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# ENERGY INFRASTRUCTURE IN YUGOSLAVIA: THE PAST AND CHALLENGES AHEAD

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## ABSTRACT

In this paper an assessment of major changes in managing electric energy system of former Yugoslavia are assessed by providing specific data on energy sources prior to 1990 and after it. The data represent a textbook example of a planning and operating paradigm shift from cooperation among loosely connected entities to an operating paradigm in which the newly formed entities make their energy decisions in a rather decentralized, somewhat competitive way. The effect of this shift on the overall energy situation in the newly formed entities is illustrated. Technically, the case is very illustrative of challenges in moving from an infrastructure designed for one type of coordination to the infrastructure in which this cooperation is no longer assumed and changes in infrastructure (in this case, transmission and generation additions) are needed. The paper suggests careful assessment of this process from both technical and economic/regulatory/environmental points of view in order to make meaningful decisions in face of such major challenges. An important recognition in the paper is that conceptually the process discussed here is very related to a typical process as some other parts of the world undergo electricity industry restructuring. In this sense, the modeling, analysis and decision making tools under development for the energy industry under restructuring are useful to keep in mind when moving forward with the energy solutions in the Balkans after the war.

Key words: energy economics, managing systems, planning

## 1. INTRODUCTION

### THE BASIC PROBLEM OF ENERGY ECONOMICS IN THE BALKANS

It is well known that that former Yugoslavia has been in the political turmoil over the past decade. What is less known and documented are the major infrastructure changes caused by this process. Major effects and estimates of the damage of physical equipment in current Yugoslavia were documented at the most recent CIGRE meeting in Paris by one

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of our co-authors as the major contributor to this evaluation . In this paper we first briefly summarize the findings of this study on the energy equipment damages. Then, we move on to consider somewhat hidden consequences of the war on the shift of operating and planning paradigms in the newly formed entities. We devote this paper to the energy problem and its economics as one of the major infrastructures; however, we recognize that similar issues are present in other parts of the infrastructure.

The basis for writing this paper was the recognition of the authors that this problem has conceptually much in common with a typical process that is taking place in many parts of the world as the electric power industry transitions from a regulated monopoly to a competitive industry, in which energy is based on basic supply/demand laws of economics. The rationale for this parallel is described briefly in this paper, as well. It basically rests on the conceptual change from cooperation to competition. This, furthermore, points into the direction that as one considers new operating and planning approaches to energy provision in the Balkans, much of the knowledge and experience gathered on industry restructuring could be used to proceed with systematic solutions of energy provision in the Balkans. In particular, since the first author of this paper has been deeply involved in the power industry restructuring related research and development, it became somewhat obvious that teaming up of researchers who had intimate knowledge of the data and current operating and planning approaches in Yugoslavia with those working on more general restructuring problems made much sense. This is how this paper was conceived.

## **BASIC PROBLEM OF INTEREST**

The problem of interest here is two-fold. How does one supply energy to the load demand within a loosely organized entity, first under cooperation and second, under competition. To start with, the researchers in former Yugoslavia have been actively engaged in managing the energy system by means of a Control Center similar to the control centers elsewhere in the world. Much effort has been put into developing software for managing the available energy sources as efficiently as possible. Techniques such as security constrained economic dispatch, automatic generation control, planning tools and alike have advanced great deal over the years. This knowledge was organized in the recent papers and textbooks published by the co-authors. The basic principles of operating a coordinated system began to change as the country separated and its various parts began to connect to new neighbors. The reader not familiar with the hierarchical control underlying power pool under cooperation could consult these references.

After the political turmoil, once fully coordinated operations and planning fractured into subparts. The infrastructure in these subparts was not sufficient to support the energy needs of their consumers, without either investing into new power plants, or relying on new import/export patterns with the neighboring countries to which these are directly connected now. In addition, some form of demand response is possible to reduce demand when possible and desired by the users. This situation, although triggered by unfortunate political events, is a scaled-down example of a typical situation in various parts throughout the world triggered by the regulatory restructuring from fully regulated energy provision to competitive provision. Think of one of the leading power pools in the United States, such as New York or Pennsylvania-New Jersey-Maryland, and its utilities (control areas) competing for energy for their customers within once cooperating pool members. Or, think of the countries in European Union (EU) with well defined boundaries, competing for purchasing energy from neighboring countries. None of these systems were designed for

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the type of energy exchange experienced under restructuring, and, more importantly, the operations and planning were done assuming full information about the grid structure and the cost of energy sources. The sub-entities within a larger entity (utility within PJM, a single country within EU) were obliged to serve their consumers and, at the same time were guaranteed that these would be their (native) customers. This obligation to serve and an implied guarantee that one has a well defined customer to sell electricity to diminish under deregulation. Everyone could, at least, in principle purchase from everyone else, if the terms are agreeable. This creates tremendous challenge to once well understood hierarchical operations and planning. Think of the notion of Area Control Error (ACE) under so-called open access!

As Yugoslavia re-thinks its energy policies, one should consider two types of questions. The first is the difference between operations/planning at a single entity level (country) when the energy provision is regulated or competitive. Under competition, energy is planned and provide in response to price and need . This requires basic electricity market design, which could have either long-term bilateral agreements between suppliers and customers and/or shorter-term electricity purchases based on daily changes in electricity prices . Together with this comes the need for modeling, predicting and using price of electricity as an active information. Seminal work on this modeling was recently done by the first author and her associates, and this knowledge could be used to model and understand possible outcomes if individual countries in the Balkans engage in their own deregulation.

The second major question concerns the mechanisms of trading for electricity by the entities which have no direct incentives to cooperate. This is the question of managing exports/imports on competitive basis. The first author of this paper has been actively engaged in an analogous question concerning formation of so-called Regional Transmission Organizations (RTOs) in the United States, and to some extent in the Florence agreement for the EU. The issues here are harder to grasp. The basic question is if reliability could be managed as large inter-country energy exchanges take place without introducing a coordinating umbrella type mechanism. It is somewhat clear that if such mechanism were to be introduced, it has to be market based. This would be a market for managing tie-line flow exchanges based on the value they provide to the participants in this market. The first author of this paper has actively promoted formation of such an entity (Inter-regional Transmission Organization—IRTO). This is in contrast with the proposals which rely on data exchange only. It is critically important to familiarize with these alternatives as Balkan countries attempt to ensure sufficient energy to their population. As mentioned earlier, this could be done either by investing into new power plants locally, or rely on well defined markets for imports and exports. The economic effects of choosing one or the other should be assessed very carefully prior to any implementations.

This paper provides an analysis of the energy situation, and its operations and planning practices, in Yugoslavia, before and after 1990. This material and data were provided by the co-authors from Belgrade. The material provides a description of basic approaches in former Yugoslavia to planning and operations based on loose cooperation under one power pool coordinating the exchanges between different republics. This part of the paper provides very relevant data concerning the energy supply distribution within former Yugoslavia, and the typical imports and exports between the republics, and between the neighboring countries.

The paper also describes horizontal changes within the Yugoslavian interconnection (disconnect from the newly formed countries) and connection to other neighboring

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countries with which there have not been active energy trades in the past. Again, the paper offers very recent data on the actual energy situation within the country after the war, as well as data on most recent agreements for energy exchanges.

The paper next describes challenges ahead in the current Yugoslavia. These concern the major mechanisms of providing for present energy shortages. These could be provided by either investing into new, possibly smaller and environmentally more acceptable resources, such as distributed generation comprising small hydro, wind and eventually solar energy, and conserving at the same time, and/or relying on heavy import/export with the neighbors within the new interconnection. An implied question, although the process has not started, is if the basic mechanism of energy provision in Yugoslavia would become more market based in the future. This is hard to predict at this point. However, it is becoming more and more obvious that the import/export process is likely to evolve into some form of monetary-based mechanism, possibly managed by a regional exchange for backup power.

## **2. ANALYSIS OF STATUS IN FORMER YUGOSLAVIA BEFORE DISINTEGRATION ON 1991**

### **2.1. General**

Although the Socialistic Federal Republic of Yugoslavia (SFRY), before 1991 was the unique, internationally recognized country, the electric power industry within six constituent republics (Bosnia & Herzegovina, Montenegro, Croatia, Macedonia, Slovenia and Serbia) was organized in the form of economically independent entities, associated in Yugoslav Association of Electric Power Industry (known as YUGEL). This Association was in business as the "Power Pool" organization, where all functions of the development planning and system operations (including internal and external energy exchange) were coordinated. In other words, the development and operations of independent republic's public utilities were both formally and actually interdependent, that any partial analyses of various republics' power systems could give a wrong picture on their real status. After the disintegration of the SFRY, to five independent countries (retaining the same names as former republics, mentioned above, except Serbia and Montenegro proceeding to live as "Federal Republic of Yugoslavia"-FRY), each of them continued to manage the own power system, so that, in the period 1991-2000, the independent power industries in all countries, successors of SFRY should be considered.

In the consideration that follows, the year 1990 is taken as the characteristic one, because it was the last year of normal functioning of SFRY and common YUGEL power pool. Although, the SFRY formally existed in 1991, political conditions and separation of one-by-one constituent republic, beginning June 1991, has as the consequence the disintegration of the common Yugoslav power system and beginning of the life of newly formed countries and their power systems.

In considerations that follow, the main characteristic data of the development and, operation of former YUGEL power pool, up to 1990, will be given.

### **2.2. Installed Capacities, Generation, Consumption and Exchange of the Electrical Energy**

Following tables exhibit data relative to federal republics and SFRY, as an entity, in 1990, for

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Installed capacities (Table 2.1);  
Generation (Table 2.2);  
Consumption (Table 2.3);  
Internal exchange of electrical energy (within SFRY-Table 2.4);  
External exchange of electrical energy of SFRY with foreign countries (Table 2.5);  
Transmission network facilities (Table 2.6);

In addition, Fig.2.1 presents the scheme of the transmission network of SFRY in 1990.

By expecting the above tables and figure, it could be stressed that with more than 21000 MW of installed capacity, gross annual generation of 82900GWh and net consumption of 74061 GWh, the YUGEL power pool represented a medium size entity, operating within regional interconnection of South European countries SUDEL (Besides SFRY, the other members of this interconnection were national power systems of Austria, Italy and Greece), connected to the permanent operation with West European continental interconnection UCPTE (Union for Coordination of the Production and Transmission of Electrical Energy), renamed since the year 2000 as UCTE (Union for Coordination of the Transmission of Electrical Energy). There were six 400 kV international tie lines (three with UCPTE member systems and three with COMECON countries of East Europe) and four 220 kV tie lines (two with UCPTE and two with COMECON countries). The total transmission capacity of tie lines with UCPTE country-members was about 2000 MW. In addition, another 2000 MW transmission capacities linked SFRY with COMECON countries (Hungary, Romania and Bulgaria), and Albania, but used for the exchange of energy, only in island type of operation (there was no permanent parallel operation of UCPTE and COMECON member systems though YUGEL power pool). According to Table 2.5, the total external energy exchange Import (Export) reached in the year 1990 about 5850 GWh (about 8% of the country net annual consumption; 48% of this exchange was realized with UCPTE and 52% with COMECON countries and Albania), where the export softly prevailed the import (3108 GWh: 2749 GWh).

Within the YUGEL pool, the internal exchange of electrical energy within SFRY in 1990 was four times more intensive, where some of republics (Serbia, Bosnia & Herzegovina) were net-exporters and some net-importers of electrical energy (Croatia, Montenegro), while Slovenia and Macedonia were almost self-sufficient.

Within the country, the coordination of operations was practiced in both medium-term (yearly budget-plan) and short-term (daily, weekly and monthly operation schedules), via YUGEL pool and republic utilities dispatching services. The same coordination for system economy (based on hydro-thermal coordination and merit order principles, security of operation, reliability of supply and system control (both tie-line exchange and frequency, and voltage-reactive power controls), was performed in close mutual cooperation of pool and republic's utility operators.

The policy of tariff systems and buying/selling prices of energy were the responsibility of republics, under strong monitoring and control of republic's governments. Within particular republics, transmission networks were under unique supervision of republican government controlled public enterprises, while energy producers and distribution companies, were (formally) independent organizations. Thus, some centrally supervised (on the level of republics) decentralization within electric power industry existed, under self-management principle of "associated work" in that time. After disintegration of the SFRY, these principles were abandoned everywhere, and in new independent countries, the electric power industry transformed to public service type of government-owned organizations.

**Table 2.1. - Installed gross capacities in SFRY on the end of 1990 in [MW]**

Type of the generation	Republic						
	Bosnia & Herzegovina	Montenegro	Croatia	Macedonia	Slovenia	Serbia	Yugoslavia
Hydropower plants	1838	667	2072	428	739	2931	8675
- Run-of river	901	-	467	55	705	1935	4063
- Storage	491	649	1305	332	-	374	3151
- Pumped-storage	420	-	276	-	-	588	1284
- Distribution	26	18	24	41	34	34	177
Thermal power plants	1947	210	1617	960	1531	5944	12209
- Coal	1947	210	125	750	991	5473	9496
- Oil	-	-	965	210	-	134	1309
- Gas	-	-	195	-	208	337	740
- Nuclear	-	-	332	-	332	-	664
Total, public plants	3785	877	3689	1388	2270	8875	20884
Industrial thermal power plants	371	24	94	57	38	311	895
Total	4156	901	3783	1445	2308	9186	21779

**Table 2.2. – Gross generation (including plant auxiliaries) in SFRY, 1990 [GWh]**

Type of the generation	Republic						
	Bosnia & Herzegovina	Montenegro	Croatia	Macedonia	Slovenia	Serbia	Yugoslavia
Hydropower plants	3476	1012	3742	491	2922	8449	20092
- Run-of river	1573	-	1413	108	2842	6992	12928
- Storage	1422	996	2001	323	-	596	5338
- Pumped-storage	405	-	279	-	-	787	1471
- Distribution	76	16	49	60	80	74	355
Thermal power plants	10675	1142	6625	5146	6719	29682	59989
- Coal	10675	1142	550	5146	4396	28440	50349
- Oil	-	-	3495	-	-	160	3655
- Gas	-	-	271	-	12	1082	1365
- Nuclear	-	-	2309	-	2311	-	4620
Total, public plants	14151	2154	10367	5637	9641	38131	80081
Industrial plants	945	21	609	100	385	759	2819
Total	15096	2175	10976	5737	10026	38890	82900

**Table 2.3. – Net consumption of the electrical energy in SFRY, 1990 [GWh]**

Republic	Type of the consumption				Net consumption at the transmission network
	Direct consumers	Distribution consumers	Transmission losses	Water pumping	
Bosnia & Herzegovina	3192	7827	354	287	11660
Montenegro	2011	1238	106	-	3355
Croatia	2703	11594	453	-	14750
Macedonia	1713	3358	163	-	5234
Slovenia	2621	2621	7248	305	10174
Serbia	1308	25208	1215	1157	28888
	13548	56473	2596	1444	74061

**Table 2.4. – Internal exchange of electrical energy within SFRY in 1990 [GWh]**

Republic	Delivery							SFRY*
	Bosnia & Herzegovina	Montenegro	Croatia	Macedonia	Slovenia	Serbia		
Bosnia & Herzegovina	?	58	1670	62	1167	58		3015 + (14)
Montenegro	62	?	17	1	3	541		624
Croatia	38	4	?	5	8	43		98 + (28)
Macedonia	222	23	65	?	110	231		651
Slovenia	242	6	40	143	?	53		484
Serbia	552	1841	2232	376	421	?		5422
SFRY*	1116	1932 + (7)	4024	587 + (11)	1709 + (24)	926		10294 ± (42)

\* Mismatch of data

**Table 2.5. – External exchange of republic and SFRY with foreign countries in 1990 [GWh]**

E	Yugoslav republic	Yugoslav republic						SFRY*
		B&H	Mon	Cro	Mac	Slo	Ser	
	IMPORT:							
	France	-	-	-	-	-	11*	11*
	Germany	-	-	-	-	-	11*	11*
	USSR	265	-	449	-	-	-	714
	Bulgaria	-	-	56	157	-	234	447
	Czechoslovakia	84	-	218	-	-	-	302

Greece	4	5	3	1	-	4	17
Italy	168	13	141	15	7	9	353
Hungary	5	-	2	-	-	72	79
Austria	15	-	-	3	-	2	20
Romania	-	-	-	-	-	5	5
Switzerland	308	7	438	9	-	-	762
Albania	9	1	-	-	-	18	28
Total import	858	26	1307	185	7	366	2749
EXPORT							
Bulgaria	-	-	16	-	-	57	75
Greece	17	3	2	8	14	164	208
Italy	266	3	287	36	6	586	1184
Hungary	-	-	-	-	-	62	62
Austria	1	-	-	-	-	2	3
Romania	-	-	-	-	-	1077	1077
Switzerland	3	6	22	-	9	183	223
Albania	2	-	4	6	-	264	276
Total export	289	12	331	52	29	2395	3108
Transit from Albania to:							
Romania	-	-	-	-	-	-	18
Bulgaria	-	-	-	-	-	-	18
Switzerland	-	-	-	-	-	-	1
Italy	-	-	-	-	-	-	7
Transit from Italy to Albania	-	-	-	-	-	-	73
Transit from Switzerland to:							
Albania	-	-	-	-	-	-	66
Greece	-	-	-	-	-	-	56
Transit from Austria to Greece	-	-	-	-	-	-	16
Transit from Bulgaria to Switzerland	-	-	-	-	-	-	8
Transit from Germany to Romania	-	-	-	-	-	-	61
Transit from France to Romania	-	-	-	-	-	-	63
Total transit	-	-	-	-	-	-	387

\*Compensation for transit to Romania

**Table 2.6. – Transmission network in SFRY on the end of 1990**

Republic	Transmission lines [km]			Transformers stations [MVA]		
	400 kV	220 kV	110 kV	400/x kV	220/x kV	110/x kV
Bosnia & Herzegovina	835	1421	3010	4500	2247	4821
Montenegro	254	318	657	600	700	1143
Croatia	733	1053	4453	3400	2850	6672
Macedonia	256	165	1565	1800	700	2947
Slovenia	414	303	1878	2100	1500	4169
Serbia	1550	2158	5880	6550	6713	11750
Total, SFRY	4042	5418	17443	18950	14710	31502

### 3. OPERATION CONDITIONS IN THE NEW COUNTRIES

#### 3.1. Establishing of the second UCTE synchronous zone (Balkans interconnection)

Second UCTE Synchronous Zone was formed as the result of war activities on the territory of former Yugoslavia.

Due to the destruction of interconnection lines in Croatia, one part of UCTE Interconnection was separated from the rest of UCTE network, on September 26<sup>th</sup> 1991. At that moment, this isolated part of UCTE Interconnection consisted of electric power systems of Bosnia and Herzegovina, FR Yugoslavia, FYROM, Greece and Albania. At the end of June 1992, new interruption of interconnected lines took place in Bosnia and Herzegovina, and since then, Second UCTE Synchronous Zone is composed of power systems of Greece, FR Yugoslavia, FYROM, Republic of Srpska in Bosnia and Herzegovina and Albania. Second UCTE Synchronous Zone was twice extended by new power systems which are in temporary parallel operation within its system: one is Romania, which joined the parallel operation on April 4<sup>th</sup> 1994, and the other is Bulgaria, from April 26<sup>th</sup> 1996.

At this moment, Second UCTE Synchronous Zone includes 8 electric power utilities with the total generation amounting to 189 TWh and the consumption of 186 TWh in 1997. Total exchange between the power utilities amounted to 13506 GWh, which is the proof of their extensive cooperation.

In October 1993, electric power utilities of Serbia, Montenegro and FYROM established the Electricity Coordinating Center (EKC) Belgrade with the purpose of coordinating of common activities of power system operation monitoring, energy accounting resulting from parallel operation, organization of load-frequency control etc. In the beginning of 1997, Electric Power Utility of the Republic of Srpska in Bosnia and Herzegovina joined EKC.

The Protocol signed in August 1994 by the power utilities members of EKC and Albania created necessary conditions for reestablishment of direct parallel operation of their power systems, which was carried out for some time only through the power system of Greece.

In April 1995, Agreement on Temporary Parallel Operation of Romania Power System with Power Systems of Greece, Former Yugoslavia Republics and Albania was signed in

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Athens, and in June 1997 similar agreement was signed in Herceg-Novi with Bulgarian electric power utility.

Cooperation between these power utilities was intensified during last years, especially in the area of coordination of joint activities relative to power system control, energy accounts resulting from parallel operation, and in developing telecommunication and information links.

### **3.2. Electric Power Utility of Serbia – EPS**

In 1999, the Electric Power Utility EPS had the total generation of 30827 GWh, out of which 12030 GWh in hydro power plants and 18797 GWh in thermal power plants. Compared to the previous year, the overall production decreased by 13.31%. The consumption in 1999 was 30572 GWh, which is a decrease of 10.19% compared to the year of 1998. Within the parallel operation, the physical electricity exchange amounted to – 461 GWh, whereas in the island operation with 3<sup>rd</sup> countries it was – 440 GWh.

The Electric Power Utility EPS is in the parallel operation within the second UCTE synchronous zone as the member of the UCTE. The parallel operation is evaluated as successful. In 1999, the quality of the primary and the load-frequency control operation was not correct in general due to difficulties caused by war activities. Mean value of the control error in 1999 was – 19.62 MW, and the standard deviation was 131.28 MW.

During the period of NATO attacks in the period April-June 1999, transmission network of Serbia underwent serious damages, some of which could have been repaired in relatively short time, whereas some other elements required partial or total replacement of the equipment. The total installed capacity of damaged and destroyed 400/x and 220/x substations were 4619.6 MVA. Twenty-three transformers were destroyed and sixteen transformers were damaged. The majority of damaged and destroyed elements were repaired and replaced till the end of 1999.

### **3.3. The Electric Power Utility of Montenegro – EPCG**

EPCG is the smallest electric power system that participates in the parallel operation within the second UCTE synchronous zone.

During 1999 the total electricity production amounted to 2599 GWh, out of which 1675 GWh in hydro power plants and 924 GWh in thermal power plants. Compared to the previous year, the overall production increased by 1.96%. The consumption in 1999 amounted to 3511 GWh, which is a decrease of 1.07% compared to the year of 1998. Within the parallel operation, the physical electricity exchange was – 912.6 GWh.

The Electric Power Utility EPCG is in the parallel operation within the second UCTE synchronous zone as the member of UCTE. This parallel operation is evaluated as successful. The load-frequency control for the EPCG is being organized from the Electric Power Utility of Serbia. The quality of the load-frequency control operation was in accordance with corresponding UCTE rules.

### **3.4. Electric Power Utility of Republic Srpska - ERS**

In 1999 the Electric Power Utility ERS had total electricity production of 5005 GWh, out of which 2631 GWh in hydro power plants and 2373 GWh in thermal power plants. Compared to the previous year, the overall production increased by 17.52%. The consumption in 1999 amounted to 3106 GWh, which is on increase of 4.89% compared to 1998.

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Within the parallel operation, the physical electricity exchange was 1517 GWh, whereas in island operation with 3<sup>rd</sup> countries it was 381.8 GWh.

The load-frequency control of ERS is being organized in the Electric Power Utility of Serbia. The quality of the primary control operation in 1999 is evaluated as correct.

### **3.5. The Electric Power Utilities EKC members (EPS, EPCG, ESM, ERS)**

In 1999 the electric power utilities EKC members (EPS, EPCG, ESM, ERS) had total electricity production of 44819 GWh, out of which 17720 GWh in hydro power plants and 27098 GWh in thermal power plants. Compared to the previous year, the overall production decreased by 8.2%. The consumption in 1999 amounted to 43485 GWh, which is a decrease of 7.5% compared to 1998. Within the parallel operation, the physical electricity exchange was 236 GWh, whereas in island operation with 3<sup>rd</sup> countries it was – 58 GWh.

The production in thermal power plants decreased by 17.9% compared to the previous year, whereas the production in hydro power plants increased by 12.1%. The quality of the primary and the load-frequency control operation is not correct in general due to difficulties caused by war activities.

### **3.6. System frequency program**

In the Second UCTE synchronous zone, the load-frequency control is organized in five control areas (blocks). The EKC control block consists of two control areas.

EPS + EPCG + ERS and ESM. In this block, the load frequency control is organized on hierarchical principle. All other companies have their own control areas.

In the Second UCTE synchronous zone, all necessary accounts (inadvertent deviations, compensations programs, control programs, etc.) are made by EKC, on the same manner as it is done by Accounting services in the Main part of UCTE.

The system frequency program is scheduled by EKC. Since October 30, 1997, this program is prepared every day for the next day in the steps of 50 mHz (49.95; 50.00 and 50.05 Hz). These steps are adjusted according to the size of this part of UCTE Interconnection.

### **3.7. Export – import of energy (the EPS of Yugoslavia)**

In the year 1999 was noticed increased power exchange between the EPS of Yugoslavia and other utilities of Balkans Interconnection. Total import was 2536.7 GWh, and total export was 1407.7 GWh.

Energy exchanged for the purpose of the regulation (primary and secondary) had the next values: imported 882.4 GWh and exported 869.7 GWh.

In accordance with different export - import agreements between the EPS of Yugoslavia and other utilities of the Second Synchronous Zone different exchange coefficients were used for winter and summer periods (from 1.18 up to 1.32). However, in some cases the energy was paid by currency. The average prices of that kind of transactions were \$30/MWh.

## **4. CHALLENGES AHEAD FOR YUGOSLAVIA: MARKET-BASED APPROACH TO ENERGY SUPPLY?**

The question raised here has two distinct parts: The first question concerns possible mechanisms and regulatory structures for provision of electricity within Yugoslavia, and

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the second question concerns the import/export process within the interconnection with the other countries. We briefly assess each of these.

#### **4.1 New sources of energy within Yugoslavia**

It is quite premature at this time, given unsettled political changes to predict the probability of competitive power production and consumption within Yugoslavia. It is quite clear, however, that some financing mechanisms should evolve for catalyzing provision of new energy sources of one sort or the other. As explained earlier, this part of the Balkans has historically relied on mid-to large-size hydro- and thermal power plants. The economics of type of energy sources to be chosen should be studied carefully. This is even further stressed by the recognition that different energy sources will have different long-term environmental impacts in the country. The new investments in generation, be it privately or publicly financed, should be a result of careful analysis of most recent technological advances (cost-effective smaller power plants, so called distributed generation (DG), including wind and solar options), as well as the economic and environmental attributes of these choices. The other parts of the world are considering DG as a serious option, qualitatively different from the traditional options, in which the planning paradigm rests on building many rather small power sources whose overall power production would be equivalent to at least a medium size power plant. In addition, different consumers may be willing to conserve at times when there is real shortage in order to pay less per MWh electricity charges. The cumulative effect of this response on the consumers side may again amount to considerable help toward reducing the need for more generation. It is interesting to observe that typical planning tools may have to be revised in order to make the assessment of the effect of many small changes, often at the distribution level closer to the customers, on the performance of the overall interconnection. This is an important theoretical challenge [4]. Without performing any in depth analysis of this kind, we believe that investing in small hydro plants may still be a very effective immediate option in Yugoslavia.

#### **4.2. Exchange with the neighbors outside Yugoslavia**

This is an important challenge ahead. The same way as the reserve sharing processes worldwide for reliability support have become less voluntary than in the past as a result of deregulation, the sharing of reserves with the neighbors may be more based on economic than strictly technical signals. In this case, the cause may be either political change within former Yugoslavia or competitive provision of reliability support within the interconnection. In other words, we are likely to see, and are already seeing, more competition than voluntary cooperation when it comes to supplying shortages under unplanned system conditions, as well as in more normal operation when there is simply not enough at each country level. The same is true in the case of Yugoslavia. This creates the need for some sort of regional market development for reliability management. It is worth observing that this challenge is one of the key questions facing of many other parts of the world undergoing structural changes from regulated to competitive electric power industry. One possible solution could lie in careful management of tie-line flows between different countries within the interconnection in the Balkans by creating a market for inter-country exchanges while allowing sufficient autonomy to each country to decide on its own level of reliability, and willingness to participate in regional reliability market. One such possible solution is described in [5, 6]. Given the technical expertise of the engineers in the region,

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it would be possible to proceed with such solution in a fairly straightforward way. Such a market would be based on information exchange between the market maker and the individual countries, offering (supplying) tie-line flow control for reliability and, on the other hand, the users of tie-line flow capacity by the countries needing to buy and sell reliability reserve across the inter-country tie-lines. A creation of such market would facilitate meaningful decision making between investing in new power sources for reliability within Yugoslavia, on one hand, and purchasing/selling reliability reserves from/to the neighbors by participating in a regional market

## **CONCLUSIONS**

Possibly the most interesting challenge ahead of the Balkan countries in the energy sector is understanding the full potential of small scale, so called distributed generation. This is primarily wind, solar and some other kinds of so-called renewable resources, which are environmentally most acceptable, but also small "micro-turbines" fueled by oil and gas. Yugoslavia, now smaller in size, will have to consider choices of this type, namely many small sources of electricity instead of very few single large sources. This is the problem of understanding the tradeoffs and designing market mechanisms to support penetration of many small environmentally friendly power sources, which, cumulatively, amount to one large power plant. Their operation, location and control within the grid which was designed for accommodating either very large power plants and/or large energy transfers is a technically challenging problem.

An interesting conceptual question here is a possible formation of a loose coordination of Yugoslavia and other countries for energy trades, so called regional market. This coordination would be market based, in which members exchange energy as needed with the well defined monetary values for these trades. At present, the trades are ad hoc and negotiated in a bilateral manner among the countries exchanging energy.

To approach these challenges systematically, it is important to draw on the knowledge and experience related to the electric power industry restructuring worldwide.