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GENERATION EXPANSION PLANNING CHALLENGES IN COMPETITIVE MARKET IN BOSNIA AND HERZEGOVINA

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1. Introduction

The *Generation Expansion Planning* (GEP) task is defined as a problem of determining *What, When* and *Where* of new generation units should be built over a (long-range) planning horizon in order to *efficiently* and *reliably* satisfy future energy demand. The GEP is part of a wider National Energy Planning process which is a strategic planning task for any country. The GEP problem is characterized by uncertainty associated with the input data (i.e. forecasted power demand, economic and technological characteristics of new generating technologies, trends in fuel and electricity prices, construction lead times and government regulations). It also presents a planning challenge since its solution requires simultaneous consideration of several (often conflicting) technical, economic, environmental, social and political objectives. The GEP objectives depend upon the structure of power industry and differ for power companies operating in a traditional industry, characterized by a *regulated monopoly,* and companies operating in a *competitive market* environment.

The aim of a traditional power company, operating as a regulated monopoly, has been to provide an adequate supply of electric energy to its consumers at *minimum costs*. Due to energy self-sufficiency concept local fuel sources were primarily used. Various GEP models have been developed to fulfill this corporate aim, incorporating optimization algorithms and deterministic/probabilistic production costs simulation. Most GEP problems have been modeled as a single-objective optimization problem, considering only the total utility costs (*utility least-cost approach*). The purpose of a least-cost GEP model was to determine generation units to be constructed (size, type and location) and time of their integration into the system so that the total costs (fixed and operational) of the company are minimized.

A long-term GEP problem is a constrained non-linear discrete dynamic optimization task. Its nonlinearity originates from the production costs models and the set of nonlinear constraints. Several optimization methods have been used to solve the GEP problem:

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- Traditional approaches such as linear, mixed-integer, non-linear, decomposition schemes and dynamic programming
- Meta-heuristics approaches such as simulated annealing, tabu search, evolutionary algorithms, particle swarm optimization and
- Combinations of traditional and meta-heuristics approaches.

One of the most used GEP algorithms in regulated monopoly industry has been Dynamic Programming (DP) approach. Many utilities use as GEP decision supporting tools commercial software packages based on DP. The most frequently used and best proved conventional GEP package in public sector is The Automatic Wien System Planning (WASP). WASP software was originally developed in the United States for the needs of the International Atomic Energy Agency (IAEA). WASP is determining least-cost expansion plan within pre-specified reliability criteria. It uses heuristic tunnel-based technique to deal with so called "curse of dimensionality" troubles in the dynamic programming routine (L1). It has been used for long-term GEP with the time horizon of up to 30 years. Modifications of dynamic programming algorithm incorporate expert systems techniques.
In order to include the impact of Demand Side Measures (DSM) on generation expansion (as a supply side measure) Integrated Resource Planning (IRP) method has been developed. DSM includes alternatives such as *efficient energy use* and *demand side management* (i.e. shaving of peak load). The objective of IRP optimization problem is minimization of the costs to the utility and society.
GEP has been totally redirected through the introduction of deregulation of electric power industry due to market based competition among generating companies. Competition in electricity market is primarily realized through a wholesale market, where generation and supply market participants compete for their market shares. Therefore not only are future demands within a given region uncertain but due to competition with other generation companies the utilities' market share is uncertain as well. Deregulation also attracted private investors which brought to power industry both their own investment preferences and *maximization of profit business philosophy.*
In addition, today's power industry is faced with evolving regulations concerning its environmental impact, especially regarding greenhouse gas emissions. In response to these environmental concerns many countries adopted a *sustainable development* concept, systematically subsidizing generation from *renewable energy resources* and efficient energy use measures. This trend accompanied with improvements in technologies for small generation units, which price per MW is no longer much more expensive than that for large units, provided opportunity for small private

investors to enter power markets. Finally, due to very uncertain future fuel price trends a concept of (national) *energy security* has recently (re)emerged as important planning criteria in today's industry.

Due to the above described changes in power industry modern corporation's needs for optimization models in GEP decision making process have substantially changed. The GEP problem solution in today's industry requires simultaneous consideration of several, often conflicting, objectives (i.e. maximization of the system reliability, minimization of total costs, minimization of impact on environment, promotion of economic development, support for renewable energy generation and DSM, etc.). In *perfectly competitive markets* the problem of GEP has been reformulated from being cost minimization to profit maximization. Therefore the GEP decision makers need decision support tools which explicitly model tradeoffs among objectives, recognize uncertainty and account market prices and profits of generators. These GEP tools are classified as market-oriented tools. *For a perfect competitive market, under a well designed reliability, the result of least cost planning matches the market oriented planning.*

At the moment an intensive power system planning activity is undertaken in Bosnia and Herzegovina (B&H) by different stakeholders using various planning methodologies and GEP models. Problem with application of a coherent GEP methodology in B&H is caused by the fact that its electricity market is in a process of transition with structural characteristics of both regulated and deregulated markets. In order to contribute to ongoing discussion regarding approaches to GEP this paper addresses this issue both from theoretical and practical point of view. First a review of GEP models and solution methods, which have been used in different power systems for GEP both in regulated and market environments, is given. It is followed by a short presentation of restructuring and deregulation process both in developed and developing countries is given. Since B&H power system will be operating integrated with neighboring South East Europe (SEE) power systems and later with EU power markets a review of EU energy policies and SEE power market structures is presented as well. Especially the results of SEE GEP study (Generation Investment Study) and their implications on GEP in B&H are reviewed. Than an analysis of power market in B&H, with identification of major challenges for GEP process and their implications on the selection of GEP models, is elaborated. Finally, recommendations for necessary steps which should be taken for a successful market implementation as well as a proposal of GEP methodology are given.

2. Generation expansion planning in competitive markets

In the last three decades trend to introduce market based principles in almost all modern economic activities has been predominant. Process of introducing market principles is usually called market *liberalization* or *deregulation* or simply market reforms. In many countries deregulation of traditionally "state controlled" sectors (air transportation, telecommunications, banking, railway transportation and electric power) has also been or is being implemented. The main objective of the deregulation process is introduction of market based competition and eventually transfer of the sector control from state to private companies. Main reasons for initiation of deregulation process are:

- Lack of finances for new investment projects
- Economic in-efficiency of state controlled industries
- Poor technical performances.

Infrastructure sectors (i.e. telecommunications, gas and water supply systems and electric power sector), which are characterized by intensive capital investments, economy of scale and natural geographic monopoly, and hence difficulties to attract private investors, present a challenge for market reforms. These sectors were traditionally controlled by the national governments. Even after the market implementation the government influence is evident through monitoring function of regulatory bodies which should enable proper market function and prevent eventual monopolistic operation.
In spite of evident problems in reforming infrastructure sectors numerous industries, like air transportation and airport management and in the network industries telecommunications, have been successfully reformed. In all these sectors reforms initiated positive competition pressures and resulted in better consumer satisfaction and lower prices. Because of these results the reforms have attracted support of political decision makers, too.

2.1. Deregulation and restructuring of electric power industry

Electric power sector deregulation seems to represent to most difficult reform task among the infrastructure industries. Main reason for this difficulty lies in the following characteristics of this industry:

- Evident economy of scale of large generation units, which represents substantial entry barrier for new market players
- Specific technical characteristics of Electric Power System (EPS), which give preference to centralized control versus decentralized coordination (i.e. inability to store energy, need for demand and supply to match at all time etc.)

- Luck of substitutes (for many users electricity has no substitute)
- Electricity is a standard product (switching to another supplier cannot produce better "electricity" so in the well functioning markets prices are inevitably driven down to the short term marginal cost, which is too low a level to justify new investments).
- Impact of technological innovations, like increased competitiveness of smaller production units, is not yet sufficient to trigger fundamental changes in business models of Electric Power Companies (EPC).
- Environmental impact, especially on greenhouse gas emissions, of electric power system is substantial and the market will not deliver the necessary emissions reductions.

These characteristics of electricity mean that perfectly wholesale and retail market in electricity is not possible. The key question is: "Are economically efficient wholesale electricity markets possible?" Since generation makes up to 50% of retail bills the idea behind electricity market introduction was that generation could be transformed from a monopoly to a competitive market, which would result in price reductions. The other key assumed advantage was that investment risk would be transferred from consumers, where it generally falls in a monopoly market, to the shareholders of the generation companies. It was supposed to force a generation company to invest only in profitable options.

In spite of evident difficulties, in the last 30 years deregulation reforms have been initiated both in developed and developing countries and countries in transition. Based on the acquired experience in the developed countries a theoretical "standard" model of electricity market has been developed and implemented in the market design. In the advanced industrialized world the results of deregulation, when implemented properly, have generally confirmed the theory that markets for power can allocate resources more efficiently than had state-dominated systems. The experience in England and Wales in particular has been successful. In developing and transitional countries the experience with electric power markets has been quite different. It is mainly because the deregulation has been implemented partially - market forces operate only at the margins of a system that remains dominated by the state. Experts attribute this gap between theory and practice to poor rule of law, week market institutions and influence of "politics". In transition economies politics determines character and speed of the reforms. In these "systems in transition", with mixed state-controlled and market-driven mechanisms it is very difficult to model power system market operation and GEP.

2.2. Generation Expansion Planning in perfectly competitive markets

In perfectly competitive power markets a company is expected to look for maximization of its profits. The power system behavior is determined by the economic market equilibrium which is result of interaction of the market participants. The following business factors heavily influence the market position of a company:

- Ownership structure
- The technology mix
- Technological and managerial capacity
- Company's perception of risk

In addition, external factors such as behavior of competitors, regulatory issues and economic factors also influence market behavior of a company.
In competitive power markets the price of energy is affected by the following exogenous and endogenous factors:

- Availability and costs of the primary energy resources
- Ratio between installed generation capacity and load demand
- Power generation technologies and efficiency
- Availability and reliability of generation-transmission system
- Demand elasticity with respect to price
- Energy exchange/trade with bordering systems
- Limitations of interconnection network
- Market arrangements
- Strategic behavior of the market players, especially of generation companies.

Modeling of short term market efficiency has been in main focus of researchers. In modeling of market equilibrium in competitive markets the following approaches have been proposed: microeconomics theory, theory of non-cooperative games, mixed complementary problems and mathematical programming with equilibrium constrains.
Long-term investment performance modeling in competitive market has attracted less interest of research community. Modeling of GEP in competitive markets is a complex problem due to conflicting business interests of generation companies. The investment objective of each generation company is to maximize profits, which is correlated, interlinked and in conflict with investment objectives of competing generation companies. In this interaction among generation companies a problem of extreme over/under investment in power market can arise. If the power

market has to function well it has to bring benefits to its consumers. Thus the role of market regulator is to prevent such over/under investment situations through coordination among generation companies, providing long-term market information. Overall objective of the regulator is to achieve security of energy supply through *an equilibrium investment solution*. The solution of this problem is based on its decomposition into two problems. The main problem of the regulator is to evaluate the market prices and generation capacity stability in a long-term sense, based on (indicative) investment strategies of individual generation companies. The sub-problems correspond to investment strategies of individual generation companies, which aim to maximize their profits using information supplied by the solution of the main problem. An equilibrium investment solution is found through an iterative solution of the main problem and the sub-problems.

2.3. Multi-criteria decision making methods in Generation Expansion Planning

In order to grasp conflicting nature of trade-offs among different objectives of the GEP process and to select satisfactory compromise solutions the decision makers need the aid of multi-objective models. In multi-objective models the concept of optimal solution in single-objective models is replaced by the concept of the non-dominated solutions. The concept of non-dominated solutions is also known as Pareto optimum, non-inferior optimum and efficient solution. Non-dominated solutions are feasible solutions for which no improvement in any objective function is possible without sacrificing at least one of the other objective functions.
Multi-criteria decision making methods can be classified into *multi-objective* (multi-criteria) decision making and *multi-attribute* decision making groups. In multi-criteria methods the alternatives are not pre-determined and decision problem is solved using multi-objective linear or non-linear programming models. In multi-attribute methods the alternative candidate solutions are evaluated using combination of analytical tools. The most commonly used multi-criteria methods in planning studies in electric power industry are: utility function, tradeoff analysis, analytical hierarchy process (AHP), TOPSIS and PROMETHEE (L3).

3. Deregulation and restructuring in EU

The general objective of deregulation reforms in developed industrialized countries (i.e. the EU members) is introduction of competition and diversification of suppliers in order to decrease energy prices. Diversification of

suppliers, especially of natural gas, is very important for energy dependent countries of the EU. Therefore the EU energy policy aims to increase security of energy supply in the future. Currently the EU energy needs are supplied form: oil (36.8%), gas (24%), coal (18.2%), atomic energy (14.4%) and renewable sources (6.4%) (L4). The EU countries produce 2/3 of their current energy needs. However by 2030 it is expected that this relation will be reversed. In order to avoid *energy dependency* the EU has adopted common energy policy aiming to increase energy mix and diversify energy sources. In order to realize the designed energy policy the EU aims to develop strategic partnership relations both with energy producers and energy (especially gas) transit countries. The South East Europe is seen as an important transit route for natural gas (and oil) pipelines from the Central Asia region and Turkey.

It is expected that natural gas will take more prominent role in the future energy needs of the EU. Currently the EU imports 1/2 of its gas needs (from Norway, Algeria and Russia). The half of the EU gas import comes from Russia. The natural gas use in the EU will be increased in households' consumption, in industry and especially in electric energy production. It is expected that between 2002 and 2030 the natural gas consumption for electricity production in the EU will quadruple. According to Austrian Energy Concern OMV by 2030 the EU will import 80% of its natural gas needs. With expected decrease in gas production in the North Sea (in Great Britain and Norway) the EU dependency on gas supply from Russia is expected to increase. Therefore, Russia will become dominant gas supplier for the EU. Europe's growing dependence on Russian energy and recent Russia's apparent willingness to use its energy power for political ends has fueled speculations that Moscow will use the "energy weapon" to try to influence future foreign or economic policy of the EU. All these issues have led Europeans to begin to plan more seriously for their future and to make energy policy a higher priority within the EU. Especially the EU intends to make use of the fact that European market is geographically close and secure market for the Russian gas. The EU is also a potential investor for modernization and development of the Russian energy industry. Therefore, the energy relationship between the EU and Russia is and will be one of mutual dependence. This situation of interdependence and conflicting interests at the same time between the EU and Russia will substantially determine their future political relations. Since South East Europe region is an important transit corridor for oil and gas supplies to the EU it is expected that conflicting interests of these "superpowers" will collide there and substantially influence the energy policies of countries in the region.

3.1. The EU Energy Policy

Although the EU 27 member states have ceded some sovereignty and competencies to the EU's institutions, they have retained the responsibility for energy policy. Decisions regarding long term energy priorities continue to be taken by the individual member states. Despite the lack of common European energy policy the European Commission (EC) has used its existing competencies in competition and environment and consumer protection policies to increase its influence over member states' energy policies. The proposed Treaty on a European Constitution would elevate energy policy to a "shared" competency.

In 1991 the EU launched the Energy Charter Declaration, an initiative intended to promote energy cooperation and diversify Europe's energy supply (L). The Declaration was followed by the Energy Charter Treaty (ECT) and that entered into legal force in 1998 and the Protocol on Energy Efficiency and Related Environmental Aspects (PEEREA) which was signed in 1994, which established a framework of rules and agreements to promote international energy cooperation. Bosnia and Herzegovina, among more than 50 countries, ratified the Charter in 2000 and participated in the Review of Energy Charter process which was concluded in 2004. The Treaty and Protocol seek to create a level playing field of rules regarding *promotion of foreign energy investments, free trade in energy materials, freedom of energy transit through pipelines and grids, real-cost reflecting prices, promoting energy efficiency and providing mechanisms for addressing disputes.*

In March 2006, the European Commission (EC) released a "Green Paper" (L8) detailing continent's energy challenges and outlining broad policy options for a comprehensive EU-wide energy security strategy. The paper called on member states to complete the process of opening their energy markets, dismantle protectionist policies, and create a single European electricity and gas market by mid-2007. Other priorities included measures to encourage efficient mix of energy fuels to foster an integrated approach to climate change, to develop new energy efficient technologies, and to create a coherent external energy policy. In a January 2007 follow-up to the Green Paper, the Commission unveiled a series of more specific policy actions that were officially recommended to EU member states at the European Council summit in March 2007. In the area of sustainability the Commission proposes a 20% EU-wide reduction in carbon emissions compared with 1990 levels by 2020. It also urges EU member states to seek international agreement on a 30% reduction target by 2020 in a post-Kyoto Protocol carbon emissions treaty. To attain these goals the Commission envisions a series of measures to increase the use of bio-fuels and other renewable energy sources, with the

target to produce 20% of energy from these sources by 2020, and to improve energy efficiency by 20% by 2020. Detailed analysis of European energy policy is elaborated in (L9).

3.2. The EU Electricity and Gas Directives

The EU Council of Ministers adopted a Directive concerning common rules of the internal electricity market (Directive 96/92/EC) in December 1996 and on gas (Directive 98/30/EC) in June 1998. These were superseded by Directives 2003/54/EC (electricity) and 2003/55/EC (gas) of June 2003. At the heart the Directives aim to transform electricity and gas industries from a monopoly basis to a one operated on competitive principles by making wholesale and retail competitive markets.

The 1996 Directive established rules in the following areas: generation, transmission and distribution, unbundling and regulation. It also had potentially significant implications for ownership and international trade. For the construction of new plants the Member States could adopt two options: *tendering and authorization*. Under tendering procedure generation expansion planning would continue to be centrally planned. An official body would determine the amount of capacity that needed to be built and the specifications bidders would need to meet. The lowest bid would win the tender. It is expected that winning bidders would be given a *long-term Power Purchase Agreement* (PPA) as a guarantee of volume and price of sales that would allow finance for the construction of the plant to be obtained. Under authorization anyone could build a plant, whenever and wherever they wanted providing it complies with legal regulations. From the point of competition authorization procedure enables free entry and free exit and contributes to market development.

The Directives also required Member States to open their market for large users and distributors. To enable generators and retailers to get their power to final consumers there were measures to ensure all competitors would be able to get non-discriminatory access to the network. There were three options: negotiated third party access (TPA), regulated TPA and the Single Buyer. Transmission and Distribution System Operators (TSO and DSO) would determine who would get access to the networks. They also determine the development of the network. Some corporate separation *(functional unbundling)* of the network and generation/retail activities was required as well. Even though the Directive did not require privatization, if the spirit of the Directive was to be followed and competitive markets introduced into generation and retail, in the countries where electricity industry was dominated by a single nationally-owned company new private companies

have to be brought in. For markets to be truly competitive no company would have to have a market share of no more than about 25 per cents.
The Directive was deficient regarding creating competitive markets in four areas: it did not require provision to break up dominant companies, it did not require creation of the whole sale market and retail market opening and there was no requirement for sector regulator.
In 2001 the EC introduced new Directive that accelerated market opening. In addition to the previous four areas the new Directive had provision on *security of supply.* Under the new Directive authorization would be the rule for generation expansion capacity. Member states could also use tendering procedure to promote "infant" technologies and to meet environmental objectives. It also specified that all consumers should be allowed retail competition by 2007. Regulated TPA was defined as the only option for transmission and distribution networks access. The methodologies for calculating network tariffs had to be approved by the regulatory body. Unbundling requirements were substantially strengthened: *legal separation* between TSO and DSO activities and generation or retail activities of integrated companies was required. The Directive also encourages international trade promoting construction between national systems. The member states were required to designate *a sector regulator* that had to have a competence to set at minimum network charges. It also committed the Commission to set up a European Regulators Group for Electricity.
The previous Directive had little explicit discussion on security of supply which was left to be dealt with under "*public service obligation*". It allowed Member States to impose public service obligation "to ensure security of supply and consumer and environmental protection which free competition, left to itself, cannot necessarily guarantee". The new Directive also acknowledged there was a risk that relaying on market signals might not be enough to ensure there was sufficient generating capacity. So the Directive allows Member States, in the event that sufficient generation capacity is not built on the basis of authorization procedure, the possibility to contribute to security of supply through the launching of a tendering procedure. This will require authorities to monitor the supply and demand balance sufficiently far in advance (at least six years ahead) to take remedial measures is a shortage appears probable. However this provision distorts the investment signals that exist in the markets and might prevent efficient market functioning.
From 2008 the Energy Security of Supply Directive has entered into force. The Directive is concerned with technical security of the electricity system and contained measures in the following areas: network security (adequate reliability standards of transmission and distribution networks), maintaining balance between demand and supply, network investment. Directive requires

to set-up an autonomous regulatory body. It also requires that owners of the network have no effective connection with companies that sell or produce electricity. To counter the risk that the savings in transmission operation will be at the expense of system reliability regulators are introducing performance standards. The Directive is also concerned with the security of supply peaking capacity. Detailed analysis of implementation of the above mentioned Directives in individual EU member states and how far efficient markets have been created in the EU is available in (L8).
For GEP consideration the following EU Directives and Regulations are also important:

- Directive 97/11 EC of March 3 1997 on the assessment of the effects of certain public and private projects on the environment
- Directive 2001/77/EC of September 27 2001 on the promotion of electricity produced from the renewable energy resources in the internal electricity markets
- Directive 2001/80/EC of October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants
- Regulation (EC) 1228/2003 of the European Parliament and The Council of June 26 2003 on condition for the access to networks for cross-border exchanges of electricity
- Directive 2006/32/EC of April 5 2006 on energy end-use efficiency and energy services repealing Council Directive 93/76/EEC

4. Energy community in south East Europe treaty

In developing countries and countries in transition electric power markets usually did not operate on economic principles. State subsidies were usual practice, both to demand and supply side. Reliability of systems was lower than in developed countries. Therefore main reason for deregulation reform was introduction of sound economic principles in operation of the sector. The reforms were mainly initiated to attract foreign investors thus providing necessary finances for investment in reliability and quality improvements.
Prior to the reforms the initial economic and technical conditions in transitional countries were different too. There had been no experience in operation of their economies in market environment. Majority of electric power systems in transition countries are relatively small systems (i.e. in this aspect Bosnia and Herzegovina is a typical example since its system had in 2006 the minimum load of 800 MW and maximum load of 2000 MW). This fact was emphasized by the load decrease during transition due to the restructuring of energy intensive industries. In energy "self-sufficient" transition countries the load decrease resulted in an excess of generation capacity (i.e. this recently

has been characteristic for Bosnia and Herzegovina system). Experience shows that "standard market model", which has been successfully implemented in much bigger systems of developed industrialized countries, is not automatically applicable to these systems. All this calls for precautions regarding complexity of the market design and timing of its implementation in these countries (L9). High social and financial costs of restructuring of power industry (in Bosnia and Herzegovina especially of the coal mining sector) in countries in transition suggest *phased and incremental introduction* of market mechanisms. All the above said indicate that short term (economic and social) strategic interests of countries in transition might require short term adaptation of the "standard" market model. Especially a delay in privatization process has been shown to be a right decision.

4.1. Power Sector in South East Europe

The countries of South East Europe (SEE) have no available major energy resources, with the exception of low calories coal - lignite. In general they are, in different degrees, dependent on the import of energy. This energy dependence is forecasted to further grow in the years ahead since an intensified economic development activity in the industrial sector is expected. General picture of the energy sector in SEE could be described by the following facts (L10):

- Generation plants and industrial energy end-use is technologically obsolete with very low energy efficiency.
- Thermal power plants are major sources of air pollution. CO_2 emission per GDP/pc is more than twice greater that the world average.
- The average energy consumption in households per square meter is 2 to 2 ½ times bigger than the average consumption in developed EU countries.
- More than half of the population for heating of houses and cooking uses wood and low calories lignite.

In order to secure the necessary energy supply for economic recovery and growth the countries of the region will have to modernize their power sectors and expand available local production. To realize necessary development project the region will have to mobilize required financing. Major part of it is expected to come in the form of foreign investments. Electric power generation represents a prime candidate for these activities. However, as a consequence of the socialist type economy, the regional electric power sectors had been operated on non-economic principles. They also were under a heavy political influence, mainly protecting "national" interests. Additionally, small size of individual national electric power markets might not be

attractive to foreign investors. In order to overcome possible problems in securing necessary financing for modernization and development the EC and the World Bank (WB) proposed and supported integration of national power markets and sector reform in line with the EC Directives and Regulations and EU energy policy.(L11, L12). Integration of the national power markets with free electric energy trade among the countries in the region in its core has the idea of *optimization of future generation expansion investments*. In order to support power industry financial viability tariff reform and improved payment discipline would also be required. Social safety net should be strengthened, too.

Implementation of the suggested reforms required realization of the following activities:

1. Existing thermal power plants had to be revitalized and modernized in order to increase their efficiency and decrease environmental impact
2. Enormous specific energy consumption per unit of industrial production had to be decreased
3. Efficiency of household energy end-use had to be improved and more efficient means of heating should be provided
4. In order to facilitate cross-border electricity trade within the region and with the EU, and thus improve security of supply and decrease costs, a common regional energy market had to be established
5. Future investment in new capacities should be evaluated considering regional perspective in order to achieve optimal allocation of new capacities
6. Supply of primary energy sources (mainly of natural gas and oil) should be secured through participation in international projects.

Activities 1 to 3 are primarily national responsibilities. Activities 4 to 6 require political and technical cooperation on the regional level and integration of the region into European energy market.

4.2. Energy Community of South East Europe Treaty

Signing of the Energy Community in South East Europe (ECSEE) Treaty on October 25th 2005 by Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Macedonia, Romania, Serbia and Montenegro and United Nations Interim Administration for Kosovo represented a major step forward in development of a regional energy market (for electricity and gas) in SEE. ECSEE Treaty represents *a legal commitment* to a process which started in 2003, as a Stability Pact initiative, following the signing of the Athens Memorandum under which countries in the SEE region agreed to develop a regional energy

market and to undertake reforms required to support this. Turkey has signed the Athens memorandum but not ECSEE Treaty. Nevertheless it will participate in the regional market. ECSEE Treaty calls for implementation of EU *acquis communautaire* on energy, environment, competition and renewable energy sources so the signing parties agreed to implement EC Directives and Regulations regarding electric power sector.

A number of significant challenges remain to be addressed if a regional power market is to be successfully implemented (L13). Chosen market design is an interim trading period, based on bilateral contracts between generators and eligible consumers, following which more sophisticated arrangements may be introduced, providing technical/institutional capacity permits. For the moment there will be no day-ahead market (except in selected countries) and real time balancing arrangements will not be market based. Cross border transmission tariff mechanism should be cost reflective. Dilemma regarding implementation of environmental regulations on regional or bilateral level should be resolved soon.

4.3. GEP in South East Europe - Generation Investment Study (GIS)

Adequate generation capacity is required in SEE in order that regional power market competition ensues. Therefore significant investments are required in power generation and transmission expansion and a framework is needed to support mobilization of required financing. In order to coordinate investments plans of individual countries the WB and the EC co-managed preparation of Generation Investment Study (GIS) on a regional base (L14). The objective of the study was to identify investment requirements to maintain capacity balance and to support market liberalization. GIS considered *regional based least cost* options for rehabilitation of existing capacities and construction of new lignite and gas fired plants and new hydro capacities to meet power demand in SEE over the period 2005-2020. WASP program was used in the analysis.

Under different scenarios, depending on future gas prices and influence of least-cost option of import of electricity from Ukraine/Russia, the following generation expansion candidates in B&H have been identified: rehabilitation of remaining production units in thermal power plants (Tuzla G6, Kakanj G7, Gacko and Ugljevik) and ongoing construction of TPP plant in Stanari as well as eventual construction of hydro power plants. However GIS represents an indicative GEP and some of identified investments might not be realized (L15).

5. Deregulation and restructuring in Bosnia and Herzegovina

Structure of electric power sector of Bosnia and Herzegovina (B&H) has been heavily influenced by the recent war. Presently three public electric power utilities, which are responsible for generation and distribution/supply, operate in B&H, namely:

- Electric Power Company of Bosnia and Herzegovina (Elektroprivreda B&H - EPB&H)
- Electric Power Company of Republika Srpska (Elektroprivreda Republike Srpske - ERS)
- Electric Power Company of Croatian Community Herzeg- Bosnia (Elektroprivreda Hrvatske Zajednice Herceg-Bosna - EPHZHB)

In Brčko District of B&H a separate distribution company – Elektrodistribucija Brčko, is responsible for distribution and supply of electric energy in this part of the country. Structure of electric power system is shown on Figure 5.1.

The structure of electric power industry in B&H is a result of the Dayton Peace Agreement between national political stakeholders. Such a complex electric power system presents substantial technical and economic challenge for planning and operation.

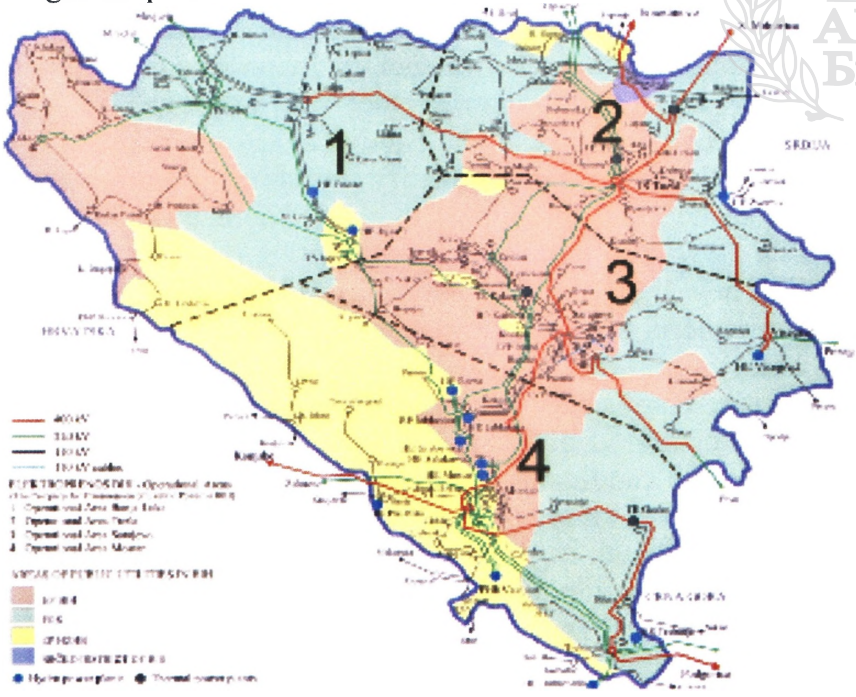

Figure 5.1 Structure of electric power system of Bosnian and Herzegovina

5.1. Reform and development documents

In 2000 necessary reforms were initiated in order to deregulate electricity industry and to increase its efficiency. Basic deregulation planning document "Bosnia and Herzegovina Power Sector Restructuring and Privatization Analysis and Action Plan" (L16), prepared by the PA Consulting in 2001, put forward recommendation for power sector restructuring and unbundling of electricity sector. It was initiated by the representatives of International Community (IC) and funded by the USAID. This illustrates the fact that reforms were "imposed" upon national political decision makers. IC substantially supported post-war reconstruction and modernization of electric power sector in B&H. This has been realized through consecutive Power Programs (Power 1-4 programs), led by the World Bank and supported by the other International Financial Institutions - IFI ((EBRD, EIB, KfW) and donors (EC,USAID, DFID, Canada, Spain, Norway, Italy, Switzerland and Japan). Power 3 and 4 programs, with the total funding of $496 millions, aimed to support the restructuring and reform processes in electric power sector.
The main objectives of the reforms were:

- Integration of electric power system of B&H
- Implementation of market oriented reforms
- Integration with SEE regional electricity market and with European Union power market.

Bosnia and Herzegovina does not have Energy Development Strategy at the national level (the EU supported project "B&H Energy Strategy" for a moment has been suspended). The only official B&H documents which to some extend contain segments of strategic policies in power sector are "Poverty Reduction Strategy Policy - PRSP", adopted by the Council of Ministers as Medium Term Development Strategy for 2003-2007, and the European Partnership which are setting goals for creating a competitive environment for electricity market and its integration into regional market. Instead of energy development strategy the legal framework for reform process has been Action Plans for Power Sectors Restructuring, adopted by the Parliament of Republic Srpska in 2003 and the Parliament of Federation of B&H in 2005. These documents established legal and institutional framework to support liberalization of electricity industry.
The reform process has been intensified following ratification of Energy Community Treaty, which entered into force on July 1 2006. So far the following main results in the transition to competitive market in B&H have been achieved:

- Power market regulators (State and Entities' regulatory commissions) have been established and *regulatory framework* is being developed (the Grid Code and Market rules are adopted, cost reflective Tariff Methodology and Third Party access rules are in place, etc.)
- Initial progress has been achieved in *industry restructuring* through establishment of a separate transmission company (TCO)
- Independent System Operator (ISO), responsible for system control, has been established. The ISO represents B&H in regional ITC mechanism (Inter TSO Compensation) and recently became associated member of ETSO (European Transmission System Operators)
- Functional unbundling of electric power companies (legal separation of generation and distribution/supply functions), that is required under the EC Treaty, is being implemented (in Republic Srpska legal separation has already been implemented).
- Since January 1st 2008 all non-household consumers are eligible buyers

5.2. Challenges to energy sector reforms implementation in B&H

Electric power market in B&H represents a typical *"market in transition"* with all deficiencies which characterize an unfinished market reforms. Additional problems in B&H, which present barriers for further implementation of the liberalization reforms, identified in (L17) are the following:

- There is no integrated state driven action plan for implementation of the reforms
- There is a big disharmony between growing international obligations and capacities of responsible state institutions for their implementation
- Neither Energy law nor Efficient Energy end-use law exist at the state level
- No Energy Efficiency agency/center exits at any government level
- No energy statistics is collected at the state level
- Mechanism for energy balance at the state level does not exist.

Additional obstacle for an efficient reform implementation presents "shared" responsibility in energy sector of the governments in B&H. Ministry of Foreign Trade and Economic Relations - MOFTER, established in 2004, is formally responsible for energy policy formulation in the energy sector. However, the entity ministries (Ministry of Energy, Mining and Industry of the Federation B&H and Ministry of Economy, Energy and Development of Republika Srpska) are *de facto* in charge of the entity energy sectors. In general, the main reason for these B&H specific problems is an *absence of*

political agreement to implement reforms which will result in an *integrated and functioning B&H electricity sector from technical and economic aspects.*
The following factors also present obstacles for development of efficient electricity market:

- According to current institutional setting there are three regulators operating in B&H. The entity regulators, among other responsibilities, are in charge of regulating generation companies. This *asymmetric regulatory structure*, combined with the absence of a mechanism for energy balance at the state level, has created problems regarding provision of energy balances (i.e. the energy balance of Aluminum Plant for 2008 was provided late in December 2007)
- *Public service responsibility* of power companies is not clearly determined. This fact creates situation where ISO has problems to secure secondary services (i.e. operational reserve and loss covering/allocation services) on a competitive base.
- Integrated energy market does not exist and ISO has not developed the market operator function. This fact creates conflicting interests between public companies' commercial interests (which prefer to export surplus energy) and interests of local consumers.
- Restructuring of the mining sector in FB&H has been delayed due to a lack of financial means (especially for financial consolidation and mitigation of social consequences of restructuring process). This endangers economically efficient operation of related TPP in a competitive market environment.
- Unfinished transition to market (with indication to revise reform process in transmission function)

Detailed analysis of power market in B&H is available in (L18).

6. Generation expansion planning challenges in Bosnia and Herzegovina

Economic development of B&H is dependent on establishing effective electric power sector. B&H is one of the few countries in the SEE region with potential for export of electricity. Therefore participation in an effective and integrated regional electricity market, based on SEEC Treaty, is seen as an opportunity for economic growth and social progress in the state.
The main benefits of creating an efficient power sector through implementtation of the designed reforms are the following (L17):

- Increasing attraction of the sector for foreign investments
- Strengthening state level authorities
- Integration of the energy sector within the country creating single B&H energy market
- Integration of the energy sector in regional end EU markets.

6.1. Generation Expansion Indicative Investment Plans in B&H

Since 1990s there has been no major investment in B&H in new generation capacities. Through the restructuring (*financial consolidation and corporatization of the companies, with payment levels reaching above 90%, and rehabilitation and modernization of the existing generation capacities*) the public electric companies have created a solid base for investments in new capacities. A large private sector interest to invest in expansion of generation capacities in B&H, in order to meet growing electricity supply need of the country and electricity deficit within the region, has been shown as well.
ISO has developed Indicative Power System Expansion Plan for 2007-2016. In (L19) the following new generation capacities were analyzed using least-cost WASP GEP software for the period until 2020:
Thermal power plants at the existing mining facilities (total capacity app.1530 MW):

- EPB&H TPP Tuzla, G7 (450 MW)
- EPB&H TPP Tuzla, G8 (450 MW)
- EPB&H TPP Kakanj, G8 (450 MW)
- ERS TPP Gacko, G2 (330 MW)
- ERS TPP Ugljevik, G2 (300 MW)

Thermal power plants at new coal mine sites (total capacity app. 1750 MW):

- TPP Stanari (410 MW, in construction by EFT company)
- TPP Bugojno, G1 (350 MW)
- TPP Kongora, G1 (275 MW)
- TPP Tuzla B, G1 (500 MW)
- TPP Kamengrad, G1 (215 MW)

Hydro power plants:

- Total capacity of 746 MW in HPP in EPRS is analyzed.
- Total capacity of 654,7 MW in HPP in EPB&H is analyzed
- Total capacity of 252.1 MW in HHP in EPHZHB is analyzed

Additional investments of 1.624 billion KM for modernization and expansion of the existing coal mines and construction of new coal mine sites were identified in (L19). In the same study necessary investments for modernization of the existing TPP in order to achieve environmental requirements regarding emission of greenhouse gases are estimated to be 368 million KM.

In (L19) an analysis of potential electric energy production from Renewable Energy Sources (RES) is analyzed as well. The following potential generation capacities are considered:
Small hydro power plants with capacity less than 5 MW (total estimated capacity app. 460 MW):

- Total capacity of planned small HHP in Republika Srpska is estimated to be 212 MW
- Total capacity of planned small HPP in Federation B&H is estimated to be 177 MW
- EPB&H plans consider construction of 34.2 MW (EPB&H is in a process of constructing 29 mini hydro power plants in Konjic Municipality)
- EP HZHB plans consider construction of 39.6 MW.

Wind power plants

- Real potential of wind generation (in southern part of B&H) until 2015 is estimated to be between 400 and 600 MW
- Gas fired thermal power plants.
- Evaluation of a 300 MW combined-cycle gas fired power plant was considered.

6.2. Generation Expansion Investment Options

No state-wide uniform and transparent procedure exist for construction of new generation plants in accordance with recommendation from EC 2003/54. Major part of future investments is expected to be provided by international investors. Different approaches for investment models have been identified, namely:

- TPP Stanari is being constructed as a Build-Own-Operate (BOO) concession
- Rehabilitation and capacity expansion in TPP Gacko and Ugljevik are being structured as joint ventures between EPRS and strategic investors
- HPP Buk Bijela is planned to be constructed as a joint development project between electric power companies of Republika Srpska and Republic of Serbia.
- In Republika Srpska financing for HPP is planned to be secured by international investors, including IFI.
- According to the proposal of the Government of Federation B&H (L20) generating capacities' expansion in FB&H is planned to be developed according a "strategic partnership model", based on combination of Build-Operate-Transfer (BOT) and Partnership in Production Ownership

models. This proposal is currently under consideration for approval in the Parliament of FB&H.

- Development of small HPP in both entities is based on BOT concessions.

6.3. Generation Expansion Planning Challenges

Biggest challenge for efficient GEP in B&H presents the fact that no comprehensive B&H energy development strategy exists. Un-coordinated investments in expansion of generating capacities among the entities of B&H could only result in a distorted market with suboptimal economic decisions. It is also difficult to apply any GEP methodology if state level coordination is not achieved. Planned "coordinated" approach to development of energy strategy that recently has been agree among the entity prime-ministers and the chairman of the Council of Ministers, in power sector cannot guarantee efficient control of investment decisions.

Second biggest challenge is unclear decision regarding development concept. Current political decision makers base their strategic plans on a big export of surplus energy (each electric power company in B&H in their development documents stated that they aspire to become "a leading company" in the SEE region). However the real importance of each of them in the region does not justify such ambition. Generation of electric energy in B&H in 2006 amounted to 13,749 GWh (56% produced bay Thermal Power Plants - THP and 44% by Hydro Power plants - HPP). In the same year consumption amounted to 11,521 GWh resulting in the net electricity surplus/export of 2,126 GWh. According to (L19) average electric energy consumption per year in B&H from 2005 until 2020 is expected to grow by 3.4% per year. Average increase of consumption on transmission grid is expected to grow by 3% per year. Based and these estimations the electric energy consumption in B&H on transmission grid is expected to increase from 11.3 TWh in 2005 to 17.6 TWh in 2020. Depending on development scenarios it is expected that the maximum load of B&H system will be in a range between 2660 to 2960 MW with load factor between 66% and 68%. In (L19) the scenario with most optimistic expansion plans estimated export to maximum 6.000-7.000 GWh (which is equivalent to a capacity of 1.000 MW in new TPP). These figures are characteristics of a rather small power system. I accordance with the stated political decisions all EPC submitted GEP which are substantially above the expected needs of B&H market. Opponents to these policies prefer "sustainable" development concept (including intensified energy efficiency programs and RES) with much more moderate generation expansion. They also emphasize that sustainable development will rationalize exploitation of local reserves of coal.

Third challenge to aggressive expansion plans is the fact that, according to (L14), there are more competitive electric energy production options in SEE. Especially potential of Kosovo coal reserves (with estimated coal price of 2 KM/GJ) which could be the base for more than 5.000 MW of feasible production in TPP, presents the competitor that B&H future generating TPP plants cannot compete with. Therefore detailed feasibility studies of candidate generating capacities first must find potential market for new export electricity production.

Finally overwhelming influence of political decision makers on energy policies, and especially on GEP, presents a danger that energy sector might be used for short term political benefits. Influence of political decision makers (in theory of electricity liberalization called "*political economy*") on reforms in power sectors in transition countries is rather a rule than an exception. And it is not always destructive (i.e. successful reforms in Slovenia, which had been designed and implemented by its government, presents a good example). However, due to complex governance structure of B&H influence of political economy is likely to be a major obstacle to development of efficient electricity market and optimal generation expansion strategy.

7. Conclusions and recommendations

Stated objective of all political decision makers in B&H is intention to position electric powers sector as important economic development driver. It is expected that this industrial sector should provide FDI, transfer of technologies, energy security, development of industries in its supply-chain (down-steam mining industry and up-stream energy intensive industries) and supporting industries (construction industries and eventually R&D), export and creation of new jobs. Potential for realization of this vision is seen in natural resources (coal and hydro-potential) of the country and favorable position in the region regarding balance of electric power demand/supply. Therefore introduction of market mechanisms in electricity trade in SEE region and integration of B&H power sector in regional and EU markets is seen as a development opportunity. In order to optimally exploit this comparative advantage, B&H stakeholders should efficiently plan use of its natural resources and develop adequate B&H research and planning capacities. Most critical element of power system development planning process is GEP.

In GEP in B&H the following external factors have to be considered:

- Electricity will be freely traded in the regional and the EU market

- Capable competitors exists in SEE market (i.e. Kosovo coal based TPP) and only most competitive generating units will be able to export electricity (for indicative least cost GEP see GIS study)
- Option outside the regional energy resources (i.e. imported high quality coal, gas and import of electricity from Ukraine/Russia should be considered as well).

Various internal factors (in this paper referred to as challenges) should also be considered as well. In order to overcome challenges and barriers to efficient GEP the following recommendations are proposed:

- Restructuring of electric power industry should be completed. In FB&H restructuring and modernization of the mining sector is prerequisite for developing efficient electric power industry.
- Energy law and Efficient Energy end-use law should be adopted at the state level.
- B&H Energy Efficiency Agency should be established.
- Energy Development Strategy and integrated state driven action plan for its implementtation should be adopted. Capacities for its regular up-date and fine-tuning should be developed.
- Capacities of state institutions in energy sector should be strengthened in order to enable B&H to fulfill its international obligations. Energy statistics at the state level should be collected.
- Efficient realization of GEP strategy requires building of wide social consensus which only could be realized through a *transparent and inclusive planning process.* Therefore procedures for involvement of scientific institutions, non-governmental organization and public in general should be developed.

Providing the suggested recommendations have been realized the following GEP process could be implemented:

- Sustainable development concept should be the base for GEP. Planning of generation expansion for export should be done on a market base. In the absence of state-level energy strategy entity-level strategies could determine strategic direction for sector development (i.e. L20).
- Electric power companies, both public and private, should be treated as *competing market players*. Each of them will have to develop its strategic development plans, incorporating generation expansion investment plans (i.e. L21). Initially these plans will be considered as indicative generation expansion alternatives.

- State level regulator (SERC) and ISO will be responsible to analyze these plans, mainly from reliability criteria, using appropriate GEP models and methodologies. The result of these analyses should be information regarding an optimum investment strategy. Initially least-cost GEP models, like WASP, could be used.
- Entity regulators will be responsible for authorization of GEP for internal B&H market. The least-cost option alternatives will be preferred.
- Investment risk for GEP which objective is electricity export should be bored by the electric power companies. Authorization of these generating capacities will be performed only from procedural aspects.

Based on the methodology explained in 2.2 this approach should lead to an equilibrium investment solution.

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