulk power exchange (depending on the Scenario). The system limitations are currently posed by four system elements mentioned in section 3, but it is probable that other internal limiting conditions would be found if these four are removed.

It has been shown that three of the twelve proposed interconnecting lines (1, 4 and 7) do offer some increased system performance in terms of power flows and loss reduction but offer no significant increases in maximum exchanges due to other internal limitations. Considering that the three projects range in price from 20million to 50million euros, it is concluded that they could not be cost justified on power flows and loss reduction issues alone.

It was recommended that the study team continue to work on the regional model and perform additional studies as follows:

- Confirm the four limiting elements with the operating experts from Turkey, Slovenia, Italy, Montenegro (Yug) and Serbia (Yug) and develop needed operation or construction plans to remedy these limitations.
- Perform additional studies to see if more internal limitations occur after the four known restrictions are remedied or if one or more of the 12 proposed new interconnections surfaces as a best candidate.
- Work with the appropriate experts from involved countries (Hungary, Albania, Romania and Serbia) in order to clear up the ignored restrictions in order to assure quality of obtained results.

5. Conclusion

The regional transmission network planning project was introduced under the sponsorship of the USAID using infrastructure of SECI initiative. Regional power system model was created in PSS/E format. The main task of the project was to test the regional transmission system under REM conditions and to evaluate new interconnecting lines in the region. Different bulk power exchange scenarios were defined, examined and analyzed. Some limitations in internal networks of Turkey and Serbia were detected. Maximum transit for each scenario was calculated according to (n-1) security criteria. Due to internal limitations, candidate interconnecting lines have no significant impact on maximum exchanges increasing. Study has shown that the regional electric transmission system as predicted to exist in the year 2005 is robust and capable of serving projected 2005 demands plus all long term contracted exchanges plus an additional 600 – 1500 MW of bulk power exchange. Evaluation of the new interconnecting lines should be continued, especially from the economical point of view.

6. Acknowledgment

The author gratefully acknowledges the contributions of P. Miller (CMS), T. Cerepnalkovski, K. Naumoski (ESM), G. Majstrovic (EIHP), S. Mijailovic, M. Vukovic, P. Miksa (EKC), N. Rusanov (EPBiH) and N. Gamov (NEK) for their contributions to this document.

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8. Biography

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4. TELE-INFORMATION SYSTEM IN SEE TO ENHANCE COORDINATED OPERATION AND SUPPORT THE REGIONAL ELECTRICITY MARKET

Sudhir Virmani, Senior Member IEEE, Christopher O'Reilley, Member IEEE, and Savu C. Savulescu, Senior Member IEEE, Electrolek Concepts, Cupertino, CA, USA

Abstract--The recent developments in South Eastern Europe (SEE) related to the design and implementation of a regional electric utility Teleinformation system are described**.**

1. Introduction

In early 2000, the United States Agency for International Development (USAID) initiated a project under the SECI umbrella to develop an architecture and basic design for a tele-information system that would enable all the National Dispatch Centers (NDCs) in the region to exchange data with each other. This was followed by a second project began in late 2001 (after the completion of the first project) to look at specific communication links that were needed for completing this network as well as to address the related issue of regional telecommunication network management and power system security monitoring. The second project was completed by the end of February 2003. The countries (electric power companies) involved in one or both projects included (some participated as observers):

- Albania (KESH)
- Bosnia and Herzegovina (ZEKC plus three Elektroprivredas)
- Bulgaria (NEK)
- Croatia (HEP)
- Republic of Macedonia (ESM)
- Greece (PPC)
- Hungary (MVM)
- Romania (Transelectrica)
- Slovenia (ELES)
- Turkey (TEAS)
- Yugoslavia (EPS Serbia and EPCG Montenegro).

2. Requirements and Architecture

Many of the electric utilities in SEE have implemented, or are implementing, extensive internal telecommunication networks based mostly on the use of OPGW. The objective of this project was to augment these networks to enable cross-border information exchanges. Thus, the experts worked closely with those in the region to ensure a coordinated and cost effective solution.

The initial capacity requirements were determined based on:

- The exchange of real-time data such as device status and analog measurements
- Exchange of study mode data such as state estimation and load flow results and models
- Voice traffic
- Management and Accounting Data.

Next an allowance was made for the extra traffic that would result from the development of a Southeast Europe regional electricity market (SEE REM). The end result was that each NDC (assumed to later become part of the TSO/ISO) should have a capacity equal to 4 E1 links to each of the other NDCs. This capacity was deemed sufficient to meet present and future needs. In addition, the architecture was designed such that there would be a redundant path between any pair of NDC. Because, in some cases, the traffic would be routed through other (third party) NDCs, some of the link capacities far exceeded the four E1 equivalent.

The resulting network is shown in Figure 1 in which details of the internal network are omitted, only the main point to point links are included.

Based on the architecture shown in Figure 1, in the second project, certain key projects were identified, appropriate technical and financial documentation prepared and brought to the attention of the International Financial Institutions (IFIs) for financing. These projects included HEP Croatia, EPS, Serbia (for which a complete business case was developed by SEETEC, Canada), ESM, Macedonia and the links between "Serbia - Kosovo- Montenegro – Albania -Macedonia". Because of the damage caused by the war, UCTE currently operates in two synchronous zones where much of SEE is in the Second Synchronous Zone. Since the re-connection of the two zones is of a high priority, the above projects are of considerable urgency. The Ernestinovo substation in Croatia is being rebuilt and it is critical for the UCTE re-connection for power system reliability. Therefore, the communication links to Ernestinovo are essential for the HEP control center in Zagreb, and constitute the HEP project. In addition, Ernestinovo acts as the communication hub for links to Serbia and Bosnia and Herzegovina. The link from Nis in Serbia via Kosovo B to Skopje in Macedonia is also essential to connect the southern part of SEE. Serbia occupies a critical geographical position and so the completion of its internal telecommunication network is of strategic importance.

The European Commission (EC) took a leadership role by convening a meeting on the SEE REM in June 2002 in Athens and required all SEE projects to coordinate with ETSO, SUDEL and UCTE. The experts have followed this directive and, for example, the specifications for the Electronic Highway in UCTE were reflected in the project's Teleinformation (TI) System Management handbook. The Electronic Highway essentially is a communication link between all of the ISO/TSO centers in the UCTE (including the Accounting Centers in Laufenberg, Switzerland and Brauweiler, Germany). The handbook, as well as a TI system management specification, was prepared to describe how the regional tele-information system should be managed. In addition, a specification for regional transmission security monitoring has been prepared and conforms to the UCTE requirements. Many of the SEE NDCs have installed the IEC 870-6-Tase.2 software for data exchange and we are providing two other systems with this software to enable all the NDC to communicate using any cost effective communication media.

3. *Conclusions*

The TI system proposed for the SEE countries will play a crucial role in the re-connection of the UCTE and in the development of a REM. In a recent Memorandum of Understanding signed by the Ministers of the SEE countries in November 2002, the TI system was identified as an urgent and critical need to be implemented with interim solutions by mid 2003 and fully implemented by 2005. It should be noted that all new interconnectors will be equipped with fiber optic ground wires making the cross-border communication easier.

4. *Acknowledgment*

The many and significant contributions made by the Telecommunication and power system

experts of the electric utilities of the region are gratefully acknowledged as are the contributions of the SECI Regional project Coordinator - Mr. Trajce Cerepnalkovski of ESM, Republic of Macedonia.

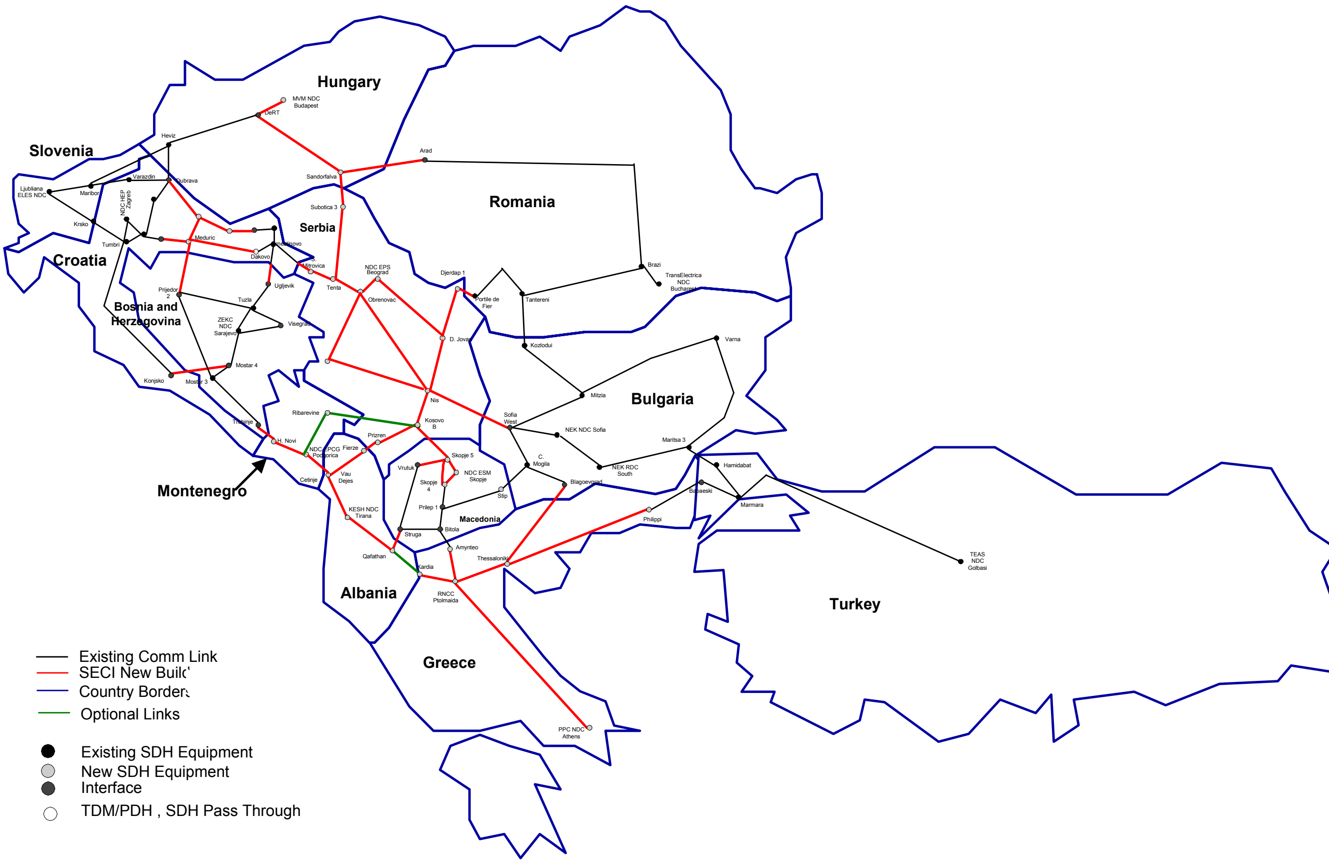

Figure 1. Regional Telecommunication Topology

5. *Biographies*

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5. ROLE AND VALUE OF HYDRO AND PUMPED STORAGE GENERATION IN A PROPOSED REGIONAL ELECTRICITY MARKET IN SOUTHEAST EUROPE

P. J. Donalek, Senior Member IEEE

Abstract—It is recognized that Hydro generation and Pumped Storage Hydro can play a unique role in the operation of modern power systems. As part of the introduction of a regional electricity market for the Balkans region, a study was made to identify the role of hydro and pumped storage in a market based regional electricity market. The study included an analysis of the hydrologic conditions in individual countries as well as for the region. The results of the hydrologic analysis determined that the region could be simulated for three hydrologic conditions; wet, normal and dry.

A power system simulation was made for year 2005 and the results used to quantify the value of hydro. The power system simulation determined cost of energy at designated nodes in a regional electricity market. Cost of energy and ancillary services were calculated. The value of hydro and pumped storage is shown in comparisons of energy costs for wet, normal and dry hydrologic conditions. The results of the power system simulation provided dispatch scenarios that can be used to evaluate impact on the regional transmission system and to further define the role of hydro and pumped storage generation in the regional electricity market.

Index Terms—regional electricity market, hydro generation, pumped storage, power system simulation, hydrologic, ancillary services, transmission congestion, location marginal price, and southeast Europe.

1. Introduction

In the 1990's the international community focused attention on the needs of countries in Southeast Europe. Attention was focused on a core group of countries along with another group of counties peripheral to the core group. The core group of countries includes: Romania, Bulgaria, Macedonia, Albania, Montenegro, Bosnia & Herzegovina, Croatia and Serbia. The peripheral countries are: Hungary, Moldova, Turkey, Greece and Slovenia. Italy may be added to the list of peripheral countries because of a high voltage direct current undersea transmission cable between Greece and Italy.

The energy sector received attention along with other social and infrastructure sectors. Among the various regional development initiatives for the energy sector, the development of a regional electricity market was identified early-on as the focus of a major effort. The broad scope of assistance to the energy sector includes several basic technical areas. These are: high voltage transmission, telecommunications, and generation.

Technical assistance programs to the electric energy sector have been formulated with a regional perspective and focused on the creation of a Regional Electricity Market (REM). Assistance has also been provided for specific needs within countries, such as repair of damaged substations, transmission lines, generating stations, communications and control centers, etc. but in the context that the facilities would ultimately function in a future regional electricity market.

The work described in this paper is the result of an assignment that addresses various aspects of the role of hydro and pumped storage generation in a regional electricity market. Since the prime mover of hydro based generation is subject to availability of water from rain and snow melt it has a variability that will influence the cost and operation of other types of generation and be reflected in the ultimate cost of energy to consumers. The assignment addressed several key questions that focus on the role and value of hydro in regional power system operation.

The region of Southeast Europe is known to experience extremes of water availability. It is well known that the region has experienced periods of drought as well as periods of abundance and flooding. A premise to be studied is that when there is an abundance of water then hydro generation will contribute as much energy as possible and that energy from higher cost generators will be minimal. On the other hand when water is in short supply there will be a minimal contribution from hydro generators and a maximum of energy supplied from thermal generators.

The distribution of energy resources and facilities through out the region is not uniform. Within the region there are areas with significant coal, oil, gas and hydroelectric resources. In addition there also are large nuclear fueled generating stations. When the political and social boundaries are imposed on the region one can see that the distribution of hydro generation throughout the region is not uniform.

The location of energy conversion systems (generation capacity) is driven by the physical geographic location of the prime energy resources. For example coal fired plants are located near coal fields, gas fueled generation is located in proximity to gas pipelines and etc. Other factors such as cooling water supply, access to bulk power transmission and railroads, and reliability issues also play significant roles in site selection.

All countries in the region have some hydro generation, however some have an abundance of hydro resources and others less so. From a regional perspective, hydro resources are spread across the region according to the location of rivers and availability of favorable geologic conditions.

Among the various energy conversion technologies, hydro generation is uniquely driven by its relation to the primary energy source with the result that some countries have developed more hydro and pumped storage than others. In times of drought these countries often cannot meet their electric energy needs from in-country generation and in times of abundant wet supply they have excess energy.

2. Technical Work Preparation

The study was focused on the following questions:

- What roles can hydro play in providing ancillary services in an integrated Balkan regional electricity market?
- What have the drought patterns been in the region and how have they affected hydro operation, larger system operation and costs/trade patterns in individual countries?
- What are the legal and structural legislative constraints on the use and availability of water for hydro generation on a country, river basin and regional basis?
- What are the implications of hydroelectric power trends for national and regional market development based on third party and open transmission access principles?
- What is the best way to use the pumped storage hydro potential from a regional perspective?

The above questions were addressed in three initiatives: (1) a study methodology development and data gathering activity, (2) a hydrology study and (3) a power system simulation.

2.1. Project Organization and Data Collection

Since the project involved the Balkans region it required the participation and cooperation of all generators in the region. Fortunately there was an organization already in operation and it provided a basis for the study of the role of hydro [1], [5].

The existing organization was the Transmission System Planning [3] task force. This group provided an initial point of contact with the utilities in the region. From these contacts a separate task force was organized for the Role of Hydro study.

Visits, by the project team, were made to each utility in the core group of countries. During these visits a proposed methodology for the Role of Hydro study was presented for consideration. The study approach was discussed and data requirements and availability issues identified. The study also included participation from hydrological institutes and interested ministries in the designated countries.

The study would be an operational study as opposed to a long range generation and transmission expansion study, and the year 2005 was selected as the study year. The year 2005 was selected because it is the first year when a regional electricity market is expected to be in operation. There are various plans in several Southeast Europe countries for membership in the European Union in year 2005. And 2005 is also the target year for several new transmission interconnections to be in operation.

An initial data collection effort was undertaken. Two data categories were identified; one for hydrologic analysis and the other for power system simulation. A sub set of the power system simulation data was a database of hydro resources for the core countries in the region.

In addition to the individual utilities in the countries of the region there are two agencies with a regional scope. One in Belgrade, Serbia [2] and the other in Zagreb, Croatia. Data from these agencies provide an initial regional database of transmission, energy demand, generation and hydro and pumped storage resources.

A detailed country-by-country data collection effort was undertaken. Hydrological data was collected for rivers with hydro generation facilities and related hydrologic background information. Power system information was collected to provide the data needed to simulate the operation of each country's power system as well as a proposed regional system. Information and data was collected for the year 2005 and it included: estimates of electricity demand and energy, technical characteristics of hydro and pumped storage generators, nuclear and various forms of conventional thermal plants, and combined heat and power plants. Expected bilateral power interchange obligations were also documented.

2.2 Hydrology

A hydrologic analysis was carried out to determine if there is hydrological diversity or if there is uniform hydrology in the region. The power system simulation included other constraints on the use and availability of water for hydro generation on a country and regional basis.

The hydrologic analysis was based on stream flow data for major rivers and specific tributaries. Only rivers with major hydro plants were included in the analysis. A separate analysis looked at precipitation data in the overall region.

The hydrological analysis was carried out using commonly available software and statistical methods. The results of the hydrological analysis are summarized as follows:

- No strong indication in any data of a pattern of dry in one area and wet in another area.
- The region has a typical pattern of high spring runoff and low late summer runoff.
- Statistically significant trend to lower flows in Albania and Macedonia over the period of record.
- Indication of multi-year periods of below average flow over the region.
- Plotted flows for the region show periods of significant similarities.
- The data appears to be primarily weighted toward hydrologic similarity.
- As hydrologic conditions move toward the extremes of wet and dry periods, hydrologic similarity in the region appears to strengthen.

- Flows on some rivers in the region will always be in contradiction to the general tendency.
- With few exceptions, years of wet and dry hydrology tend to coincide through out the region.

Based on the results of the hydrological analysis it was determined that the power system simulation would be made for three hydrologic conditions: wet, normal and dry.

3. Power System Simulation

A main objective of the study is to estimate the value of hydro and pumped storage hydro from a regional perspective and to evaluate ancillary services. It was determined that the role and value of hydro would be evaluated by power system simulation. The simulation was made on a country and regional basis.

The simulation was made for the three hydrological conditions, (wet, normal and dry) as identified in the hydrologic analysis. This allows the power system simulation to capture the uncertainty of water availability and effects of different hydrological situations on the operation of hydro power plants.

Because the study was for the year 2005, when the regional electricity market is expected to begin operation, the power system simulation was based on location marginal price concepts and assumed independent power plant operation.

The power system simulation used a software tool named GTMax; Generation and Transmission Maximization. This software was developed by Argonne National Laboratory [4].

The power system simulation analysis takes into account the topology of the electric power system, transmission interconnection transfer capabilities, chronological hourly loads and the differences in the electricity generation costs in each of the utility systems. The simulation calculates market prices for electricity sales/purchases in different regions (market hubs) of the power network based on the capacity constraints of transmission interconnections. The model simultaneously optimizes power transactions and minimizes overall operating costs in the region.

The analysis was carried out for four typical weeks in year 2005 (winter, spring, summer, and autumn). Hourly system operations were simulated for the assumed conditions of the third week of January, April, July, and October of 2005. Each utility system was first simulated as operating independently, without transmission connections to the other systems. This is identified as the "individual operation" scenario. Then, all of the utility systems were connected into a regional network and simulated under the assumed regional electricity market conditions ("regional market" scenario).

The hour-by-hour simulation of an entire week (168 consecutive hours) was important because it modeled the operational behavior of hydro and pumped-storage power plants. Most hydro power plants in the region have at least daily regulation capabilities and operate differently during the peak and off-peak hours (e.g., during the day and during the night). Also, in the case of hydro plants with greater storage capabilities there are significant differences between their operation during the weekdays and during the weekends.

Ancillary services were defined in UCTE terms and include, in North American terms; load following, spinning reserve, standby reserve, frequency regulation, load following, and reactive power. The GTMax software simulated the production of ancillary services under the independent and regional scenarios for the three hydrologic conditions.

Each utility system in the simulation was required to provide a specified amount of regulation and contingency reserve. The assignments of reserve capacity for regulation (automatic load control - ALC) and for the contingency reserves (spinning and non-spinning) to be maintained by individual power plants were optimized by GTMax on an hourly basis. The simulation showed that hydro and pumped-storage plants provide a significant amount of the ancillary services.

The Role of Hydro study was coordinated with the Regional Transmission Planning task force and an equivalent nodal transmission model was developed for the region. One or more nodes in the transmission model represent each country. The transmission model is for the year 2005 and includes several new transmission interconnections that are proposed for construction. The nodal model combines parallel transmission paths between nodes and sets a total transmission transfer capability for each transmission path.

4. Conclusions

The hydrology study showed that there is more hydrologic similarity than diversity in the region and that hydro operations can be modeled for wet, normal and dry conditions.

The power system simulation showed that the value of hydro was realized at the local level but with an impact on the regional cost of energy. Energy from hydro generators was not transmitted across the region but was consumed locally.

When water supply is abundant (wet year) hydro generators produce low cost energy and this reduces total energy cost in the region. In dry periods hydro generators produce capacity to meet peak demand but less energy and energy costs in the region are higher.

The power simulation study showed that hydro and pumped storage generation could be expected to provide significant percentages of ancillary services in a regional electricity market.

The power system simulation results should be coordinated with the Regional Transmission Planning project. The transmission planning group should review the generation dispatch scenarios from the power system simulation and make a more detailed analysis of selected cases. The transmission planning studies, using ac load flow and transient stability analysis, should identify transmission issues such as allocation of reactive power, stability issues, and line loading constraints. Transmission issues that require operation of generation as 'must run' should be imposed as constraints on dispatch in future regional power simulation runs.

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5. Acknowledgment

The project described in this paper was carried out under the sponsorship of USAID and accomplished with the efforts of numerous utility experts in Southeast Europe. The author gratefully acknowledges the contributions of J. Haapala, R. Murariu, M. Frigo and B. Trouille of MWHGlobal, F. Mihailescu of Transelectrica, Romania and Trajce Cerepnalkovski of JP Elektrostopanstvo, Macedonia for their assistance on this project.

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7. Biography

Peter Donalek (Associate Member IRE 1959-61, IEEE Member 1961-1981, Senior Member 1981 to present). Born Chicago, IL 1939. BSEE University of Illinois 1961, Master of Science Degree Electrical Engineering, Moore School, University of Pennsylvania 1970, and Masters Degree Mathematics University of Toledo 1973. Westinghouse Electric 1961-63; U.S. Peace Corps-Brazil 1963-65; Sargent & Lundy 1965-68; Spring Garden College 1969-71; Harza Engineering Company 1973-2001; MWHGlobal 2001 to present.

Mr. Donalek has been Power System Engineer and Project Manager on operational and transmission expansion planning studies of nationwide and regional power systems in: South Korea, Central America, South Asia, Africa, Central Asia, and Southeast Europe, and has carried out power system studies in over 20 countries. He was project manager and contributor to Chapter 6 “Coal-by-Wire" of the U.S. Department of Energy *National Power Grid Study,* 1979, and was principal investigator for EPRI study TR-105542, *Application of Adjustable-Speed Machines in Conventional and Pumped-Storage Hydro Projects*, 1995.

6. MODELING THE REGIONAL ELECTRICITY NETWORK IN SOUTHEAST EUROPE

Vladimir S. Koritarov and Thomas D. Veselka, Argonne National Laboratory, Argonne, IL U.S.A.

Abstract—The objective of this analysis is to investigate the potential benefits of a regional electricity market in Southeast Europe in 2005. The study models the operation of the electric power systems of seven countries. The primary software tool is the GTMax model, which was used to analyze the operation of individual utility systems, as well as their operation in a regional electricity market. Four typical weeks in different seasons of 2005 are simulated. To capture the variability of hydro inflows and their influence on hydro generation, the analysis is performed for three hydrological conditions: wet, average, and dry. For the regional electricity market scenario, GTMax is used to calculate hourly values of locational marginal prices for all nodes of the regional network and to optimize power transactions among the utility systems. A comparison of operating costs obtained for the two scenarios showed that a regional electricity market provides for significant benefits and cost savings compared to the operation of individual utility systems. Substantial cost savings are achieved in all analyzed periods and under all hydrological conditions.

Index Terms—regional electricity market, interconnections, power transactions, locational marginal prices.

1. Introduction

The analysis presented in this paper was performed within the framework of a wider study carried out by a team of experts from Montgomery Watson Harza (MWH) and Argonne National Laboratory (Argonne) under the sponsorship of the U.S. Agency for International Development (USAID). The objective of the study was to examine the role and value of hydro power plants in Southeast Europe, especially within the context of a potential future electricity market in the region. The analysis focused on the power market situation in 2005, which is, according to the Athens Memorandum of Understanding [1], a target year for starting the operation of a regional electricity market for industrial and large (non-residential) consumers.

The study modeled the operation of electric power systems of seven countries in Southeast Europe (Figure 1). Included were the electric utility systems of Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Macedonia, Romania, and Serbia and Montenegro. Turkey also participated in the project as an observer country but was not modeled. The analysis was performed using the Generation and Transmission Maximization Program (GTMax) developed at Argonne National Laboratory.

As part of the project, the GTMax software was distributed to all participating countries. USAID also sponsored a 3-day introductory training course on the use of the GTMax software for utility experts from the region.

2. Methodological Approach

GTMax is Argonne's premier software tool for the detailed analysis of utility systems operations and costs in an open market. With GTMax, utility operators and managers can maximize the value of the electric system taking into account not only its own limited energy and transmission resources but also firm contracts, independent power producer (IPP) agreements, and bulk power transaction opportunities on the spot market. GTMax maximizes net revenues of power systems by finding a solution that increases income while keeping expenses at a minimum. GTMax does this while ensuring that market transactions and system operations are within the physical and institutional limitations of the power system. When multiple systems are simulated, GTMax identifies utilities that can successfully compete on the market by tracking hourly power transactions, locational marginal prices (LMPs), generation costs, and revenues.

The GTMax analysis takes into account the topology of the electric power systems, interconnection transfer capabilities, chronological hourly loads, and the differences in the electricity generation costs in each of the utility systems. GTMax calculates market prices for electricity sales/purchases in different regions (market hubs) of the power network based on the capacity constraints of transmission interties. The model simultaneously optimizes power transactions to minimize overall operating costs in the region.

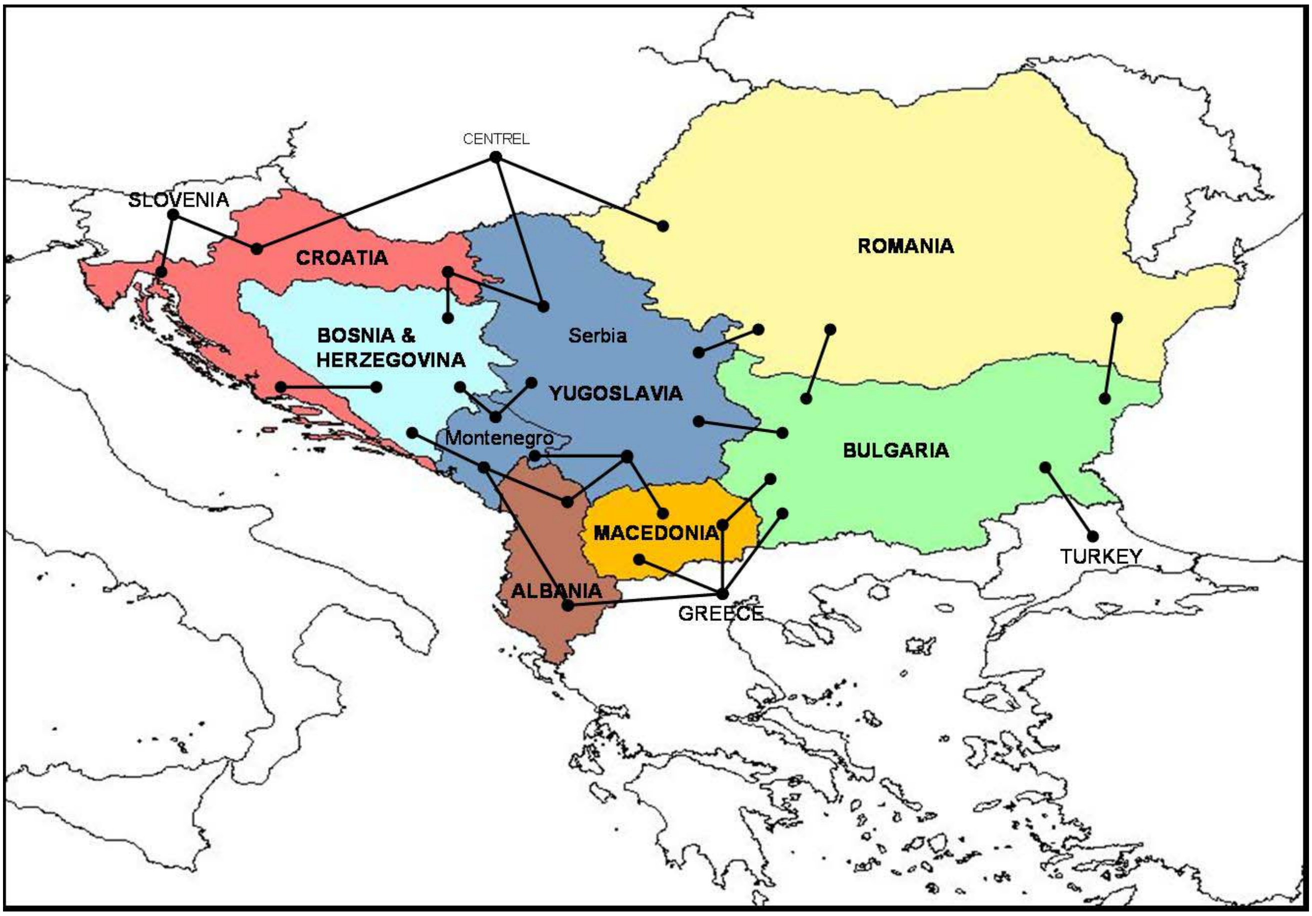

Figure 1. Regional Interconnected System

The analysis was carried out for four typical weeks in 2005 (winter, spring, summer, and autumn). GTMax was used to simulate hourly system operations during the 3rd weeks of January, April, July, and October of 2005. Each utility system was first simulated as operating independently, without the connections with other systems. This was the so-called "individual operation" scenario. Then, all of the utility systems were connected into a regional network, and GTMax was used to simulate the hour-by-hour operation of the regional electricity market ("regional market" scenario).

The hour-by-hour simulation of an entire week (168 consecutive hours) was considered very important in order to capture the operational behavior of hydro and pumped-storage power plants in the region. Most hydro power plants in the region have at least daily regulation capabilities and operate differently during the peak and off-peak hours (e.g., during the day and during the night). Also, in the case of hydro plants with greater storage capabilities there are significant differences between their operation during the weekdays and during the weekends. In order to capture the uncertainty of water inflows and effects of different hydrological situations on the operation of hydro power plants, the analysis was carried out for three hydrological conditions: wet, average, and dry.

Under both scenarios, the utility systems of the participating countries were represented with the generation and transmission facilities that correspond to the expected system configurations in 2005. Similarly, under the regional market scenario, the utility systems were interconnected into a regional network with the existing interconnection lines and with those that are expected to be in operation in 2005. The power transfer capabilities of the interconnection lines were also taken into account during the GTMax simulations of the hourly operations of a regional electricity market. In principle, for the simulation of a regional electricity market, GTMax was used to calculate hourly values of LMPs for all nodes (market hubs) of the regional network and to optimize power transactions among the utility systems. Power transactions were subject to the capacity limits (net transfer capabilities) of the interconnection links among the systems. The resulting LMPs, taking into account the power transactions, were also calculated and reported by the model for each node (or market hub) of the regional network.

3. Regional Network

The topology of the network that was configured in GTMax for the participating countries is shown in Figure 2. GTMax computes market prices of electricity at various geographical locations within the power systems and at power system interconnections. The market price is assumed to be the marginal cost of delivering energy to a specific location. The companies that generate power are paid the LMP at the point of power injection; that is, the price is dependent on the supply and demand equilibrium. In principle, the LMP price can be less than, equal to, or greater than a generator's average production cost. In this study, it is assumed that generators bid energy blocks into the market at marginal production costs.

Another factor in determining LMPs is the transmission network and its transfer capabilities. In principle, if there is no transmission congestion, power can be transferred to any node of the network and all nodes have approximately the same LMPs. However, in the case of transmission congestion, the transport of power to a particular region in the network may be limited by the transfer capabilities of transmission lines connected to that particular area, thus creating a zone with higher LMPs. Differences in LMPs between two connected regions are used to compute congestion line charges. In this study, the analysis of regional market operation was performed taking into account possible transmission congestion on the interconnection links among the power systems. No internal transmission congestion was considered within individual utility systems.

Besides the existing interconnection lines, the regional transmission network also includes new interconnection links that are expected to be in operation in 2005. These are the following 400-kV transmission lines:

- Chervena Mogila (Bulgaria) –Stip (Macedonia),
- Podgorica (Montenegro)-Tirana/Elbasan (Albania),
- Upgrade of the existing 150-kV line Bitola (Macedonia)-Florina (Greece) to 400 kV,
- Re-connection of the existing 400-kV transmission line Mladost (Serbia) – Ernestinovo (Croatia).

The connections with the outside power systems were modeled in GTMax using spot market nodes. They were used to represent the connections with Slovenia, CENTREL, Greece, and Turkey.

Regarding new generating facilities in 2005, the power systems in the region will mostly rely on generating units that are currently in operation. The only new generating units expected to be commissioned by 2005 are two gas turbines (2 x 150 MW) in Albania and one 174-MW cogeneration plant in Macedonia [2], [3]. On the other hand, two smaller 440-MW nuclear units at the Kozloduy power plant in Bulgaria will be retired (units 1 and 2) and will not operate in 2005.

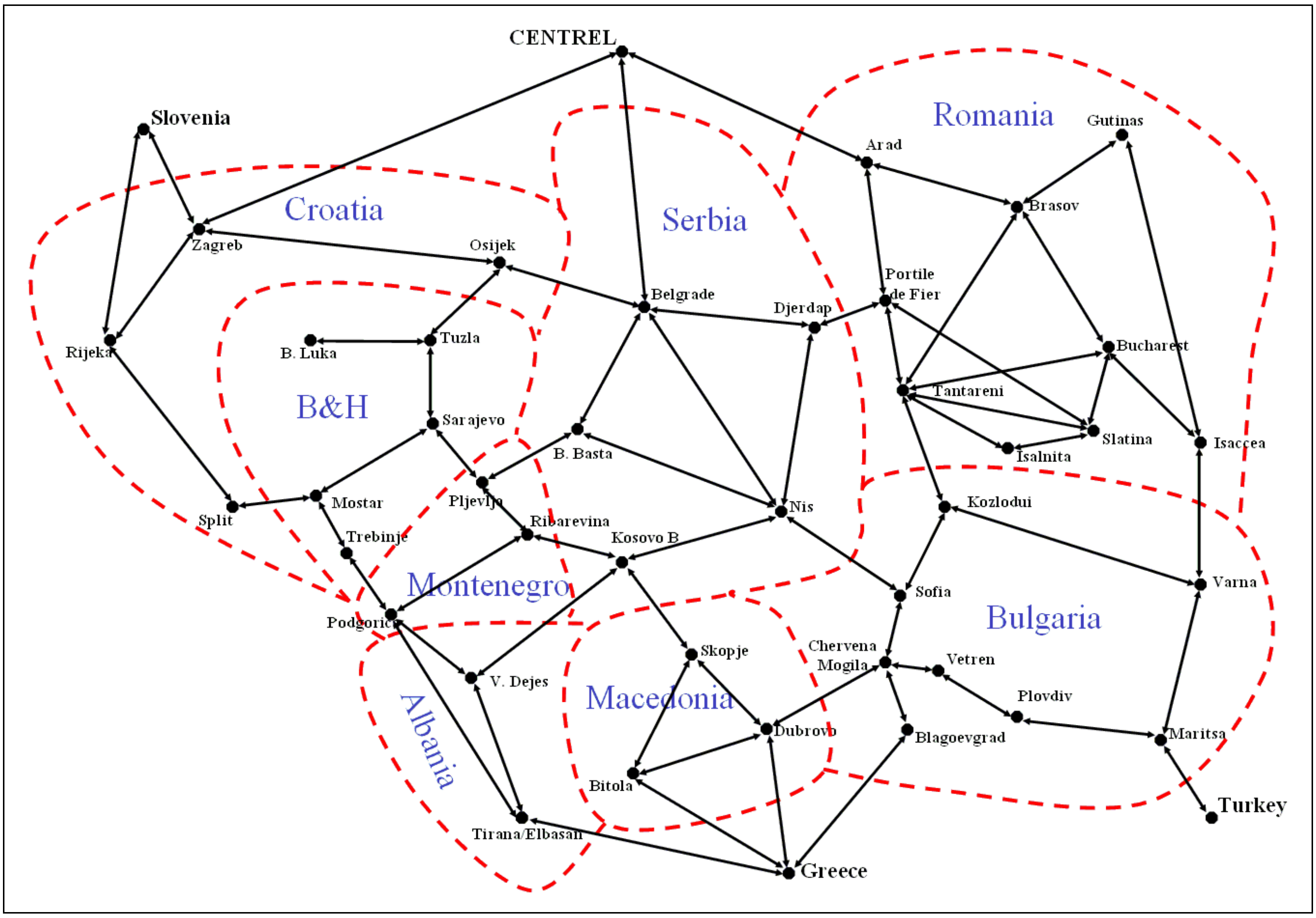

Figure 2. Simplified GTMax Representation of Regional Network in 2005

4. Regional Market Analysis

The GTMax model was first used to analyze the operation of individual utility systems and then to analyze the regional market operation. The results obtained for these two scenarios served as a basis to determine the cost differences between the operation of individual systems compared to the regional market operation. These cost differences provide an indication of possible economic benefits of integrating the operation of the power systems in the region. Most benefits and cost savings are expected to be attributable to load diversity, more efficient dispatch of generating units, reduced spinning reserve requirements, and a more reliable system operation.

Under the individual operation scenario, the power systems operate independently and do not trade, sell, or exchange energy or capacity with each other or with the other systems. The results of this scenario reveal electricity generation costs in each of the utilities under the assumption that the systems are operated as isolated entities. Therefore, each system is responsible for satisfying its own electricity demand by means of its own generation resources while maintaining an adequate level of spinning reserve to ensure system reliability.

The regional market scenario allows for power exchanges among the utility systems via the interconnection links. In this scenario, the GTMax model was used to determine the potential for power transactions, optimal energy exchanges, and nodal market prices.

5. *Main Results of the Study*

The results of the analysis show that the regional electricity market provides significant benefits and operational savings compared to the operation of individual utility systems. Table 1 compares the total weekly operating costs for the regional electricity market and the sum of operating costs of individual utility systems. The results are presented for typical weeks in different seasons of 2005 for three hydrological conditions.

Depending on the season, the total weekly savings for the entire region range from 2.7 to 9.1 million U.S. 2000 dollars. Most of the benefits occur in July under the dry hydrological condition. The smallest savings are found in April under the wet hydrological condition. In principle, the largest cost savings are realized under the dry hydrological condition ($7.5 million average savings in four typical weeks), then under the average hydrological condition (average $6.5 million), and the smallest savings are achieved under the wet hydro condition (average $4.6 million). In terms of percentage savings compared to the operation of individual systems, the results show an average of 11.3% savings under the wet hydrological conditions, 13.9% savings under the average, and 15% savings under the dry hydrological conditions. These are the average costs savings for the four analyzed weeks in different seasons of the year.

Table 1. Total Operating Costs for Two Scenarios

3rd Week of the Month	Weekly Operating Costs Under Different Hydrological Conditions (U.S.$ '000)		
	Average	Wet	Dry
Operation of Individual Systems			
January	70,290	64,296	77,867
April	32,941	26,665	40,058
July	39,792	33,985	43,478
October	48,100	42,694	53,597
Regional Market Operation			
January	61,200	57,645	71,237
April	28,420	23,965	32,946
July	32,336	28,630	34,385
October	43,162	38,864	46,606
Savings in Operating Costs			
January	9,090	6,651	6,630
April	4,521	2,700	7,112
July	7,456	5,355	9,093
October	4,938	3,830	6,991
Average Cost Savings	6,501	4,634	7,457
Average Cost Savings (%)	13.92	11.30	15.06

The GTMax results also show that the average electricity production costs in the region are significantly lower for the regional market operation compared to the operation of individual utility systems. Figure 3 provides a comparison of the average electricity production costs in the region in different seasons during the year and under different hydrological conditions. The costs shown in Figure 3 are the variable costs of electricity generation (e.g., fuel costs and costs of electricity purchases) and do not include fixed costs (e.g., fixed O&M and capital costs). Since the fixed component of the electricity generation cost is identical for both scenarios, Fig. 3 shows that regional electricity market operation results in lower average costs of electricity generation in all analyzed time periods (seasons) and under all hydrological conditions.

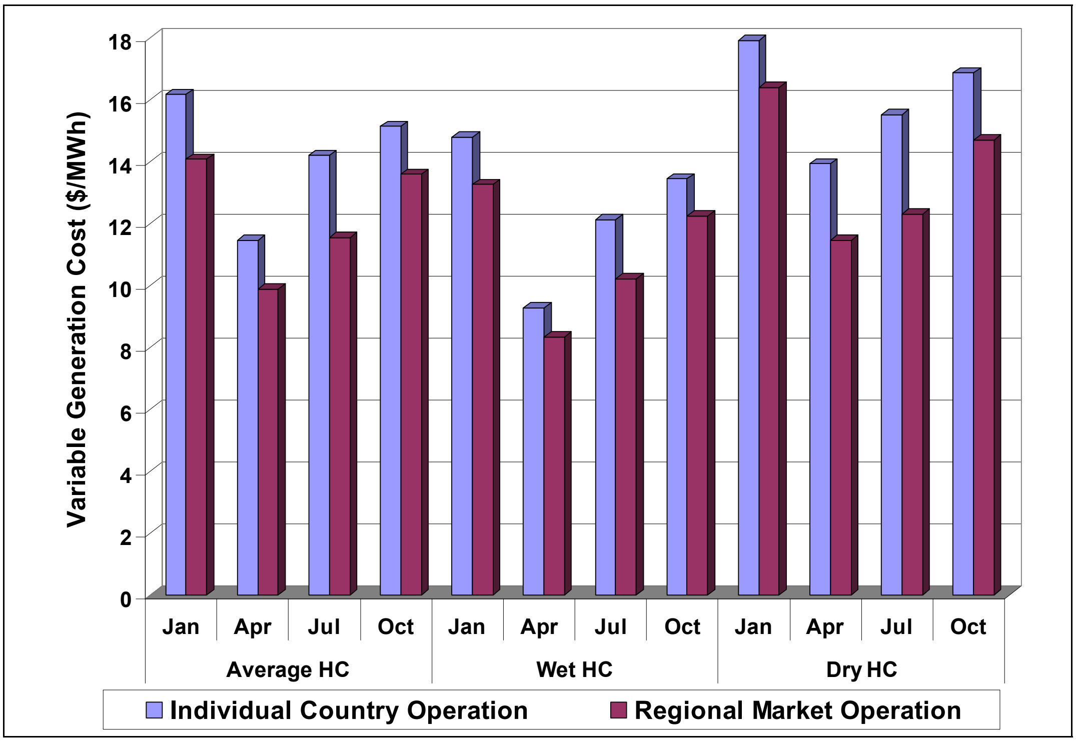

Figure 3. Comparison of the Average Costs of Electricity Generation in the Region

GTMax was also used to calculate hourly LMPs in each node of the regional network. A sample illustration of LMPs by country is presented in Figure 4, which provides a comparison of the average weekly LMPs for the utility systems in the 3rd week of October under average hydrological conditions. In the operation of individual utility systems, LMPs show wide variations from system to system, depending on the plant mix and internal generation costs. On the other hand, in the regional market operation, the LMPs show less variation and tend to equalize the prices of electricity across the region. In the regional electricity market, the variations in LMPs mostly occur when there is transmission congestion in some parts of the network. GTMax simulation results showed that in most cases the regional transmission network in 2005 (including the new transmission links expected to be in operation in 2005) seemed to be capable of transferring the power among the systems, and there was very little variation in LMPs among different utility systems. However, additional load flow, stability, and fault studies should be undertaken to determine the exact needs for transmission system reinforcements in the region. Albania was found to be an area with the weakest connections to the rest of the network, and it was regularly experiencing some transmission congestion. Consequently, the resulting LMPs in Albania in the regional market operation were somewhat higher than in the other systems.

Energy transactions in the regional electricity market intermittently loaded certain interconnections up to their contractual transfer limits. This was most true for the interconnection links between Bulgaria and Romania, and Yugoslavia (Serbia) and Romania. The reason for this was that, in the regional market operation, Romania was frequently purchasing large quantities of less-expensive power generated in Bulgaria and Serbia. However, this does not increase the LMPs in Romania since all interconnection links were not simultaneously loaded to limit. Therefore, there was always an opportunity to purchase power at a similar price from at least one interconnection point.

In the GTMax simulations, each utility system was required to provide a certain amount of regulation and contingency reserves. The assignments of reserve capacity for regulation (automatic load control - ALC) and for contingency reserves (spinning and non-spinning) to be maintained by individual power plants were optimized by GTMax on an hourly basis. Integrated operation in an interconnected regional electricity market allows for savings in ancillary services, especially in providing the contingency reserves. Compared to the operation of individual systems, all utilities had to provide significantly lower amounts of contingency reserve in the integrated regional operation scenario.

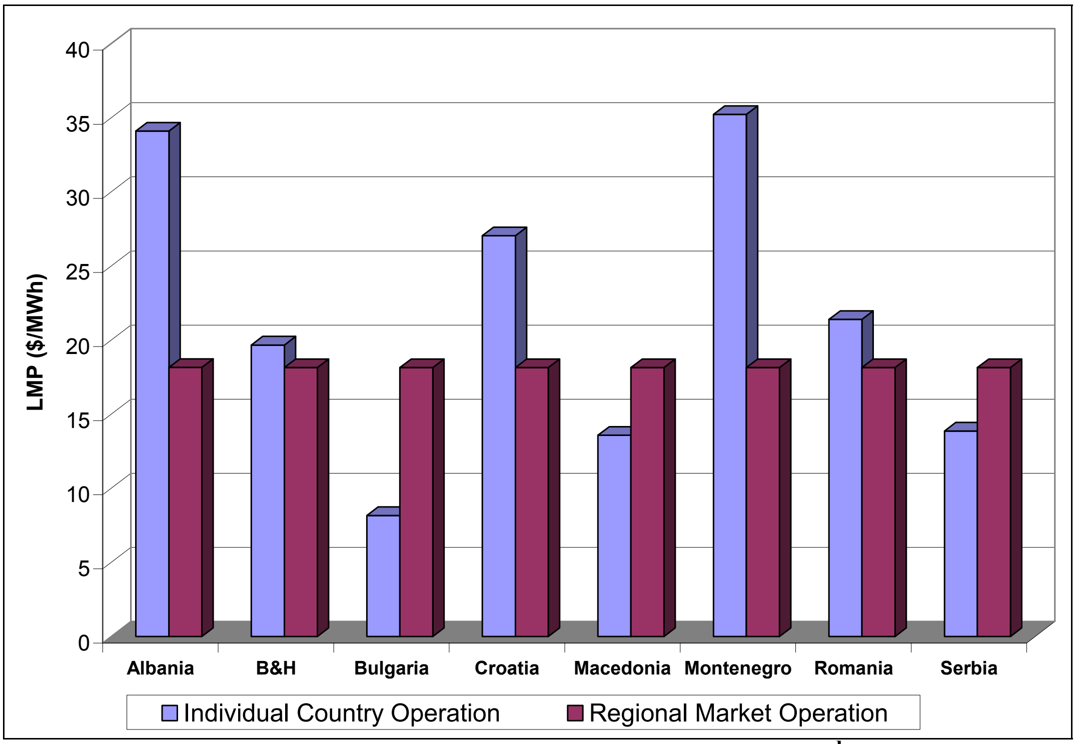

Figure 4. Average Locational Marginal Prices by Country in the 3rd Week of October 2005 under Average Hydrological Conditions

Hydro and pumped-storage plants provide most of the ancillary services in both the independent and regional market operations. The contribution of thermal power plants to ancillary services is relatively small and even further decreases in the regional market operation. In the operation of individual systems, the contribution of thermal capacity to the total regulation reserve was averaging about 121 MW, or 16.6 percent of the total. This contribution decreased in the regional market operation to an average of 76 MW, or 10.5% of the total. In the case of contingency reserves, the contribution of thermal capacity was already very small (about 1%) in the operation of individual utility systems and decreased to zero in the regional market operation.

6. Conclusions

The study shows significant benefits of a regional electricity market in Southeast Europe. Practically all of the countries can expect lower electricity generation costs, while some of the utility systems that are suffering shortages of electricity supply would also have more reliable access to power through regional market purchases. In general, the regional market operation would allow for more cost-effective electricity production in the region by increasing the utilization of the most economical generating units (and, on the other hand, decreasing the utilization of the most expensive units), reducing the need for certain ancillary services, and increasing the overall reliability of system operation through better interconnections with other systems.

7. Acknowledgments

The analysis presented in this paper was performed by a team of experts from Argonne National Laboratory and Montgomery Watson Harza under the sponsorship of the USAID. The authors would also like to acknowledge the efforts of numerous utility experts from Southeast Europe that have participated in this project. Their inputs and valuable insights were greatly appreciated.

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9. Biographies

Vladimir S. Koritarov graduated in 1982 from the School of Electrical Engineering, University of Belgrade, Yugoslavia. Until 1991 he worked as Senior Power System Planner in the Union of Yugoslav Electric Power Industry. In 1991 he joined Argonne National Laboratory, U.S.A., where he is presently an Energy Systems Engineer in the Center for Energy, Environmental & Economic Systems Analysis. Mr. Koritarov has 21 years of experience in the analysis and modeling of electric and energy systems in domestic and international applications. He specializes in the analysis of power system development options, modeling of hydroelectric and irrigation systems, hydro-thermal coordination, reliability and production cost analysis, marginal cost calculation, risk analysis, and electric sector deregulation and privatization issues.

Thomas D. Veselka is an Energy Systems Engineer in the National and International Studies Section at Argonne National Laboratory. He has provided technical support and managed projects related to electric utility systems and the environment for over 20 years. His work includes extensive hydropower systems analyses in relation to power markets. Mr. Veselka builds optimization and simulation tools and is currently a member of a multi-disciplinary team that is writing an agent-based modeling system that simulates the complex adaptive behavior of participants in a deregulated electricity market.

7. THE ELECTRIC POWER SYSTEM OF BULGARIA: ON ITS WAY TO UCTE

Bozhidar Pavlov, Head of Transmission Planning Department, National Dispatching, Bulgaria

Abstract In April 1996 the Electrical Power System (EPS) of Bulgaria started parallel operation with the neighbouring Balkan electrical power systems - members of UCTE, and the EPS of Romania. The main goal was directed to interconnecting of the Bulgarian EPS to UCTE. For the purpose, a modernization process began in the Bulgarian EPS for meeting the UCTE requirements and recommendations.

1. Introduction

The Bulgarian EPS was interconnected to the Second UCTE Synchronous Zone on 26 April 1996. The parallel operation of the Bulgarian Power System with the Second UCTE Synchronous Zone significantly improved the performance of the whole interconnection, which resulted in higher quality of the frequency control, higher stability and reliability level of the parallel operation and increase of the network transmission capacity. The National Electric Company expressed its intention for joining the UCTE. A program for the Bulgarian EPS modernization was initiated for meeting the UCTE requirements and recommendations.

2. Basic Data for the Bulgarian Power System by the End of 2002

Table 1. Installed Generating Capacities by the End of 2002

Power Plants	MW	%
Thermal	6500	53.1
Nuclear	2880	23.5
Hydro	2870	23.4
Total	12250	100.0
Peak load in January 2002	6770	

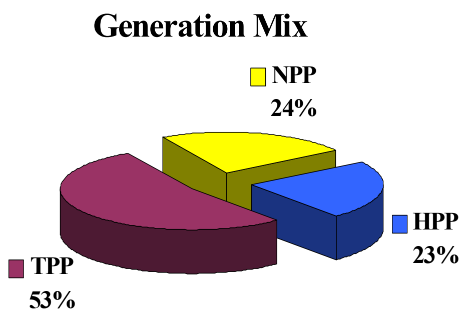


Figure1. Generation Mix

Table 2. Electricity Generation in 2002

Power Plants	GWh	%
Thermal	21214	49.7
Nuclear	18800	44.1
Hydro	2635	6.2
Total	42649	100.0
Domestic Consumption	36355	82.5
Export	6294	14.8

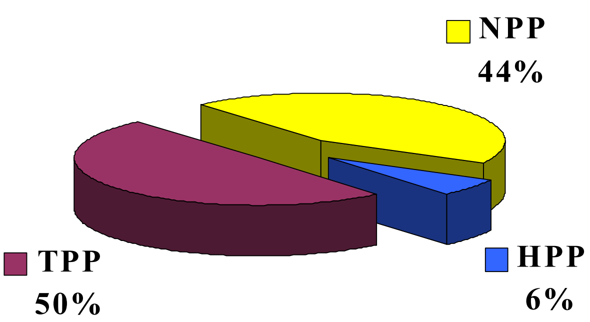


Figure 2

3. Important Steps Undertaken by NEK in the Process of Interconnection to UCTE

1992 - 1994	Feasibility Studies for Synchronous Operation of the Bulgarian and Romanian Electric Power Systems with UCPTE
26 April 1996	Synchronous connection of the Bulgarian EPS to the Second UCTE Synchronous Zone.
05February 1997	NEK sends an official letter to the UCTE President announcing the NEK intention for joining UCTE.
22 May 1997	Establishment of a Technical Committee UCTE/Bulgaria-Romania.
April 1999	The Technical Committee UCTE/Bulgaria-Romania approved a Catalog of Measures for Integration of the EPSs of CONEL and NEK into a Synchronous Operation with UCTE.
December 2000	Completion of the Technical Study “Stability of the Synchronously Interconnected Operation of the Electricity Networks of UCTE/CENTREL, Bulgaria and Romania”.
08 Jan - 31March 2001	Winter trial parallel operation of the Bulgarian and Romanian EPSs (12 weeks).
09 June – 30 Sep 2001	Summer trial operation of the Bulgarian and Romanian EPSs.
01 Feb 2002 – 31 Jan 2003	The results of the tests in isolated operation of the Bulgarian and Romanian systems were approved and one-year trial parallel operation of the Bulgarian and Romanian systems withi the Second UCTE Synchronous Zone was launched.
November 2002	Initiation of the project “Membership of Bulgaria in the UCTE Accounting and Coordination Block North”.

4. Investment Projects

The Technical Committee UCTE/Romania-Bulgaria elaborated a Catalog of Measures for Interconnection of the Bulgarian and Romanian EPSs to UCTE. The Catalog specifies the requirements that should be met by the Bulgarian and Romanian EPSs before the interconnection to UCTE. In line with this Catalog of Measures the following Investment Projects have been carried out in the Bulgarian EPS:

- SCADA/EMS modernization;
- Replacement of the turbine governors of thermal units;
- Replacement of the excitation systems of the biggest nuclear and thermal units and installation of digital voltage regulators with incorporated PSS;
- Modernization of the turbine controller software of the 1000 MW nuclear units in order to assure their participation in the primary control;
- Installation of a recording system for analyses of units behavior, participating in primary control;
- Modernization of the relay protections in the 220 kV network;
- Installation of out-of-step protections at 400 kV interconnection lines.

5. *EPS On-line Control*

- On-line control is performed by means of SCADA/EMS system TELEGYR 8000 including:

- Supervision Control and Data Acquisition system (SCADA);
- Automatic Generation Control (AGC);
- Economical Dispatch (ED);
- Real Time Network Analysis;
- Interchange Transaction Scheduler;
- Load Forecast;
- Dispatcher Training Simulator.

6. *Primary Control Reserve*

Most of the powerful units in the Bulgarian EPS are provided with new or upgraded technical equipment for operation under primary control. These involve 10 units of 210 MW each in the coal-fired power plants, 2 units of 1000 MW each in the Kozloduy NPP and about 28 units with installed capacity between 10 and 216 MW each in the hydro power plants. Now the Bulgarian EPS is able to provide up to 300 MW primary control reserve, which is in full compliance with the UCTE requirements. Currently, the required primary control reserve for the Bulgarian EPS within the Second UCTE Synchronous Zone is determined as 116 MW.

7. *Measures against Swings and Low Frequency Oscillations*

The largest power plants of the Bulgarian EPS have very strong connections to the high voltage transmission network

Nevertheless, during the last few years a modernization of the excitation systems and the replacement of the Automatic Voltage Regulators (AVR) of the biggest synchronous generators were carried out. The PSS function is incorporated within the new voltage regulators. The PSS settings are calculated for damping of local mode, regional mode and inter-area oscillations. They can be optimized and readjusted when the Second UCTE Synchronous Zone together with the Bulgarian and the Romanian EPSs are reconnected to the UCTE main grid.

8. *Tests and Results*

The tests were provided in two phases. In the first phase, the Primary Control and PSS were tested unit by unit. In the second phase, the behavior of the entire EPS was tested in a mode of "island" operation of the Bulgarian and Romanian EPSs. The "island" tests were provided with planned outages of generation capacities and load. The test periods continued for two weeks in March and two weeks in September 2001.

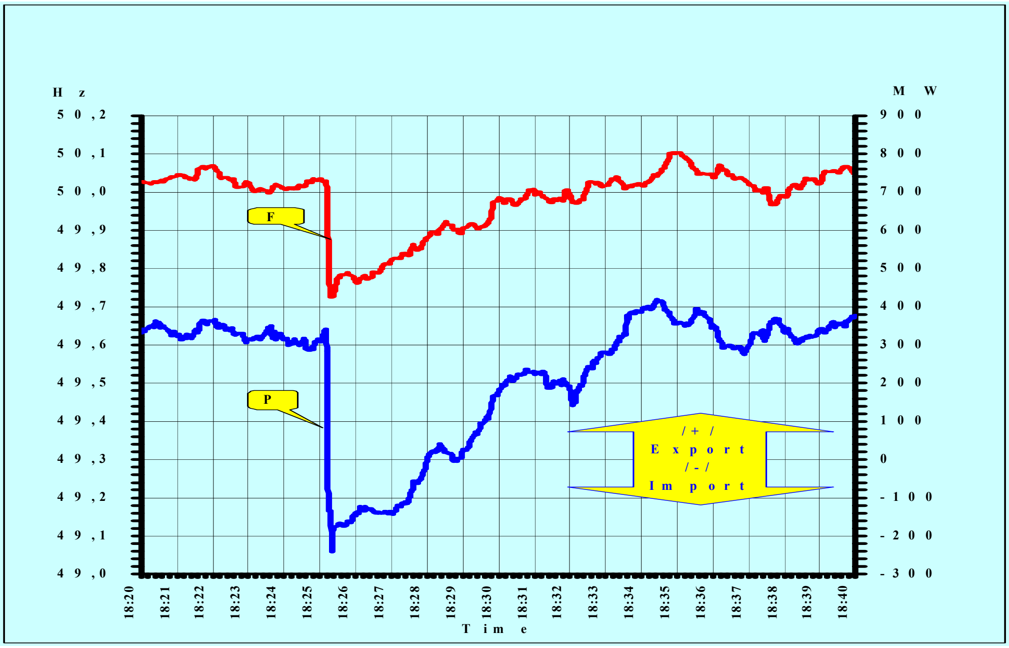


Figure 3

For example, Fiure 3 shows the frequency deviation and power exchange deviation of the Bulgarian EPS and Figure 4 shows the response of the unit 5 in Varna TPP in case of unplanned outage of 700 MW generation capacity in the Bulgarian EPS.

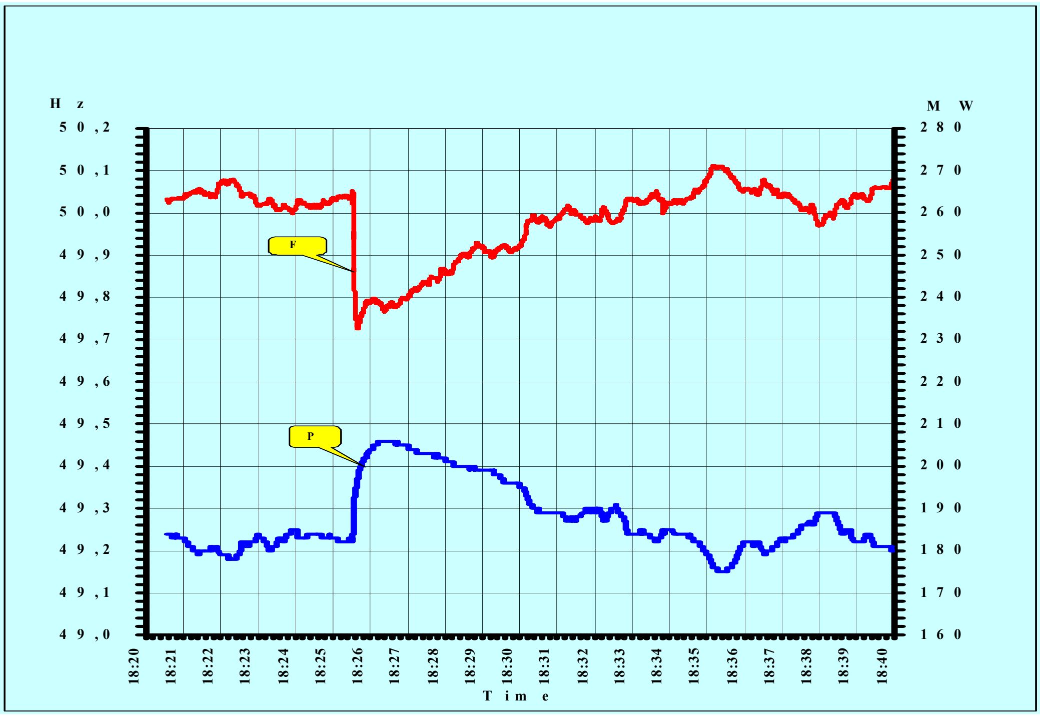


Figure 4

The generators with installed PSS were tested when the Bulgarian EPS was operating in parallel within the Second UCTE Synchronous Zone. The tests were provided with step-up signals and sinusoidal signals. The test had to prove the low frequency oscillations damping effect.

An evaluation team has estimated the test results and has come to the conclusion that the quality of the primary control reserve is in compliance with the UCTE requirements. PSS demonstrate a good damping in "island" mode of operation. They should be tested again after interconnecting the Second UCTE Synchronous Zone to the main grid of UCTE.

9. Energy Accounting

The Bulgarian TSO has made a decision to join the Accounting and Coordination Block North after the synchronization of the Bulgarian EPS to the UCTE main grid. In this regard, a project for Integration of the Bulgarian Power System into the UCTE Accounting and Coordination Block North is in progress.

The main objective of the project is to support the establishment of an Accounting Center in Bulgaria and its further integration into the UCTE Accounting and Coordination Block North, represented by RWE Net Brauweiler.

10. Acknowledgment

The achievements reported in this paper present the results of the joint efforts of the experts from the National Dispatching and from the main power plants of the Bulgarian EPS.

11. Biography

Bozhidar Pavlov has a M.Sc. Degree in Electrical Engineering from the Sofia Technical University, Bulgaria. Since his graduation he has been working for the Bulgarian National Electric Company. From 1983 to 1987 he was a NEK representative at the Central Dispatching Office of IPS (Prague) as a relay protection engineer. After his return to NEK he became a transmission planning engineer and currently he is the Head of the Transmission Planning and System Analyses Department at the National Dispatching Center of Bulgaria. International activities: Member of the UCTE WG Operation & Security; Acting secretary of the Technical Committee UCTE/Romania-Bulgaria.

8. ROMANIAN ELECTRICITY SECTOR REFORM, MARKET OPENING AND CHALLENGES

Jean Constantinescu, Director General, Transelectrica – Romania

Abstract - The transformation of the Romanian Power Sector from the monopoly of a vertical integrated structure to a competitive electric market has been gradually carried out since August 2000. The relative long transition occurred considering the initial structure of the sector, the lack of market experience, the impact of these deep changes on the market participants and the economy.

Electric market opening had a significant growth, from 10% in February 2000 to 33% in February 2002.

1. Power Sector Restructuring Process

In July 1998, the Government restructured the state-owned integrated regie RENEL, as a first step in the implementation of the power sector reform program. Further to this restructuring stage, CONEL was set up, a joint stock company including three legal subsidiaries: Termoelectrica, Hidroelectrica (generators), and Electrica (distributor and supplier). Nuclearelectrica was also set up, as a separate generating company.

In September 1998, ANRE – The National Electricity and Heat Regulatory Authority was founded within the new regulatory framework.

The second significant stage in the restructuring plan was carried out in July 2000. CONEL was split up into four fully separated joint stock companies: Transelectrica (National Power Grid Company), Termoelectrica., Hidroelectrica and Electrica.

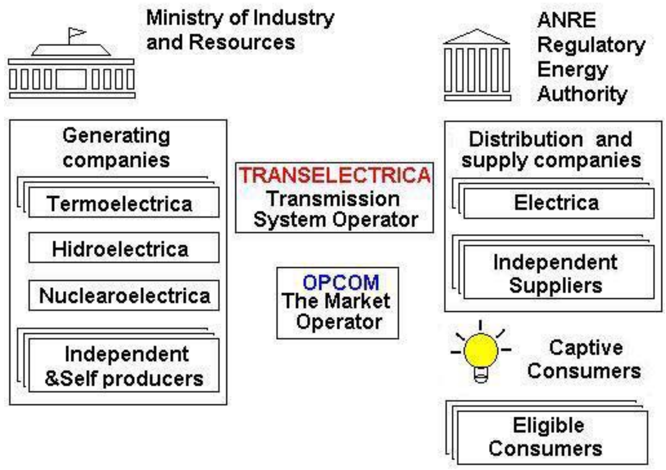
The process was further developed in a similar way in the second half of 2002. A number of 8 legal supply and distribution subsidiaries were established within Electrica, while Termoelectrica was divided into 6 legal subsidiaries. Meanwhile, a number of 40 independent electric private suppliers have emerged.

At present, the privatization of generating and supply/distribution companies is under final preparation. Transelectrica will remain wholly state-owned, at least within the mid run.

2. *Regulatory Framework*

The primary legislation is made up of Law No. 99/2000 (Energy Regulation Act), Government Emergency Ordinance (GEO) No. 63/1998 (Energy Act), and a number of Government Decisions (GD). The existing legislation is basically in line with the European Energy Directive. The secondary legislation consists of regulations issued by the Romanian National Electricity and Heat Regulatory Authority and includes:

- Licenses and Authorizations
- Technical Transmission and Distribution Grid Codes
- Wholesale Electric Market Commercial Code
- Tariffs and tariff methodologies for that part of the market that is not competitive.
- Framework contracts for trade arrangements on the electric market.



- *Figure. 1. Structure of the Romanian Electric Market*

2.1 Generation:

Termoelectrica.

At the end of 2002 Termoelectrica had 17 thermal power plants in operation, being organized in 6 legal subsidiaries and 4 branches: Deva, Rovinari, Turceni and Bucuresti.

Termoelectrica still remains the main Romanian power and heat generator. The electricity generation delivered in 2002 was 25 TWh and the thermal generation was 17200 Tcal.

After decommissioning some obsolete capacities, the installed capacity reached 9743 MW at 31 December, 2002.

A rehabilitation and repowering program for a capacity of 2350 MW is underway.

Hidroelectrica

Hidroelectrica supplies electricity and ancillary system services by using almost all the country's hydropower plants.

It generated 16 TWh in 2002, i.e., 29% of the total country generation.

The generation for an average hydrological year is about 17.3 TWh.

Hidroelectrica has 12 regional branches with 343 units (including 4 water pumping stations) and 219 micro hydropower stations, summing up an installed capacity of 6266 MW.

In 2002 a number of 8 maintenance service companies "Hidroserv" were established by Hidroelectrica.

Nuclearelectrica

Nuclearelectrica generates nuclear electricity based on CANDU 6 type nuclear technology.

Further to its commissioning on December 2, 1996, the Cernavoda Unit #1 (706 MW installed) has annually produced 10% of the overall country generation.

The Unit #2 is now 40% completed and the project is planned for commissioning by the year 2006. The nuclear program is expected to by continued by installing the Units # 3 and #4.

2.2 Transmission and System Operation

Transelectrica - the National Power Grid Company is acting as the country's Transmission System

Operator (TSO).

Transelectrica owns transmission assets, ensuring a non-discriminatory and regulated network access.

The national transmission grid operates at 220 kV, 400 kV and 750 kV having a total length of 8795 kilometers, with 76 EHV substations.

According to its operation license, Transelectrica does not have the right to trade electricity; it can only buy electricity to cover transmission losses.

Transelectrica fulfils the system operation function, through its Operational Unit – National Power Control as well. A Central Dispatching Center and five Regional Dispatching Centers provide power dispatch for a number of the 342 power units in the system.

The main responsibilities of Transelectrica are:

- Provides the real time control of the power system, by using the ancillary system services.
- Ensures interconnected operation with other power systems.
- Ensures the wholesale market administration through its fully owned subsidiary, OPCOM.
- Ensures the non-discriminatory access and grid connection to all grid customers in a transparent manner.
- Operates, maintains, modernises, plans and develops the transmission grid assets.
- Ensures the metering service for the wholesale electric market.

The 8 electricity transmission subsidiaries in Bacau, Bucuresti, Cluj, Constanta, Craiova, Pitesti, Sibiu and Timisoara are responsible for asset management and operation at the level of substations.

Transelectrica also owns key – important companies in the sector:

•**OPCOM,** the Power Market Operator, is providing a transparent transaction platform for the wholesale electric market.
•**SMART**, a subsidiary that provides grid maintenance services.
•**FORMENERG**, a subsidiary for vocational training services for all power industry.
•**TELETRANS** provides the in-house telecommunication services and IT.

On February 1st, 2003 the final stage of the UCTE interconnection program was successfully completed by the Romanian power system, under the coordination of Transelectrica. Consequently, Transelectrica is to become full UCTE member later in 2003.

2.3 Distribution

Electrica operates and owns the distribution network (110 kV and below) and provides electricity supply services for more than 8 million customers.

Electrica is now a group of 8 regional joint stock companies for distribution and supply. Electrica has also 8 regional service branches that provide maintenance and overhauling services on a contractual basis.

The Electricas have the obligation to render a public service and provide non-discriminatory access to all electricity customers in Romania, as well as to all generators requesting it.

The activities currently performed by the electricity distribution and supply branches are:

- electricity distribution;
- electricity supply (purchases on the wholesale market and deliveries on the retail market, electricity metering and billing);

According to the National Strategy, the Government has just started privatization of the first three regional subsidiaries: Electrica Banat-Timisoara, Electrica Dobrogea- Constanta and Electrica Muntenia Sud- Bucuresti.

3. Electric Market

3.1 Electric Market structure

The wholesale electric market is based on the regulated TPA principle and bilateral trade arrangements for electricity and associated services. The regulated bilateral contracts for electricity, either portfolio or PPA type, cover 67% of the market. They are concluded in-between generators and the Electricas.

Network operators ensures the mandatory public services (network connection, electricity transmission and distribution) for all licensed market participants.

The negotiated contracts represent the main competitive segment of the market (33% of the total electricity sold in 2002). They are concluded in-between generators, electric suppliers and contestable customers.

Both incumbent and old participants on the electric market are on the same level playing field. There are 45 big eligible consumers that cover 25 % of the market.

A day-ahead spot market acts as a balancing mechanism, offers the market price and some 2 to 5 % of the total energy selling. It is run within the process of power system scheduling based on merit-order principle and competitive generator offers. The generators that have guaranteed prices and quantitative deliveries through their portfolio contracts should make day-ahead competitive offers as well.

For the regulated contracts the suppliers must ensure daily payments, according to a specific procedure approved by ANRE.

Transelectrica is in charge of substantiating the portfolio selling/purchasing contracts established between the major generators and the Electricas. This is carried out by running an optimisation computer code, the model being approved by ANRE.

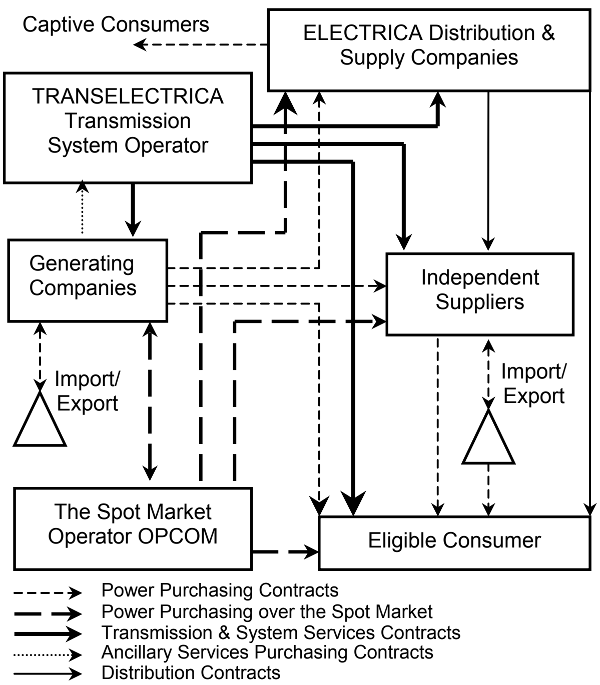


Figure 2. Contractual arrangements on the wholesale Market

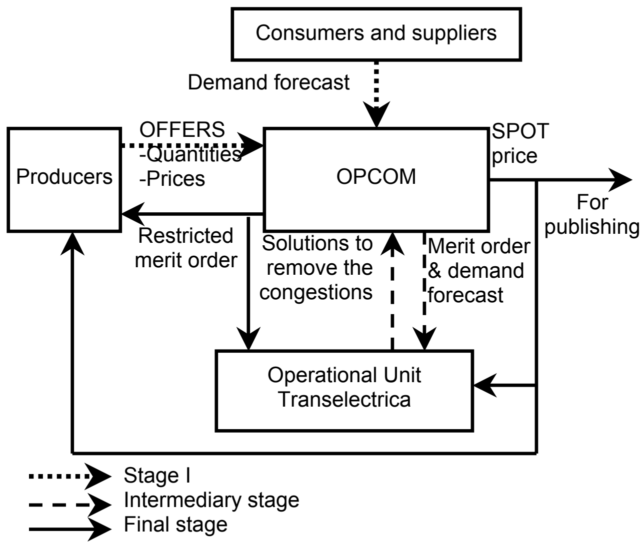


Figure 3. Transelectrica Scheduling procedure based on the producers' offers

The portfolio contractual provisions (Qxp) are defined for each hourly base accounting interval and contractual day.

The marginal cost-based transmission tariff, as a market tool, is meant to determine an efficient operation and development of the network. The tariff should ensure that the total cost of the transmission service, including the cost associated to congestion, be fairly and entirely allocated on beneficiaries, depending on the real impact this service has upon the functioning of the power system as a whole. Transelectrica applies regulated transmission zonal tariffs, separately established for delivering (G) and receiving (L) points.

3.2 Market Operation

The scheduling of the dispatchable generating units activity addresses both generating and ancillary services.

OPCOM is carrying out the generation scheduling in the following sequence:

- the generators send their power supply and ancillary services offers;
- the suppliers send the demand forecasts;
- the System Operator checks for congestion;
- OPCOM establishes the final demand forecast, the unconstrained merit order on an hourly basis, the marginal price and the operational schedule of the dispatchable units.

4. Conclusion

The 3 years electric market operation experience shows that power sector unbundling and the market tools improve efficiency and reliability of electricity service even in the early stages.

The adhering countries to the Memorandum of Understanding on the Regional Electricity Market in South East Europe and its integration into the European Union Internal Electricity Market, signed in Athens on November 2002, are willing to establish a regional market, competition and increased trade within the CEE region as a part of the EU internal electric market. After the Athens meeting the interest for a power exchange in Bucharest increased significantly and the Ministry of Industry and Resources invited all interested power companies in the Balcan region to join Transelectrica as partners. This invitation was highly considered by the European Commission.

5. Biography

Jean Constantinescu has been Director General of the National Power Grid Company “Transelectrica” – S.A. since August 2000, after having been formerly the President of the Romanian Electricity and Heat Regulatory Authority (ANRE) since February 1999. He joined the Romanian Electricity Authority (RENEL) in May 1997, as the Coordinator of the Strategy and Reform Committee. He was also Director General and Director of the R & D Center with the Energy Research and Modernizing Institute (ICEMENERG) and head of the Power System Department with the National Power Control Operational Unit.

Dr. Constantinescu is a member of the EURELECTRIC Board of Directors and Chairman of EURELECTRIC Romanian National Committee, Vice-Chairman and Member of the Editorial Staff of “Energetica” Review, Member of the Romanian National Committee to the World Energy Council, and Chairman of the R & D Energy Commission, Ministry of Education and Research.

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