Aalto University
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# Benefits of regional cooperation in the South East Europe electricity sector

Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Technology.
Espoo, September 11th 2015
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**Diplomityön tiivistelmä**

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**Työn nimi** Alueellisen yhteistyön edut Kaakkois-Euroopan sähkömarkkinoilla

**Laitos** Energiatekniikan laitos

**Professuuri** Yhdyskuntien energiatekniikka ja energiatalous **Koodi** Ene-59

**Työn valvoja** Professori Risto Lahdelma

**Työn ohjaaja(t)** Eveliina Ishii, M.Sc. (Tech.)

**Päivämäärä** 11.9.2015 **Sivumäärä** 95 **Kieli** Englanti

**Tiivistelmä**

Diplomityön tavoitteena on tutkia valittujen Kaakkois-Euroopan maiden sähkömarkkinoiden vapauttamista ja niiden tämän hetkistä tilaa. Lisäksi työssä tutkitaan onko odotettuja alueellisen yhteistyön tuomia etuja mahdollista saavuttaa valitulla alueella. Sähkömarkkinoiden tilaa ja vapausasteita kartoitetaan saatavilla olevien raporttien ja julkaisujen perusteella. Yhteistyön synnyttämien etujen saavuttamisen tutkimiseksi työssä suoritetaan alueellisen markkinan simulointi, jonka lähtöarvot perustuivat alueen todelliseen dataan.

Työn tutkimus on rajattu alueellisen yhteistyön kannalta vain päivittäismarkkinoihin. Näin ollen rahoitusmarkkinat, päivän sisäiset markkinat sekä säätösähkömarkkinat jäävät tutkimuksen ulkopuolelle. Lisäksi infrastruktuurinen integraatio ja tarvittavien instituutioiden ja toimintatapojen kartoitus eivät kuulu tämän työn rajaukseen.

Tehty sähkömarkkinakatsaus osoittaa, että sähkömarkkinoiden uudistaminen ja vapauttaminen on edennyt vakaasti ja lupaavasti kaikissa tutkituissa maissa. Huomionarvioista on tosin se, että maat ovat hyvin eri vaiheissa uudistustensa kanssa. Simulaation tuloksien selvitys jaettiin kolmeen osaan: tuotantokapasiteettien aktivoinnin analysointi, hintojen analysointi ja odotettujen sähkönsiirtojen analysointi. Yleisesti simuloinnin tulokset osoittavat että alueellisen yhteistyön tuomat edut on mahdollista saavuttaa Kaakkois-Euroopan alueella. Simuloinnin osoittamat vakaat sähkön hinnat indikoivat tuotannon erikoistumista ja tehokasta allokointia. Lisäksi yhtenäiset sähkön hinnat koko vuoden ympäri luovat turvallisen ympäristön sähkösektorin investoinneille ja näin edelleen edistävät markkinoiden vapauttamisprosesseja.

**Avainsanat** sähkömarkkinat, alueellinen markkina, markkinoiden vapauttaminen, alueellinen yhteistyö, Kakkois-Eurooppa

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**Abstract of Master thesis**

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**Title of thesis** Benefits of regional cooperation in the South East Europe electricity sector

**Degree programme** Energy technology

**Professorship** Community energy systems and Energy Economics **Code** Ene-59

**Thesis supervisor** Professor Risto Lahdelma

**Thesis advisor(s)** Eveliina Ishii, M.Sc. (Tech.)

**Date** 11.9.2015 **Number of pages** 95 **Language** English

**Abstract**

This thesis aims to study the current electricity market liberalization status in the selected jurisdictions in the South East Europe and investigate if the expected benefits of regional cooperation in electricity market could be achieved in the region. The current states of market openings in South East Europe jurisdictions are researched based on the available reports and literature. In addition, regional day ahead market simulations are carried out to investigate the possibility of reaching the benefits. The simulation relies on the existing underlying data of the selected regional electricity sector.

The research in this study is limited to the day ahead part of the regional market setup. Thus, financial markets, intraday markets and balancing markets are not taken into account. Furthermore, integration in infrastructure, regulatory institutions and commercial practices are also left out of the scope and analysis.

It was found that there has been quite stable and well progress in the electricity sector reforms in the selected jurisdictions. However, the reforms are in quite difference phases in different jurisdictions. Simulation result analysis was broke into three parts: generation utilization, prices and electricity flows. Overall, the simulation results indicate that the benefits of regional a cooperation in the electricity markets could be achieved within the selected region. Stable prices and change in production patterns seen in simulation results indicate better specialization in electricity production for South East Europe region. In addition, even electricity prices during a whole year would provide safe environment for electricity sector investments and further assist the reform processes.

**Keywords** regional electricity market, market liberalization, market opening, power markets, regional cooperation, South East Europe

# Acknowledgements

*This Master's thesis has been written in the employment of Nord Pool Spot during the year of 2015. I would like to thank Nord Pool Spot for giving me the opportunity to write this thesis and allowing me to fully concentrate on it.*

*I would like to thank to my advisors Eveliina Ishii and Hans-Arild Bredesen for valuable guidance and support during my work process. I would also like to thank my thesis supervisor Risto Lahdelma for the advices. In addition, I would like to express my gratitude to Sami Oksanen and other persons in Nord Pool Spot who have helped me forward with my thesis and studies. Finally, I want to give a big thanks to my family and friends for the precious support and motivation during my studies.*

Espoo 11.9.2015

*Matias Peltoniemi*
Matias Peltoniemi

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## List of abbreviations

| | |
|---|---|
| AL | Albania |
| ATC | Available Transmission Capacity |
| BA | Bosnia and Herzegovina |
| BG | Bulgaria |
| CAO | Coordinated Auction Office |
| ETS | Emission Trading Scheme |
| EU | European Union |
| FYROM | Former Yugoslav Republic of Macedonia |
| GR | Greece |
| HR | Croatia |
| HU | Hungary |
| LCOE | Levelized Cost of Electricity |
| ME | Montenegro |
| MK | Macedonia |
| NTC | Network Transmission Capacity |
| PCR | Price Coupling of Regions |
| RES | Renewable Energy Scheme |
| RO | Romania |
| RS | Serbia |
| SEE | South East Europe |
| SI | Slovenia |
| TSO | Transmission System Operator |

# 1 Introduction

Traditionally national electricity markets have mainly been based on bilateral contracts and thus lacking transparency and free trading. Furthermore, majority of the electricity production capacities and electricity generation business and have been often owned by the same state owned enterprise. In many cases, these same enterprises have also been involved in other electricity market related activities such as electricity transmission and distribution operations. European Union took initiative to steer the member countries for electricity market liberalization and unbundling of the energy field activities. In order to reach these goals European Union has introduced several liberalization directives. Latest of them, third energy package, entered into force in 2009 aiming to fully open the electricity markets in the European Union member countries. Nordics and Western Europe have been leading the way in the liberalization processes and already have organized open electricity markets through power exchanges. In addition, both vertical and horizontal unbundling of the energy sector activities have been progressing smoothly in these areas. Recently, the liberalization trend has been spreading to South Eastern Europe. In the past few decades the countries in the region have initiated energy sector reforms and thus they are now heading towards full unbundling of the electricity market activities and wholesale market opening. Electricity market liberalization theory background indicates that a regional cooperation in the electricity sector would be beneficial next step for the South Eastern Europe.

The goal of this thesis is to study the current electricity market liberalization statuses in the selected jurisdictions in the South East Europe. The selected jurisdiction set includes Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Former Yugoslav Republic of Macedonia, Kosovo, Montenegro and Serbia. This country set is selected for this study so that they do not have any existing functional regional collaboration in electricity markets. In order to further investigate if the benefits of a regional cooperation could be achieved in the selected region, simulations for a regional day ahead market are carried out in this study. The simulation relies on the existing underlying data of the selected regional electricity sector. The research in this study is limited to the day ahead part of the regional market setup. Thus, financial markets, intraday markets and balancing markets are not taken into account. Furthermore, integration in infrastructure, regulatory institutions and commercial practices are also left out of the scope and analysis.

This study is divided into six main chapters where the chapters from two to four provide general background information about the electricity market liberalization and an overview of the current state in the electricity sectors of the selected jurisdictions. Building on top of the background study, the chapters from five to seven concentrate on the benefits of the regional cooperation in electricity markets and analyzes the regional day ahead market simulation results. The literature research part of this study will start up by introducing the basic theory background behind the electricity market liberalization. In addition, a brief outlook to European Union energy policy development is given. In chapter four the latest states of the electricity sectors in the selected South East European jurisdictions are presented. The respective electricity sectors are researched both from regional and national perspective. Chapter four continues the outlook of the selected region by investigating the current state of the market openings in the selected jurisdictions. Market opening statuses are examined from horizontal and vertical unbundling point of views and in addition the current customer eligibility thresholds and overall market openness situations are presented.

The last three main chapters of this study concentrate on the regional cooperation and on the expected benefits of it. Chapter five introduces the concept of regional power markets and the benefits related to it. In addition, recommended market model for South East Europe region is discussed. Also an example of a functional regional cooperation is given by providing a brief overview to the European Price Coupling of Regions. Chapter six lays the background for the regional day ahead market simulations by introducing the input values, intended scope and the required assumptions. Also the price optimization algorithm which was used in the simulations is briefly explained. Furthermore, the simulation procedure and fictional regional market area setup is illustrated. Finally, the gained simulation results are analyzed, possible benefits are reflected and conclusions are drawn.

# 2 Liberalization of electricity markets

Liberalization of electricity markets requires certain perquisites and reforms at many levels of the electricity sector. However, there are several benefits which can be achieved with a successful liberalization and reform process. Usually the liberalization of electricity markets includes establishing open electricity markets through power exchanges. The theory behind electricity market liberalization and the potential benefits are discussed in this chapter. In addition, brief overlook to European Union targets is given. Finally, it is presented why the liberalization process should include transforming from bilateral markets to exchange markets.

## *2.1 Electricity market liberalization*

Energy sectors have long been characterized by vertically integrated natural monopolies due to the importance of the secure electricity supply and its impacts on the societal and environmental welfare. Vertical integration means that the components of the electricity supply chain consisting of generation, transmission, distribution and retail supply were mainly owned by same enterprise. In addition, the energy sectors have historically been strictly regulated. Therefore, vertically integrated energy sector typically has high operating costs, high construction costs for new utilities, high retail prices and falling costs of production. Thus, the old-fashioned energy field led to costly large-scale investments, low-quality service and lack of competition in generation and supply business. In order to improve the situation, the energy sector reform process has been ongoing in many countries worldwide in the last three decades. The goal has been to arrange the energy sector in a new way to provide long-term benefits to society by producing electricity in respect to actual marginal costs of production. However, it has been widely accepted that distribution and transmission services should remain mostly as natural monopolies to maintain the security of supply. (Joskow 2008, Bacon, Besant-Jones 2001)

One the main drivers for energy sector reform is poor performance of state-run electricity entities resulting in high costs, insufficient expansion of network system and unreliable supply. Furthermore, the driving forces to initiate a reform are the lack of the required expansion of the energy sector, the need for a large amount of subsidies and gains for government from selling the energy sector components to private entities. Bacon and

Besant-Jones write that successful electricity market liberalization creates three sources of improved economic performance. First of them is better overall allocation of resources which lowers the prices to match the marginal costs of production. This improvement source includes also termination of the subsidy programs. These programs may produce major welfare losses in terms of overall economic welfare. Secondly, open market and competitive environment encourages for efficient use of the generation capacity and for innovations to lower the production costs. Lastly, increased competition will in most cases lower the electricity prices and thus transfer some of the positive impacts to the end customers as well. (Bacon, Besant-Jones 2001)

In order to initiate reform of an energy sector, there should be positive atmosphere towards the reform and the need for it should be generally perceived. In addition, the reform also needs be pursued by the political authorities in the area and it is required to be politically feasible to archive. The mutual positive atmosphere towards the energy sector reform is usually natural consequence of badly performing existing system. Thus, the reform is more likely to take place in such systems where obvious problems do exist such as electricity outages or shortage of supply. Political approval and feasibility for reform is important since the reform most likely includes privatization and unbundling of publically owned assets and deregulation of electricity prices. (Bacon, Besant-Jones 2001)

Liberalization of electricity markets can be achieved in multiple ways. However, in most cases the liberalization process contains some mix of increasing competition, reducing regulation and privatization of the industry. Similar to all processes, they include subjecting energy sector utilities to market forces i.e. replacing monopolies with open competition. Kopsakangas-Savolainen and Svento introduce six factors which should be accomplished in successful deregulation process. The number of the active players is identified as one of the most important factor in restructuring process. Regardless of the market model, if there are only few big market players they tend to have too dominant position in the markets. Therefore, they can manipulate the electricity prices by holding some of their capacity from the markets or offer electricity at unrealistically low prices. On the contrary, if market has many active players then each individual player has less effect on the market prices. Thus, market manipulation becomes much more difficult and

has less effect. Second factor is the rules of the bidding procedure within the market. Bidding procedure defines the way the market price is formed and therefore it should be designed so that it can increase the market efficiency. Next identified factor is organization of the demand side operation. Basically, there are two ways of organizing demand side, it can either be based on demand forecasts or it can be real-time demand response. Forecast based demand planning can increase generators' market power when the demand level is fixed and can be estimated easily. However, the more modern approach, real time demand response, gives the consumers more power to adjust their consumption to low price hours. Real time demand response also supports better the actual marginal cost based generation of the electricity. Fourth factor for successful deregulation process is supportive operation of the transmission grid. In order for electricity markets to function efficiently, the transmission grid cannot be too congested. Thus, electricity transmission grid needs to be operated in such way that the electricity can flow freely according to the calculated optimal schedules. This will also further lower the dominant position of the big market players since electricity flows will balance deficit and excess areas and compensate prices. Diversity of generation technologies is introduced as fifth factor to impact the outcome of the competitive market. Higher diversity in generation possibilities will reduce the volatility of the market prices. Finally, ownership structure has some impact on the successfulness of a competitive market. Mainly private owned supply side tends to aim for profit maximization whereas mainly state owned generation might have wider objective than purely pursuit maximum profits. The mix of these two ownership types and goals in electricity market has effect on market prices. (Kopsakangas-Savolainen, Svento 2012)

Joskow elaborates the standard liberalization prescription for restructuring electricity markets. The prescription starts with horizontal and vertical unbundling of the energy sector. Vertical unbundling means privatization of the state-owned electricity monopolies and separation of potentially competitive segments from natural monopoly activities. This means legally separating different parts of electricity market operations such as transmission, distribution, exchange and regulatory operations. One important part of vertical unbundling is creation of an independent transmission system operator to ensure the security of the grid, maintain balance in grid and to support electricity market by scheduling the electricity flows. Horizontal unbundling includes restructuring of the

generation segment to create sufficient amount of competition to markets in order to spread the market power and ensure competitive electricity prices. Next step in the liberalization prescription is creation of a voluntary public wholesale spot electricity markets and operating reserve markets. The main objective for these two is to create economically beneficial trading opportunities for suppliers and consumers and to further in economically effective manner balance supply and demand. Furthermore, reserve markets are meant to provide quick response for disturbances in electricity balances and increase the security of the transmission grid. Also developing active demand side response institutions to enhance real time demand response is part of the reform prescription. Liberalization prescription describes also adoption of such regulatory rules which provide equal access to transmission network for all market players. In addition, an efficient allocation of the transmission capacities should be included in the efficient adoption of the regulatory rules. Related to the adoption of rules, it is proposed that an independent regulatory agency should be established to monitor the market and to regulate the pricing of the natural monopolies in the energy sector such as distribution and transmission operations. Finally, the prescription recommends the abolition of the retail tariffs. (Joskow 2008)

## 2.2 EU energy policy development

The push for electricity market liberalization in Europe originates mainly from the European Union (EU). The process towards liberalized national markets started already in late 1996, as can be seen in Figure 1, when the European Parliament introduced the first electricity market liberalization package. This directive provided progressive market opening scheme so that from 1999 to 2003 member states were required liberalize 25-33 percent of their national markets. This further began the unbundling of the electricity market activities. (Eising 2002)

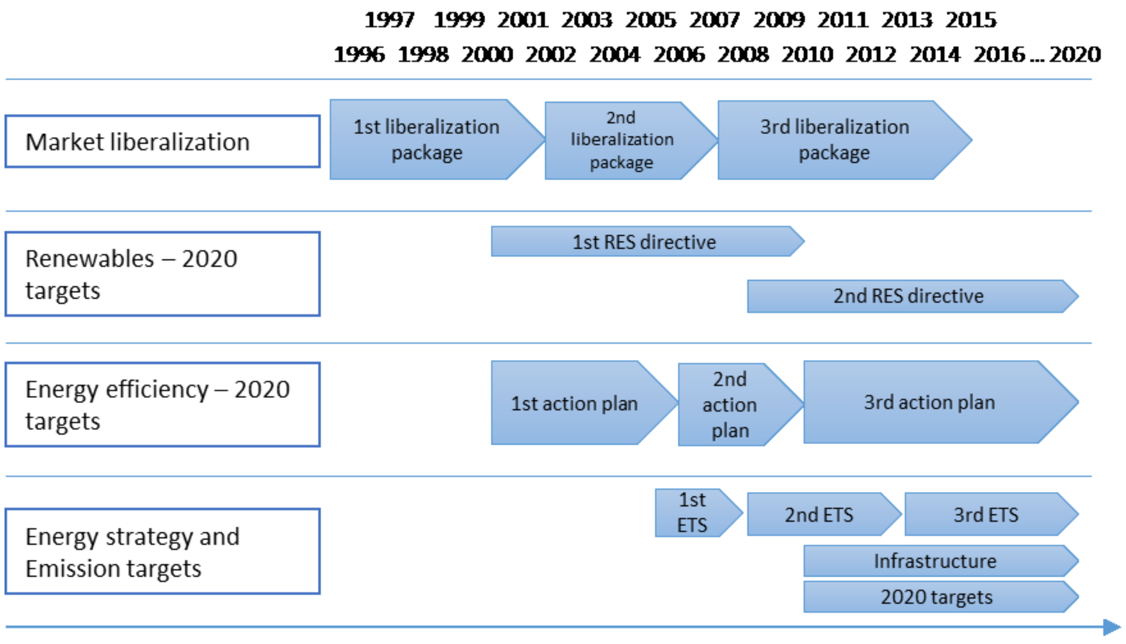


**Figure 1. Overview of EU Energy Policy (Eurelectric 2011)**

The second liberalization package was given in 2003 and the package contained series of measures to further open the national electricity markets. Directive established common rules for generation, transmission and distribution of electricity. It further required EU member states to designate separate transmission and distribution system operators, meaning legal unbundling of the two activities. (2003/54/EC 2003) The second package also deemed all non-household customers eligible. Eligible consumers have the legal right to freely choose their supplier. (Meeus et al. 2005)

The most recent and the most extensive energy package was introduced 2009. It continued from where the second package left to extend the national electricity market opening. The directive 2009/72/EC further continued efforts to unbundle different actors in electricity market. All customers were given right to choose their electricity provider and to change it easily within three weeks. In other words, all customers were deemed eligible. In addition, access to transmission system network was required to be granted to all third parties. National authorities were given rights to participate electricity undertakings but these activities were required to be kept separate from the transmission and distribution services. In other words, the aim was to unbundle energy production and supply interests from the network. Furthermore, one important point was to establish independent National Regulatory Authorities. Their role is to determine transmission and distribution

tariffs, cooperate in cross-border issues, monitor the transmission system operators and ensure user access to customer consumption data. (2009/72/EC 2009)

South East Europe (SEE) regional integration started in 2002 with the Athens process, which target was to create regional SEE electricity market. This regional co-operation continued so that in 2006 the jurisdictions of Albania, Bosnia and Herzegovina, Croatia, the Former Yugoslav Republic of Macedonia (FYROM), Montenegro, Serbia and the United Nations Interim Administration Mission in Kosovo and European Community signed the Energy Community Treaty (EnCT). The main aim of the EnCT was to adopt EU energy targets in SEE countries. In addition, it aimed to establish common rules for the functions of the national electricity markets and for the safeguard methods of the national markets within the SEE region. EnCT also obligated the respective countries to setup a regional electricity market and open the national markets for all customers by 2015. (2006/500/EC 2006, Karova 2011) Energy Community has evolved since the founding and currently also Ukraine and Moldova are its members and signatories of the EnCT. In addition, Croatia has left Energy Community since it joined European Union in 2013. Lastly, Armenia, Georgia, Norway and Turkey are taking part as observers and Georgia is currently a candidate to become a full member of Energy Community. (Energy Community 2015)

## *2.3 From bilateral markets to exchange markets*

The power market is currently dominated by two types of electricity market models: bilateral based trading and power exchange trading. Bilateral markets are more traditional way of organizing the electricity trades. However, power exchanges play crucial part in successful electricity market liberalization.

### 2.3.1 Bilateral trading

Traditionally predecessor of the regional electricity wholesale markets is bilateral electricity trading. In bilateral trading the electricity is traded directly between the supplier and the consumer. Thus, in this model there is no third party involvement.

Three distinctive designs for bilateral trading can be identified. First of them is customized long-term contracts. With such contract the supplier and the consumer usually agree on a delivery of a large amount of electricity during a long period of time and thus

securing the amount of electricity needed for that time interval. Second option is over the counter trading, meaning usually short period delivery deals for smaller amounts of electricity which are typically based on a standardized contracts. The third option is electronic trading where the participants of the trading can place their willingness to buy or sell electricity to electrical marketplace. Then the marketplace system tries to match the offers and if no match occurs, the bids are left open in the marketplace waiting for better matching offers. In all three described design methods the price is set independently by the parties involved in a trade. Also the details of the deals are not published, making the market less transparent. (Kirschen, Strbac 2004)

Bulgarian market structure can be used as an example of a functioning bilateral market. The market is based on bilateral supply contracts and balancing power market. The bilateral market is further divided in regulated and non-regulated part. The regulated part is based on the contracts between the regulated customers, state owned public supplier and public providers. The prices in these contracts are regulated by Bulgarian independent national regulation authority. The non-regulated part is based on freely negotiable contracts between the eligible suppliers and consumers. (Ganev 2009)

In order to keep the balance in the transmission grid, the Bulgarian TSO has a role in this market model as Balance Market counterparty. The non-regulated part of the market needs to balance their real consumption or production to match their contractual delivery schedules. Producers who have generated less than agreed and consumers who have consumed more than agreed need to buy electricity from the TSO to correct their imbalance. The other way around, if produces have generated excess electricity or consumers have used less that what was agreed, they are required to sell electricity to the TSO. (Electricity System Operator 2006) The Bulgarian bilateral power market design is further illustrated in Figure 2.

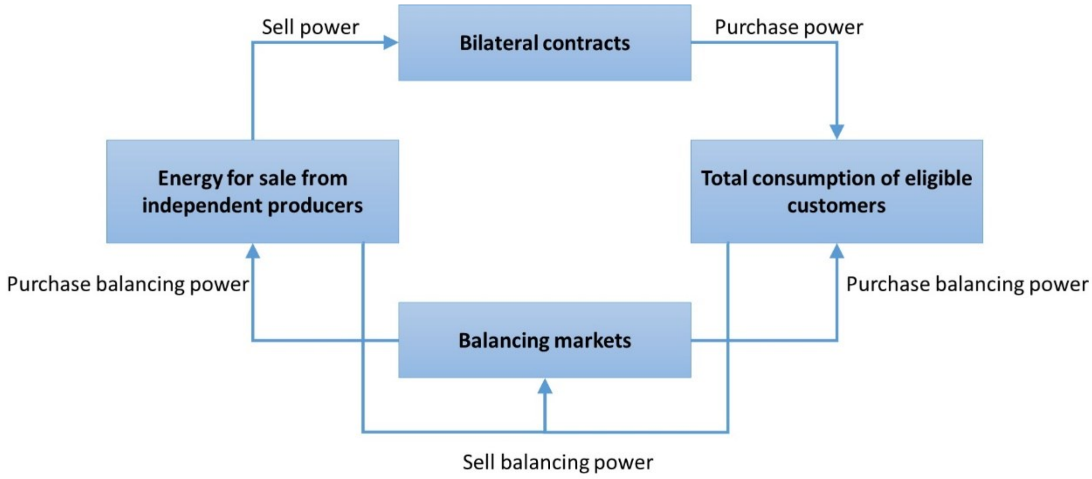


**Figure 2. Bulgarian bilateral electricity market design. (Electricity System Operator 2006)**

### 2.3.2 Power pools and exchanges

The more modern and competitive electricity market designs are called electricity pools or electricity exchanges. In these designs, rather than agreeing for long term contracts directly between the supplier and the producer the trading is done in a centralized manner. In power pools the production and consumption are matched in a systematic way and it does not rely on single interactions between the suppliers and the consumers. The basic idea is that all supply offers are combined to aggregated supply curve and all demand offers are combined to aggregated demand curve. Then the mechanism used by the power pool (optimization algorithm) searches the intersection of these curves, also called as market equilibrium. All the supply offers which are priced equal or lower than the market equilibrium price are realized and similarly all the demand offers which are priced equal or higher than the market equilibrium price are realized. All suppliers are paid the same market equilibrium price and all consumers pay the same market equilibrium price. (Kirschen, Strbac 2004)

Even though bilateral and power exchange market designs are very different, it should be noted that both can exist at the same time. Electricity market participants may decide to trade certain amount of their electricity needs in power exchange and trade some proportion with bilateral contracts. A good example of this it model presented in World Bank’s study showing that especially during transition period from bilateral trading to open exchange trading the eligible consumers and suppliers can have different layers of

contracts. The base load or base need is covered by bilateral contract with the public supplier, by own production and by non-regulated bilateral delivery contract. Then the rest of the trading is done in the power exchange (World Bank 2011). This trade layering is illustrated in Figure 3.

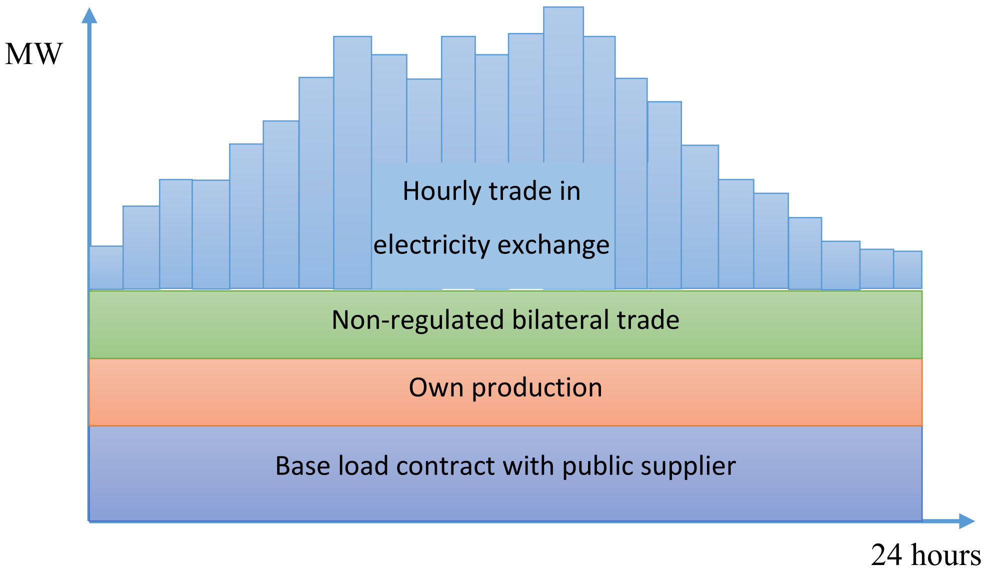


**Figure 3. Combining bilateral and power exchange trading. (World Bank 2011)**

Example of well-functioning power exchange based market design can be found from Nordics where Nord Pool Spot operates a physical power exchange. The so-called Nordic market model consists of four distinctive parts: financial market, day-ahead market, intraday market and balancing market. The financial market is used mainly for market participants' risk managing purposes. In the financial markets, participants can trade with futures, forward and options. With these instruments they can hedge their trading amounts and secure certain price for their trades. Contracts can be made up to ten years in future. The financial market is operated by Nasdaq OMX. (Nord Pool Spot 2015a)

The next two parts are operated by Nord Pool Spot. First part is day ahead market which is like the power exchange described earlier. The primary role of Day Ahead market is to establish equilibrium between the demand and the supply. Nord Pool Spot publishes price for each hour of the next coming day for each day of the year. To complement Day Ahead (DA) market, Nord Pool Spot also operates Intraday (ID) market. In this continuous market the trading takes place up to 30 minutes before the physical delivery. Therefore,

participants are able to balance their actual positions compared to the agreed positions earlier in the DA market. In other words, participants can buy more electricity from ID markets or sell excess to ID market to balance out their portfolios. (Nord Pool Spot 2015a)

The final piece in the Nordic model is balancing market operated by the national TSOs. In the balancing power market the market actors can submit up-regulation or down-regulation offers which are then activated by the TSO if the transmission system needs balancing. The main purpose of such balancing is to maintain stable frequency in the transmission network. (Fingrid 2015)

### 2.3.3 Why exchange rather than bilateral market

In bilateral markets the delivery contracts and deal negotiations are done independently between two parties. Therefore, in a way the bilateral markets are more flexible than the power exchange based markets. However, the negotiation process can be expensive and assessing the reliability of the counterparty can be risky. Exchanges provide security for market participants since it works as their counterparty for all traders and therefore mitigates the counterparty risk. Other advantages on exchange's favor over bilateral trading are lower trading costs and increased competition. Since there are more actors in the market, it naturally increases the competition and forces market participants the use different kind of bidding strategies. Exchanges also produce publically observable price which can be used as price signal for further adjusting bidding strategies or electricity sector investments. It should also be noted that since exchanges work in standardized and efficient way, their trading is much faster and reliable in day to day level. (Stoft 2002)

Other considerable aspects in favor of exchange based market design are enhancing investment on climate and transparency. In the Nordic electricity markets electricity is produced so that most affordable production methods are activated first. Different production methods are activated in merit price order one after another as long as the demand is met, this is illustrated in Figure 4. In other words, this market model tends to support more climate friendly production methods due to their lower marginal costs. On the other hand, in bilateral contracts producer and consumer agree only on the amount and price and thus does directly favor climate friendly generation methods.

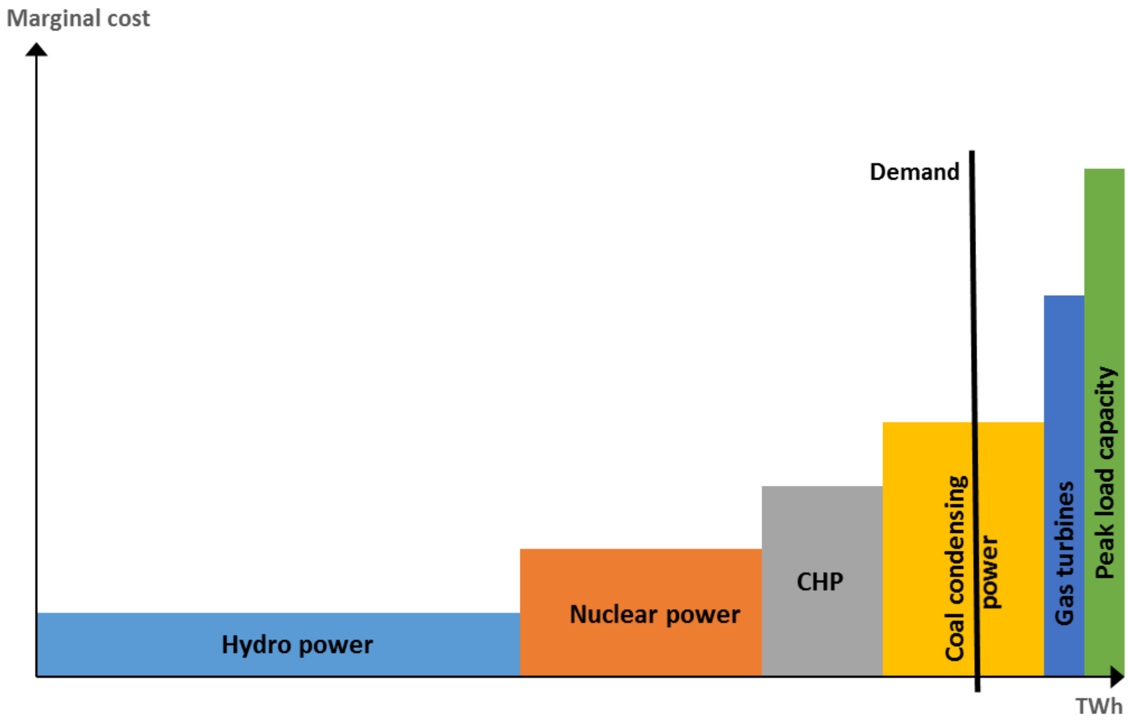


**Figure 4. Merit order of production. (Liski 2006, Suomen ElFi 2015)**

Transparency is one of the aspects EU legislation aims to improve in electricity markets. In line with that target, exchange market design provides more transparency to the markets. In the Nord Pool Spot's markets the insider trading and market manipulation is permitted. In addition the operations of the exchange are explained publically stating how to price is calculated. Exchange also provides price-relevant information publically for everybody's use. (Nord Pool Spot 2015c).

# 3 Overview of South East Europe electricity sector

This study focuses on a particular set of countries in South East Europe. The set includes Albania (AL), Bosnia and Herzegovina (BA), Bulgaria (BG), Croatia (HR), Montenegro (ME), Former Yugoslav Republic of Macedonia (FYROM), Serbia (RS) and Kosovo (XS). The country set which is researched in this study is chosen so that the countries do not have any existing major regional collaboration in electricity markets. Other SEE/CEE countries Hungary, Romania, Czech Republic and Slovakia already collaborate in 4M Market Coupling and Slovenia has market coupling with Italian power exchange GME. Thus, they are left out of the scope. In this chapter the electricity sectors of the selected jurisdictions are investigated closer and the most relevant electricity sector figures are presented.

## *3.1 Electricity sector at regional level*

Final electricity consumption in selected countries has stayed pretty stable on the last three years. Final electricity consumption includes electricity used in transportation, industry and other end use sectors such as residential, services, forestry/agriculture and fishing. Serbia is the only jurisdiction which has notable decreased in their electricity consumption during the last few years. Opposite to that, Albania and Kosovo have slightly increased their consumption, keeping the total regional consumption around the same level throughout the last five years. The final electricity consumption in the selected South East Europe countries can be seen in the Figure 5. Total regional electricity consumption in 2013 was close to 102TWh. Data for the figure is acquired from Eurostat, except for Bosnia and Herzegovina and Kosovo. Final electricity consumption values for these two jurisdictions are extracted from Energy Community annual reports. It should be noted that the overall regional electricity consumption is quite low. As reference, electricity consumption only in Finland was around 82TWh in 2013 (Energiateollisuus 2014).

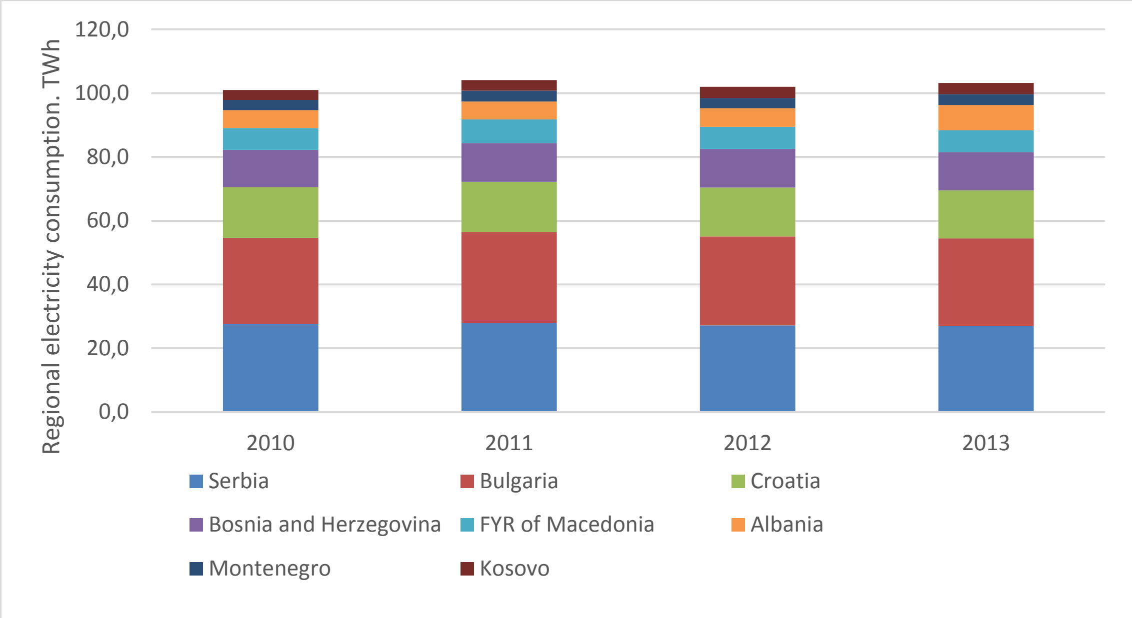


**Figure 5. Regional development in electricity consumption. Data source: Eurostat, (Energy Community Secretariat 2012, Energy Community Secretariat 2014)**

Taking a closer look to year 2013, it can be seen that Bulgaria and Serbia are the main consumers of electricity in the region, illustrated in Figure 6. The yearly final electricity consumption in both two countries is around 27TWh, making them distinctively the biggest electricity consumers in the region. The next largest electricity consumers are Croatia and Bosnia and Herzegovina consuming yearly around 15TWh and 12TWh respectively. The least consuming group is formed by FYR of Macedonia, Albania, Montenegro and Kosovo. All of these jurisdictions have yearly final electricity consumption under 10TWh. Also the distribution losses are illustrated in the Figure 6. All of the jurisdictions have quite high distribution losses, Serbia standing out with almost twenty percent distribution losses compared to the final electricity consumption. High distribution losses imply that the power systems in the region are not in good state and investments are needed to bring the losses down. Again, if the distribution losses are compared to Finland where the losses were around 3% of yearly electricity consumption in 2013, it can clearly be seen that the losses are outstanding issue in SEE region (Energiateollisuus 2014).

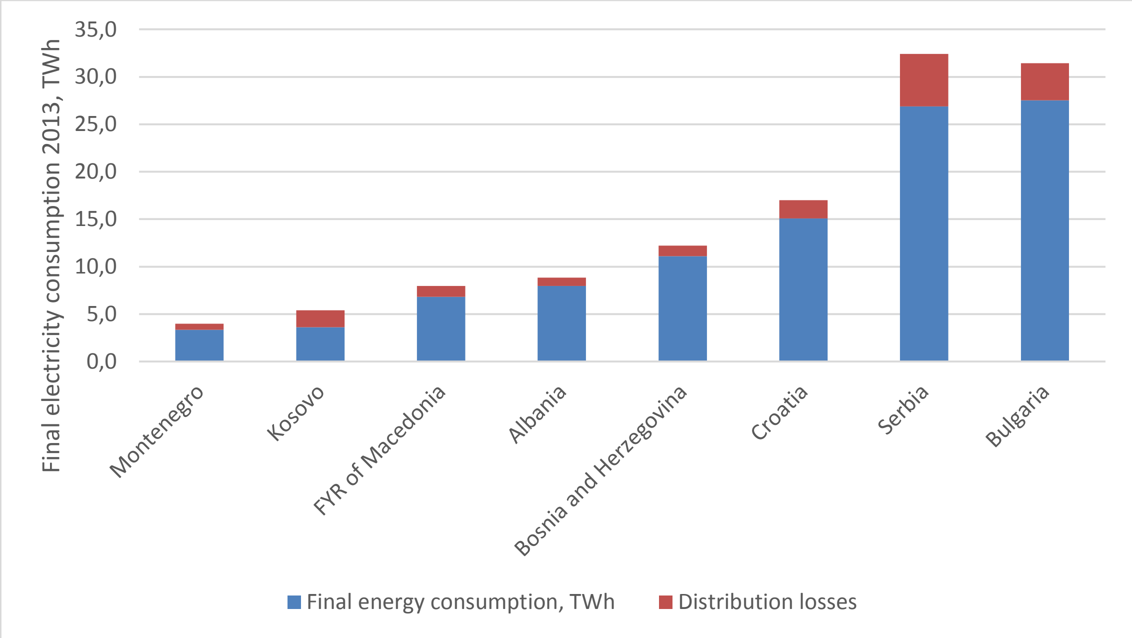


**Figure 6. Final electricity consumption and distribution losses in 2013. Data source: Eurostat, (Energy Community Secretariat 2012, Energy Community Secretariat 2014)**

The selected region generates most of needed electricity with own installed generation capacity. Figure 7 shows the yearly electricity production per fuel type for each country. The regional total production is close to 135TWh. Most of the electricity is produced by two fuel types: coal and hydro. Majority of the yearly production of electricity, approximately 70TWh, is produced with coal-fired power plants. Next largest production cluster is hydro power plants, following with 42TWh yearly production. Bulgaria is the only country having nuclear power plants making it the sole producer of nuclear energy in the region. Nuclear powered production is covering 10,5% of region's electricity production. Rest of the region's electricity is generated by gas-fired power plants, renewable energy resources, oil-fired production and other production such as biomass/gas powered generation. The electricity production mix in the region is not quite versatile since almost 83% of all production is covered by coal and hydro power. In addition, electricity generation patterns are quite different in the different jurisdictions. Many of the jurisdictions rely only for either coal or hydro power. However, distinctive to other jurisdictions in the area, Bulgaria generates electricity with almost all possible power production possibilities.

Data for Figure 7 is constructed mainly from Eurostat database. Exception is made for Bosnia and Herzegovina of which data is from ENTSO-E database and Kosovo of which data is from Energy Community report assuming that 3% production was generated from hydropower (according to installed production capacities).

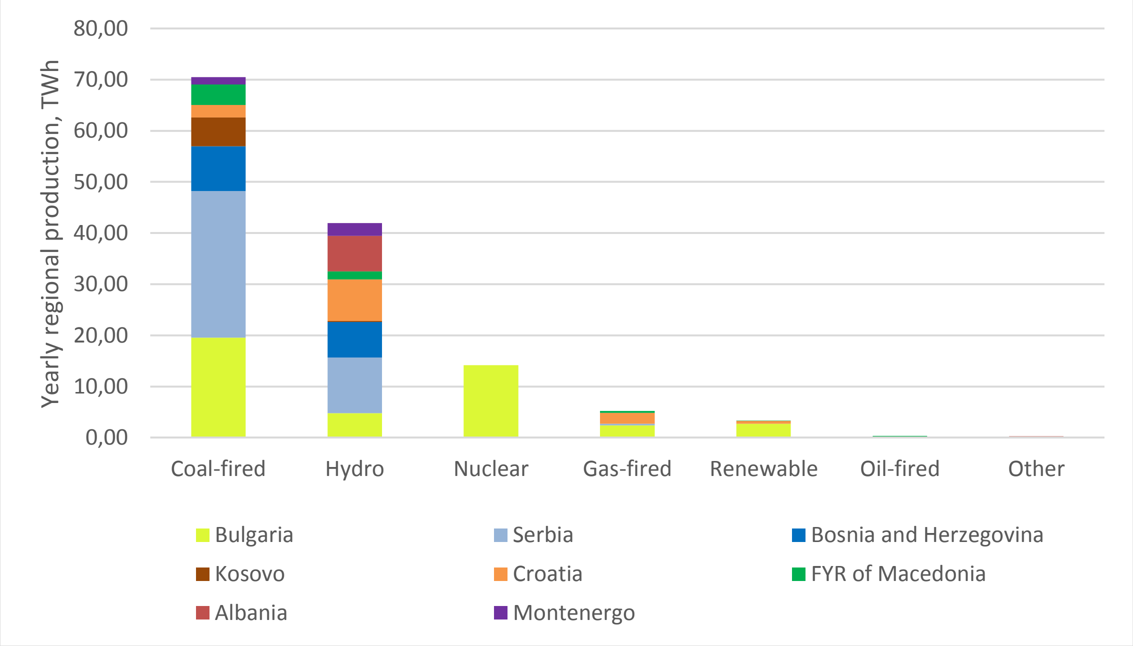


**Figure 7. Yearly electricity production per fuel type in 2013. Data source: Eurostat, ENTSO-E, (Energy Community Secretariat 2014)**

European Network of Transmission System Operators for Electricity (ENTSO-E) is association of European electricity transmission system operators mandated by European Union. The main tasks for ENTSO-E includes coordinated, reliable and secure operations of the interconnected network, helping development of integrated and transparent electricity markets, supporting network research and design work and give guidance to stakeholders. All other jurisdictions and their TSOs in the selected region expect Albania and Kosovo are members of ENTSO-E. They all are also are part of the synchronized network in central Europe. Albania is synchronously operated with the continental Europe but has not met all the strands to be accepted as ENTSO-E member. However, ENTSO-E and Albania have agreement on permanent synchronous operation of Albanian and Continental Europe transmission systems. (ENTSO-E 2014b, ENTSO-E 2014a, ENTSO-E 2014c) As mentioned, Kosovo is also not part of ENTSO-E. Kosovo's transmission system operator KOSTT states that their primary objective is to join ENTSO-E but there

are some barriers in meeting the membership criteria and in cooperation with Serbian transmission system operator (KOSTT 2015). Therefore, Kosovo is included under Serbian control area in ENTSO-E provided data sources (World Bank 2011).

Looking at the electricity flows between ENTSO-E countries it can be identified which jurisdictions are net importers and which are net exporters. It should be noted here that since Kosovo is not recognized as own network area by ENTSO-E, it does not have separate values. Instead, the electricity exchange from and to Serbia and Kosovo network area is presented as single value. The yearly total electricity exchange values from 2013 and sum of total imports and exports per jurisdiction are presented in Table 1. Note that Greece, Hungary, Romania and Slovenia do not have import and export sums in Table 1 since only electricity exchange between them and selected region is relevant for this study. As can be seen from the Table 1, Albania, Croatia and FYR of Macedonia are net importers of electricity whereas Bulgaria, Bosnia and Herzegovina, Montenegro and Serbia and Kosovo network area are net exporters of electricity. Albania imports most of the electricity from Montenegro and in addition smaller amount from Greece. Albania also exports minor amount of electricity to Serbia and Kosovo network area. Majority of Croatia's electricity imports are coming from Bosnia and Herzegovina. In addition, Croatia imports also large amounts from other neighboring countries Hungary, Slovenia and Serbia and Kosovo network area. However, Croatia also exports considerable large amounts to Slovenia making it net exporter in their power trading. FYR of Macedonia imports electricity quite evenly from both Bulgaria and Serbia and Kosovo network area and also minor amount from Greece. All areas which have connections out of the selected region are exporting and importing with neighboring regions. Greece has cross-border trades with Albania, FYR of Macedonia and Bulgaria. Romania trades with Bulgaria and Serbia and Kosovo network area. Hungary has cross-border flows with Croatia and Serbia and Kosovo network area and finally Slovenia trades with Croatia. Total yearly electricity import to selected region was 10,45TWh in 2013 while yearly export from selected region was around 11TWh. Thus, the selected region was net exporter of electricity in 2013 with electricity mount of 0,57TWh.

**Table 1. Yearly cross-border flows in GWh 2013. Data source: ENTSO-E**

| FROM/TO | AL | BA | BG | GR | HR | HU | ME | FYROM | RO | RS | SI | Export |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AL** | | | | 566 | | | 230 | | | 642 | | **1438** |
| **BA** | | | | | 4207 | | 2117 | | | 541 | | **6865** |
| **BG** | | | | 1746 | | | | 2139 | 202 | 860 | | **4947** |
| **GR** | 729 | | 5 | | | | | 54 | | | | |
| **HR** | | 1127 | | | | 417 | | | | 13 | 5207 | **6764** |
| **HU** | | | | | 2911 | | | | | 278 | | |
| **ME** | 1508 | 518 | | | | | | | | 1316 | | **3342** |
| **FYROM** | | | 9 | 1490 | | | | | | 36 | | **1535** |
| **RO** | | | 2912 | | | | | | | 973 | | |
| **RS** | 83 | 1526 | 427 | | 1563 | 952 | 666 | 1760 | 440 | | | **7417** |
| **SI** | | | | | 2589 | | | | | | | |
| **Import** | **2320** | **3171** | **3353** | | **11270** | | **3013** | **3953** | | **4659** | | |

## *3.2 Local electricity field characteristics*

The net electricity production capacities per jurisdiction and hourly load curves for each jurisdiction are described in this chapter. This data is further used in the simulations performed in this study. Figure 8 shows the regional electricity production capacities in each country. In the SEE region hydro power capacity has the highest share in the total generation capacity amount since all of the jurisdictions have some amount of it. Total hydro capacity amount in the selected region is around 13,5GW and the majority of this capacity exist in Bulgaria and Serbia. The second largest generation capacity cluster consists of coal-fired power plants. The theoretical net production capacity with coal is close to 12GW. Similar to hydro generation capacity, almost all jurisdictions have some amount of coal-fired capacity. However, Albania does not any have fossil fuel power generation units except really minor (98MW) availability for oil-fired production. Instead, basically all Albanian production is based on the hydro generation. Gas-fired generation units are located mainly in Bulgaria, Serbia and Croatia. Nevertheless, the amount of gas-fired generation in the region is moderate. Only country possessing nuclear generation capacity is Bulgaria. Bulgaria has two nuclear power plant units totaling to 2000MW production capacity (Bulgarian Energy Holding 2015b). There is also some amount of renewable production is the region mainly containing wind, biofuel and solar generation units.

Overall observation is that the region has quite good mix of different generation types per fuel. The situation is similar to Nord Pool Spot market area where there is good variety of different types of generation facilities. Figure 8 shows that the generation mix is very different in different jurisdictions. If each jurisdiction produces electricity independently without effective electricity exchange then the coordinated and effective activation of generation resources is challenging. However, large variety of different generation possibilities can efficiently be utilized within the regional electricity market. Thus, considering the generation structure in selected jurisdictions, there is great opportunity to improve the activation order of the generation units if they are considered as available resource units for whole area.

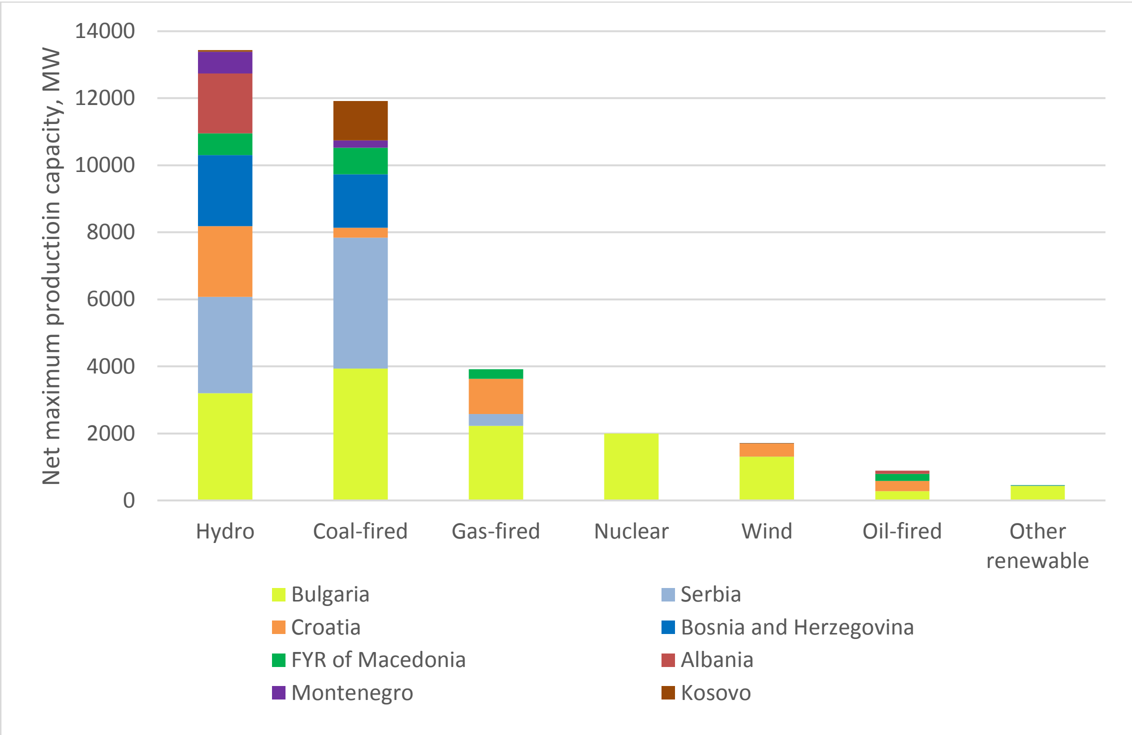


**Figure 8. Net maximum production capacity per fuel type at the end of 2013. Data source: ENTSO-E, (Energy Community Secretariat 2014)**

If the net maximum production capacity in the selected region is compared to the actual yearly production pattern which occurred in 2013, it can be seen the hydro and coal-fired production have changed the places. This can be indication of two things, firstly all of the hydro capacity cannot be fully utilized every day of the year. Secondly, since there is no market cooperation within the region, all of the hydro production is not necessarily utilized in the most efficient way. There also seems to be more gas-fired electricity

production potential than what was realized in 2013. This can potentially be explained by gas-fired co-generation (Combined Heat and Power generation) where all electricity potential is not used at the times when also heat is produced.

In order to efficiently analyze demand side the averaged day approach is used in this study. Hourly load values were extracted from ENTSO-E database for all selected jurisdictions, these values show occurred demand for each hour of the year. Average for each hour of each month were calculated so that a typical day was identified for each month. These days are named from D1 to D12 in respect to the months and used as such further in this study. Naming convention is clarified in Table 2. Figure 9 illustrates the averaged 12 days, each representing a typical day in each month from January to December. It should again be noted that since Kosovo is not considered as own network area by ENTSO-E, Serbia and Kosovo is considered as one network area also in these figures. In addition, since Albania is not member of ENTSO-E its yearly consumption in 2013 (according to Eurostat database) is divided evenly for all hours of the year creating a flat curve. The curves show that there is clearly seasonal and daily variation in demand amounts in all jurisdictions. During summer months less electricity is consumed whereas winter months are the peak demand months. Inside one day the peak hours occur during morning around 7:00 and then again at the evening around 19:00. The load curve profile is quite similar for all selected jurisdictions.

**Table 2. Naming of averaged days.**

| Typical day in | Naming convention |
|---|---|
| January | **D1** |
| February | **D2** |
| March | **D3** |
| April | **D4** |
| May | **D5** |
| June | **D6** |
| July | **D7** |
| August | **D8** |
| September | **D9** |
| October | **D10** |
| November | **D11** |
| December | **D12** |

In line with the yearly final electricity consumption illustrated earlier in Figure 6, also hourly consumption shows that Serbia and Kosovo network area and Bulgaria are the highest consumers in the region. Their yearly consumption varies quite much from 2700MW to 6200MW. Montenegro, Albania and FYR of Macedonia are the smallest areas when it comes to hourly loads. Their values are varying from 200MW to 1200MW. Between these two consumption classes there are Bosnia and Herzegovina and Croatia with hourly consumption levels between 1200MW and 2200MW.

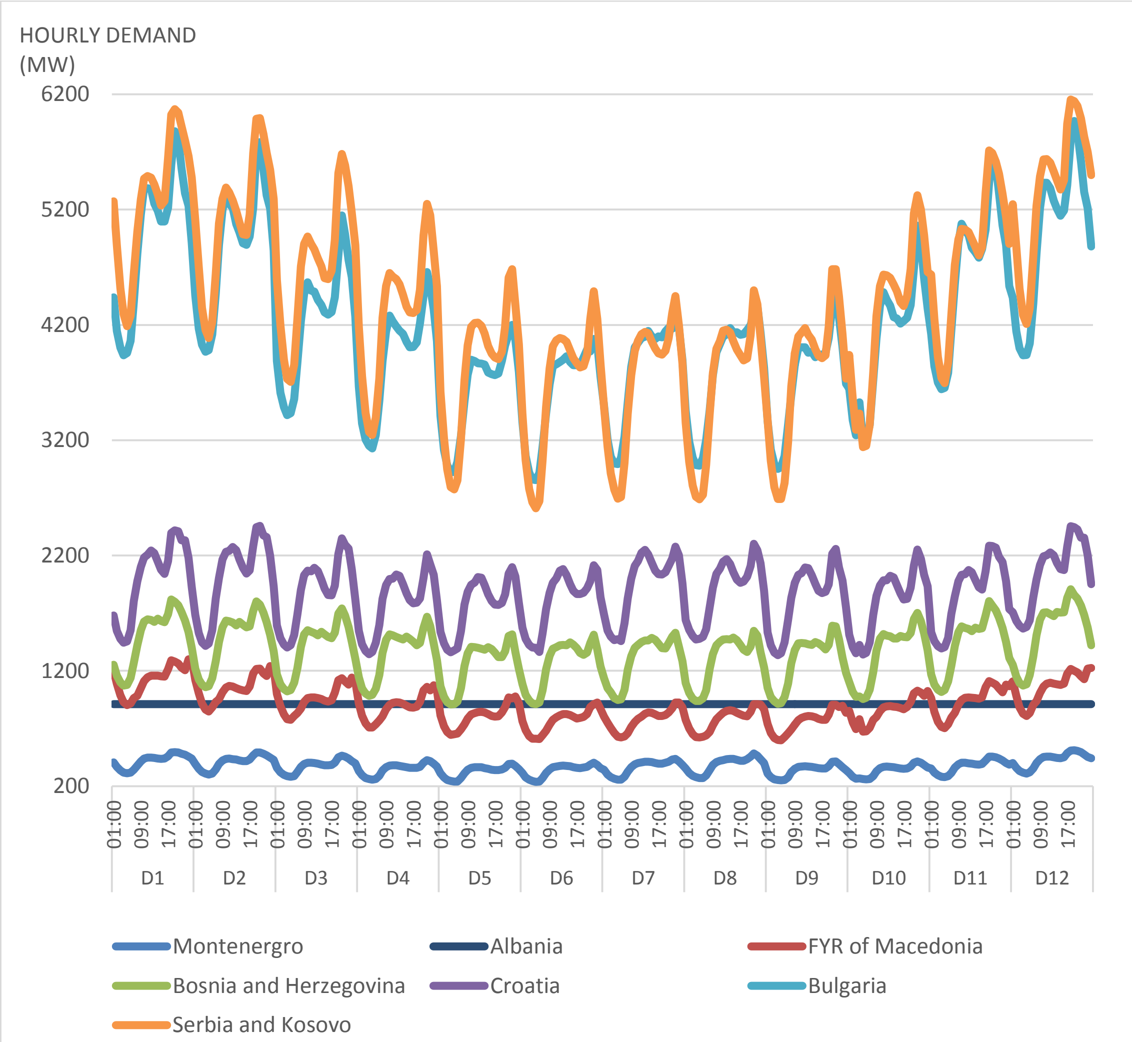


**Figure 9. Hourly and seasonal variation of consumption in 2014. Data source: ENTSO-E, Eurostat**

# 4 Current state of market opening in SEE region

There are three main dimensions for the electricity market opening status: degree of vertical unbundling, degree of horizontal unbundling and finally eligibility threshold and overall market openness. In this chapter, the latest statuses of these dimensions are given for each selected jurisdiction. Firstly, the degree of the vertical unbundling of the state-owned energy enterprise is observed. Vertical unbundling means legally separating different parts of the electricity market operations such as transmission, distribution, exchange and regulatory operations. Secondly, the degree of the horizontal unbundling is researched i.e. how well the state owned generation capacity is privatized. Lastly, the overall market openness is studied focusing on the eligibility threshold and the state of establishing an electricity exchange.

## *4.1 Albania*

As shown in previous chapter, the electricity sector in Albania is relatively small. The electricity transmission system in Albania is operated by fully state-owned company OST. OST was created and legally separated from Albanian Power Corporation in 2004 as part of the vertical unbundling process. OST is also responsible for dispatching and market operations in Albania. (OST 2015)

Even though OST and its activities are separated from other energy sector activities, the legal unbundling of network operations is not included in Albanian power sector law. In addition, Albanian distribution company OSHEE is not functionally unbundled to separated supply and distribution activities. In fact, OSHEE is functioning both as distribution system operator and as public retail supplier in Albania. Due to these reasons, the vertical unbundling process in Albania is still uncompleted and requires restructuring of OSHEE and updates to the power sector law. Also horizontal unbundling in Albania is not accomplished. The wholesale market is monopolized by state-owned company KESh which owns majority of Albanian generation capacity. (Energy Community Secretariat 2014)

In Albanian market model KESh is required to provide ancillary services needed to maintain grid security and power balance. KESh is also functioning as Wholesale Public Supplier. Therefore, all the generation is agreed by annual contracts and fixed prices

regulated by Albanian regulatory authority ERE and sold to KESh. There are also so called small power producers (SPP) and independent power producers (IPP) in the Albanian market model. The difference between them is that SPPs are connected to distribution network while IPPS are connected directly to the transmission network. SPPs are allowed to trade with qualified suppliers, traders and distribution system operator with freely negotiated terms. Therefore this trading is bilateral based. In addition, small power producers are allowed to sell directly to the wholesale public supplier KESh with regulated price. IPPs have similar rights to sell to OST, eligible customers, qualified suppliers or traders at freely negotiated prices and with regulated prices to KESh. (Enti Rregullator i Energjise 2015) Nevertheless, since KESh owns the majority of the generation capacity in Albania, the share of the free market and the role of the SPPs and IPPs is currently really minor. However, this situation may change in near future since Devoll Hydropower and Statkraft are contracting a project of building a 256MW hydro power plant in Albania. This will increase Albanian electricity production by 17 percent and increase the IPPs market share significantly when fully operational in 2018 (Devoll Hydropower 2015).

Albanian regulator ERE grants eligibility status based on the annual consumption levels. Thus, only few large customers have acquired eligibility status giving them right and obligation to contract their supply outside of the regulated system. For the customers not having the eligibility status granted by ERE, the market is foreclosed on the wholesale and retail level due to the monopoly statuses of KESh and OSHEE. There is no power exchange or other liquid market place in operation in Albania. In addition, there is no daily auctions for cross-border trades between Albania and Kosovo. Instead, all the cross-border trading happens in pro-rata basis. However, ENTSO-E allowed Albania to join central Europe synchronized transmission network and Albania also joined SEE Coordinated Auction Office (SEE CAO) which aims to have joint capacity allocation for the whole region. (Energy Community Secretariat 2014)

Albania aims to have liberalized wholesale markets function by the year 2018. As part of this process, Albania will adopt new energy laws in 2015 to adapt the market model which is in line with the 3rd EU energy package requirements. (Mediterranean Energy Regulators 2015) Furthermore, Albania joined SEE Coordinated Auction Office early 2015 and thus

capacity between Albania and Montenegro is now included in SEE CAO monthly auction process. (SEE CAO 2015) In addition, Albania and Kosovo have plans to create common market for electricity. These plans are elaborated further in this study in chapter 4.6.

## 4.2 Bosnia and Herzegovina

The jurisdiction of Bosnia and Herzegovina is split into two autonomous entities: the Federation of Bosnia and Herzegovina and the Republika Srpska. (Central Intelligence Agency 2015a) This division is also reflected to the energy sector of Bosnia and Herzegovina. The state level legislative authority belongs to the Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina. However, both entities have also their own institutions for energy governance: Federal Electricity Regulatory Commission and Regulatory Commission for Energy of Republika Srpska. Electricity production, distribution and supply activities are governed by the two entities in their respective areas, whereas transmission and regulation activities are governed at state level. Due to the split in the political level, there has been difficulties in state level cooperation and in the energy sector reform in recent years. State Electricity Regulatory Commission functions as state level regulatory authority but does not have power over the whole energy sector in Bosnia and Herzegovina and therefore has to cooperate with entity level regulatory authorities. (Energy Community Secretariat 2014)

The unbundling and market reform process in Bosnia and Herzegovina is behind its neighboring countries. Law of establishing independent transmission system operator was adopted already 2004 at state level. Independent System Operator in Bosnia and Herzegovina (ISO BiH) was established in respect to the new law. However, the transmission activities are still split between ISO BiH and Elektroprenos BiH. ISO BiH is responsible for dispatching and balancing activities and allocation of the cross-border capacities whereas Elektroprenos BiH owns the transmission network and is in charge of connections, transmission, metering, maintenance and development of the infrastructure. Furthermore, the Energy Community report indicates that transmission investments and independent decision making have not been effective which further questions the effectiveness of the unbundling of the transmission activities. (Energy Community Secretariat 2014)

Unbundling of the distribution operations is not realized in Bosnia and Herzegovina. In Federation of Bosnia and Herzegovina distribution operations are handled by two vertically integrated enterprises EP BiH and EP HZHB. Same companies are also responsible for supply and power generation operations in the respective entity area. Similarly, in the Republika Srpska the distribution activities are carried out by ERS enterprise subsidiaries and remains both legally and functionally bundled with their supply operations. However, in Republika Srpska the generation activities of ERS are legally unbundled from their distribution and supply services. (Energy Community Secretariat 2014)

Also granting eligibility status to all customers in Bosnia and Herzegovina is still not accomplished. Regulatory Commission for electricity of Republic of Srpska has stated that from the beginning of 2015 all customers are eligible and can freely choose the supplier from whom they will buy electricity. However, the electricity prices will still remain regulated (Regulatory Commission for electricity of Republic of Srpska 2015) . In the Federation of Bosnia and Herzegovina eligibility status is granted at entity level. In theory, the wholesale market functions at bilateral and over-the-counter basis. However, there is no real competition in the markets and it lacks liquid trading platform for electricity. The number of the generation companies representing at least 95% of the national generation in Bosnia and Herzegovina was only two in 2013. In addition, electricity consumers mainly have to choose their local producer as their supplier. (Eurostat 2015a)

## 4.3 Bulgaria

Bulgarian energy sector and domestic market is highly concentrated around the Bulgarian Energy Holding (BEH) Company. It is state owned company originating from Bulgarian Oil and Gas Company established already in 1973. During recent years the company has split even more to amend the EU energy legislation. BEH has also a daughter company NEK which is the national electricity supply company and owns around 45% of the all installed capacity in Bulgaria. Anyhow, the legal vertical unbundling in Bulgaria has progressed well. In 2013 NEK terminated its electricity transmission activities and Electricity System Operator (ESO) applied for the role of electricity system operator. In 2014 the last phase of the split between NEK and ESO was completed and ESO became

the legally unbundled owner of the Bulgarian transmission grid. ESO is also full member of ENTSO-E. In addition, the distribution network has been privatized and is owned by CEZ, EVN and Energo-Pro. Therefore, the distribution and supply activities in Bulgaria are legally unbundled. However, ESO is still fully owned by BEH. Furthermore, as part of vertical unbundling process BEH group licensed its subsidiary Bulgaria Energy Exchange (IBEX) to be able to operate organized power exchange and Day Ahead market in Bulgaria. Bulgarian energy sector is regulated by independent authority State Energy and Water Regulatory Commission (SEWRC), which was established already 1999. The electricity market in Bulgaria is regulated based on the Electricity Trading Rules and the newest version of them was applied in 2013 to meet the requirements of the EU's third liberalization package. Thus, the new amendments to the rules meet all the perquisites for establishment of working Day Ahead market by IBEX. (Bulgarian Energy Holding 2015a, European Commission 2014a, State Energy and Water Regulatory Commission 2014)

Market opening in Bulgaria has also been progressing already for several years. In 2007 all consumers became eligible, resulting in theoretical full market liberalization. The current Bulgarian market model includes methods to trade electricity. In the first method electricity is traded at regulated prices approved by SEWRC and in the other one electricity is traded in liberalized electricity markets bilaterally. The bilateral contracts are freely negotiated between the parties on the markets. The liberalized part of the market was opened in 2013 and it covers about third of the trade, including mainly consumers connected to the transmission network. However, the Bulgarian market is highly concentrated and in 2012 just 33 percent of the market participants covered 92 percent share of the whole markets. Bulgaria also has active cross-border trading with neighboring areas where the cross-border capacity is allocated and agreed bilaterally between the auction operators of the neighboring systems. (European Commission 2014a, State Energy and Water Regulatory Commission 2014, Ganev 2009)

Early 2015 Nord Pool Spot and IBEX announced that Bulgaria will further develop their power markets by launching a competitive Day Ahead power market in Bulgaria. IBEX shall develop a transparent and efficient power markets where Nord Pool Spot will work

as their partner to deliver the required trading systems. The planned launch of market operations is by the end of Q4 2015. (Nord Pool Spot 2015b)

## 4.4 Croatia

Similar to Bulgaria, also Croatia's energy sector has been concentrated around state owned energy holding company, which has been unbundled to separate operations during recent years. HEP Group was engaged in all electricity market activities being production, transmission, distribution, supply and trade. However, in recent years the legal unbundling of aforementioned activities has been carried out, except for distribution and supply. In 2013, transmission activities were unbundled from HEP Group when Croatian Transmission System Operator (HOPS) was established. HOPS equity capital was increased and founding acts amended to strengthen the unbundling from HEP. Electricity distribution and supply activities are carried out by Croatian distribution system operator HEP-ODS. Same company also provides electricity supply as public service. Since HEP-ODS is owned by HEP Group and distribution and supply are not unbundled, the vertical unbundling in Croatia is still ongoing process. (Croatian Energy Regulatory Agency 2014, European Commission 2014b, Energy Community Secretariat 2013)

Croatian energy regulatory authority HERA was established already 2004 and it is regulating the energy sector independently. The newest energy law was adopted in Croatia in 2012 which aims to align their national legislation with the EU third energy package. In addition, as part of Croatian energy sector reform Croatian energy market operator HROTE was established in 2005 by HEP-Group and later transferred to Croatian state in 2007. HROTEs main responsibility is to organize electricity and gas markets as public service and therefore it is operating under supervision of HERA (Croatian Energy Regulatory Agency 2014, Energy Community Secretariat 2013). In order to facilitate open electricity market and Day Ahead electricity auctions, HROTE and HOPS co-founded CROPEX power exchange in 2014 (Trhulj 2014). Mid 2015 CROPEX further announced that they have signed Cooperation Agreement with Nord Pool Spot to create first competitive Croatian day-ahead power market. By creating an efficient Croatian power market, Croatia aims to join the pan-European multiregional coupling of power markets. Nord Pool Spot will function as CROPEX's partner to operate the market.

Communicated start date for market operations is the end of the fourth quarter of 2015. (CROPEX 2015)

Currently, Croatian markets are functioning at bilateral basis and the prices are freely negotiable. However, the competition in the market is very limited. The generation sector is dominated by HEP-Group and it was the biggest generator in 2012 with 82% market share. Another bigger producer is TE Plomin d.o.o which is co-owned by RWE and HEP. Still at the end of 2013, 95 percent of the generation capacity in Croatia was owned just by two companies. Croatia also actively performs cross-border trading and HOPS is one of the co-owners of SEE Coordinated Auction Office. Cross-border capacity auctioning with Hungary and Slovenia is conducted by SEE CAO whereas capacity allocation with Bosnia and Herzegovina and Serbia is done via daily auctions. (Croatian Energy Regulatory Agency 2014) Eligibility in Croatia is well adopted and Croatian legislation states that all customers are eligible and free to choose their supplier. (Energy Community Secretariat 2013)

## 4.5 Former Yugoslav Republic of Macedonia

Energy sector reform in FYR of Macedonia has proceeded relatively well. The base for the reform is Energy Law from 2011. In terms of vertical unbundling process, FYR of Macedonia has independent transmission system operator, Electricity Transmission System Operator of Macedonia (MEPSO), which is fully state owned company established in 2005. MEPSO's existence is also required by law, in line with the Third Energy Package. (Energy Community Secretariat 2014) However, unbundling of distribution and supply activities has not yet taken place. There are two companies operating in this field, ELEM and EVN Makedonija. Majority of the distribution system and activities are handled by EVN which owns close to 99,5% of the physical network whereas ELEM owns the rest around 0,5% of the network. Both of them supply to customers at regulated prices. (Energy Regulatory Commission of the Republic of Macedonia 2015)

Since the beginning of 2015 all customers have been eligible in FYR of Macedonia. However, the market is dominated by ELEM which is responsible for 91 percent of all electricity generation in the country. Rest of the supply is from unregulated domestic

producers, small hydroelectric power plants and photovoltaic power plants. The second phase of the electricity market liberalization in FYR of Macedonia started early 2014 and all customers expect households and small non-households were required to purchase electricity through tender procedure. However, most of the customers failed to find supplier before the end of 2014. Therefore, FYROM's regulatory authority, Energy Regulatory Commission (ERC) obligated ELEM and EVN to provide electricity as public service to those not landing in supply agreements through tenders. ECR approximated that their electricity market liberalization percentage was around 45% at the end of 2014. (Energy Regulatory Commission of the Republic of Macedonia 2015)

The electricity market in FYR of Macedonia is divided into two parts, unregulated and regulated. The regulated part concerns mostly ELEM and MEPSO and thus the majority of the market. The price which ELEM uses to sell electricity is regulated by ECR. Therefore, most of the electricity market in FYR of Macedonia is price regulated. The unregulated part of the market concerns mostly eligible consumers and other electricity generators, suppliers and traders. They can sell and purchase electricity at freely negotiated prices with own choice and risk. (Energy Regulatory Commission of the Republic of Macedonia 2015) FYR of Macedonia is working towards the market opening and new electricity market rules, tariff system and purchase rules to cover network losses became into force in 2014. In addition, the distribution grid code was updated. (European Commission 2014d)

FYR of Macedonia is trading with its neighboring areas and cross-border capacities are allocated through yearly, monthly, weekly and intra-day auctions. The cross-border capacities are divided half between FYR of Macedonia and each neighboring area. Taxation issues have prevented MEPSO to join SEE Coordinated Auction Office. (Energy Community Secretariat 2014) Slovenian power exchange BSP South Pool released news already in 2009 about plans to co-operate with FYR of Macedonia to establish trading infrastructure on their electricity markets. (BSP SouthPool 2009) However, there are no recent news of this project or progress of establishment of a functional power exchange in FYR of Macedonia.

## 4.6 Kosovo

Kosovo jurisdiction is slightly different from the other jurisdictions discussed in this study. Kosovo declared its independency and separation from Serbia in 2008 but Serbia has not recognized Kosovo's independency yet and treats it as autonomous area. However, over 100 other United Nations countries have recognized Kosovo and since 2013 Kosovo and Serbia has committed making progress between their relationships. (Central Intelligence Agency 2015b) The political situation naturally also affects the energy sector and the electricity market opening process.

The Ministry of Economic Development in Kosovo is responsible for energy sector legislation and is in progress to transpose European Union third energy package content into their Law on Energy, Law on Electricity and Law on Energy Regulator. Electricity sector activities are divided into three main companies; Kosovo Energy Corporation (KEK) is the public electricity generator in the jurisdiction, KOSTT operates as transmission system operator and Kosovo Electricity Distribution and Supply (KEDS) is responsible for the distribution operations. Furthermore, the energy sector is regulated by single authority Energy Regulatory Office (ERO). (Energy Community Secretariat 2014) ERO's independence status is doubted due to the intervention and interference by Kosovo's government. (European Commission 2014c)

KOSTT is fully unbundled in theory. However, KOSTT has been included in the control area of the Serbian transmission system operator EMS. Thus, KOSTT has not been able to allocate cross-border capacities nor handle congestion management. Long-term cross-border capacities with neighboring areas have been allocated through SEE Coordinated Auction Office. (Energy Community Secretariat 2014) Late 2014 KOSTT and EMS signed Operational Agreement which regulates the bilateral relations regarding the operations of the two transmission system operators and their network areas. This agreement separated Kosovo to independent network and trading area operated by KOSTT. (KOSTT 2014)

Distribution and supply activities remain bundled in Kosovo. KEDS is still operating in both fields, even though it has namely separated these activities into two different internal divisions. All customers became eligible in Kosovo at the beginning of 2015. (European

Commission 2014c) However, the ability to switch supplier is still theoretical in Kosovo due to the lack in competition. The electricity market is fully regulated and KEK is obligated by law to provide KEDS the required amount of electricity which further delivers it to the end customers with regulated prices. In addition, all producers with over 5MW capacity are obligated to sell their electricity to KEDS. Further market opening is also seen difficult since there is not enough liquidity in Kosovo's markets in order to facilitate efficient competition. (Energy Community Secretariat 2014) However, Kosovo and Albania are planning to establish common energy market with common market area to overcome the lack of production capacity. They see that their power systems are complementary since Albania has lot of hydro production whereas Kosovo has coal-fired conventional production. In order to facilitate this project Kosovan and Albanian Governments have established joint Steering Committee and signed Memory of Understanding on creation of the common market. In addition, Albanian TSO (ERE) and ERO have agreement of understanding for the project, as well as Albanian TSO (OST) and KOSTT have inter TSO agreement. Furthermore, KEK and KESH from Albania, the main producers, have agreement on electricity exchange. (Ministry of Economic Development of Kosovo 2015, Bejtullahu 2014)

## 4.7 Montenegro

Energy law in Montenegro is from 2010. Since 2013 Montenegro has started to transpose Third Energy Package content as amendments to their legislation. The Energy Regulatory Authority of Montenegro (RAE) functions as regulator in the jurisdiction. RAE has legally independent status and has also financial independence. However, Montenegro parliament approves RAE's annual reports which allows some level of political intervention. (Energy Community Secretariat 2014)

Unbundling process in Montenegro has been done only for transmission activities. CGES is functioning as transmission system operator in Montenegro and it is owned 55% by state, 22% by Italian TSO TERNA and rest is owned by investment funds and other legal entities. CGES is legally unbundled from any other activities. (CGES 2015) However, distribution, supply and power generation are all still bundled in Montenegro's biggest energy utility EPCG. EPCG's main owners are state of Montenegro with 55% share and Italian utility company A2A with 44% share. Rest of the ownership is divided between

other physical and legal entities. (EPCG 2015) EPCG has proceeded with the unbundling by separating distribution, supply and generation activities to three different functional units and by unbundling the accounting for each of them. However, since both EPCG and CGES have the state of Montenegro as their main owner, the unbundling will require further efforts to spread the share of ownership. (Energy Community Secretariat 2014) RAE has stated that legal unbundling of EPCG is one of its main objectives during 2015 and they are planning to be intensively engaged in monitoring of the implementation of the separation process. (The Energy Regulatory Agency of Montenegro 2014)

All non-household customers are eligible in Montenegro. In addition, there are plans to complete market opening by allowing all customers to be eligible during 2015. (Energy Community Secretariat 2014) The final step for full market opening has been postponed to latter half of 2015 since the unbundling of EPCG is not yet done and thus there is not enough competition for the supply activities. (Prekic 2015) Fully state owned company COTEE is functioning as market operator in Montenegro. The electricity prices for customers connected to transmission network are not regulated. However, the amount of suppliers at this level is very limited and the amount of customers connected directly to the transmission network is also small. Customers connected to the distribution network have to purchase their electricity using prices regulated by RAE. The price regulation is following European Electricity Exchange (EEX) Phelix baseload settlement price. In addition to the two aforementioned prices, also the electricity price for non-eligible customers is regulated and the electricity is provided by EPCG as public service. (Energy Community Secretariat 2014)

CGES's was approved to SEE CAO and starting from mid-2015 Montenegro – Albania cross-border allocation will be handled through CAO. (SEE CAO 2015) Rest of the interconnection capacities are divided half between the neighboring countries and remain to be allocated through annual, monthly and daily auctions. (Energy Community Secretariat 2014) In addition, The Council of European Energy Regulators (CEER) accepted RAE as observer party to their cooperation council early 2014. (CEER 2014)

## 4.8 Serbia

Serbian energy sector is based on the energy law from 2011. The Energy Law was renewed at the end of 2014 by modifications to conditions for electricity and natural gas public supply entitlement. In addition, it includes legislation for staged electricity market opening. The Energy Agency (AERS) is the single authority in Serbia regulating the energy sector. (Energy Community Secretariat 2014)

Currently, the legal vertical unbundling of electricity sector activities is progressing well. Serbian transmission system operator Elektromreza Srbije (EMS) is legally unbundled and responsible for transmission activities. However, EMS is fully state owned company. Also Elektroprivreda Srbije (EPS) is fully state owned enterprise, operating in the fields of distribution, supply and generation. (Energy Community Secretariat 2014) In 2013 EPS started to unbundle its activities and created legally separate company EPS Supply to take care of the supply activities. (Energy Agency of the Republic of Serbia 2015a) In addition, recently in 2015 EPS continued the unbundling process and announced the creation of legally separate distribution company EPS Distribution. EPS also announced plans to transition from public state owned enterprise into stock company at the summer of 2016. (Electric Power Industry of Serbia 2015) Therefore, the unbundling process in Serbia is technically completed. Furthermore, the horizontal unbundling process has been started.

All customers have been eligible in Serbia since the beginning of 2015. However, households and small customers are still entitled to public supply at regulated prices if they wish so. Due to the eligibility statuses, all customers in Serbia need to conclude supply contract at market prices. If they fail to find a supplier, EPS Supply will function as a public supplier and provide electricity at regulated prices to them. (Energy Agency of the Republic of Serbia 2015b) Serbian electricity market consists of bilateral electricity market, balancing market and organized electricity market. EMS functions as market operator in Serbia. In the bilateral part of the market, participants can trade electricity at freely negotiated prices. However, EPS has dominant positions in the markets. (Energy Agency of the Republic of Serbia 2015a) Mid 2015 EPEX Spot announced that together with EMS they will launch Serbian Day-Ahead market by the end of November 2015.

South Eastern European Power Exchange (SEEPEX) will be compatible with current Pan-European market coupling model. (EPEX Spot 2015)

Currently, EMS is not part of SEE Coordinated Auction Office. Instead, Serbia allocates the available transmission capacity between neighboring areas through joint explicit auctions on yearly, monthly, daily and intra-daily basis. However, in 2014 AERS created action plan considering joining coordinated congestion management. (Energy Agency of the Republic of Serbia 2015a)

## *4.9 Summary of current situation*

In order to gain a clear overview on the situations in the selected jurisdictions, the aforementioned statuses on the vertical and horizontal unbundling, eligibility threshold and market openness are gathered into the following Tables 3, 4 and 5.

**Table 3. Status of vertical unbundling.**

| | Transmission operations | Distribution and supply |
|---|---|---|
| **Albania** | OST **legally unbundled** but fully state-owned. | **Not unbundled**. OSHEE responsible for both. Legal unbundling not part of Albanian legislation. |
| **Bosnia and Herzegovina** | **Partially unbundled**. ISO BiH responsible for dispatching, balancing and allocating the cross-border capacities.<br><br>Elektroprenos BiH owns the transmission network and in charge of connections, transmission, metering, maintenance and development of the infrastructure. | **Not unbundled**.<br><br>EP BiH and EP HZHB responsible for both distribution and supply activities in Federation of Bosnia and Herzegovina.<br><br>ERS subsidiaries responsible for both in Republika Srpska. |

| | | |
|---|---|---|
| **Bulgaria** | ESO **legally unbundled** | **Legally unbundled**. NEK responsible for supply. CEZ, EVN and Energy-Pro responsible for distribution. |
| **Croatia** | HOPS **legally unbundled** | **Not unbundled**. Both activities done by HEP-ODS |
| **FYR of Macedonia** | MEPSO **legally unbundled** but fully state owned. | **Not unbundled**. EVN owns 99,5% of the distribution network. ELEM owns the rest. Both also involved in supply activities. |
| **Kosovo** | KOSTT **legally unbundled**. Late 2014 KOSTT and EMS signed operation agreement for KOSTT's independent operations in Kosovo. | **Not legally unbundled**. KEDS involved in both activities. KEDS has separate divisions for distribution and supply activities. |
| **Montenegro** | CGES **legally unbundled**. 55% owned by state | **Not legally unbundled**. EPCG still active in both fields. EPCG has separated functions to different units. |
| **Serbia** | EMS **legally unbundled** but fully state owned. | **Legally unbundled**. EPS Distribution and EPS Supply functioning in their own fields. |

**Table 4. Status of horizontal unbundling and eligibility threshold.**

| | Horizontal unbundling | Eligibility |
|---|---|---|
| **Albania** | Market monopolized by state-owned company KESh. | **All non-household customers**. However, based on voltage level or annul consumption and status granted by ERE. |
| **Bosnia and Herzegovina** | The electricity market in Bosnia and Herzegovina is heavily concentrated and customers mostly need to rely on their local producers. | In Federation of Bosnia and Herzegovina dealt **exclusively on entity level**.<br><br>In Republika Srpska **all customers** from beginning of the 2015. |
| **Bulgaria** | NEK owns 45% of all installed capacity. In 2012 33% of market participants had 92% share of whole market. | **All customers** eligible. |
| **Croatia** | State owned HEP-Group had 82% market share in 2012. In 2013 95% of the generation capacity owned by two companies. | **All customers** eligible. |
| **FYR of Macedonia** | ELEM responsible for 91% of all electricity generation. | **All customers** eligible. |
| **Kosovo** | KEK has dominant position in the market. | **All customer** eligible. But no real choice for other supplier than KEDS. |

| | | |
|---|---|---|
| **Montenegro** | EPCG has dominant position in the market. | **All non-household customers**. Plans to grant status for all during 2015. |
| **Serbia** | Fully state owned EPS company responsible for generation but transitioning into public stock company in 2016. | **All customers** eligible. |

**Table 5. Status of market opening and power exchange.**

| | **Electricity market and trade status** |
|---|---|
| **Albania** | Plans to amend Third Energy Package to Energy Law during 2015. Aim to have liberalized wholesale market by the end of 2020. Joined SEE CAO early 2015. Trade mostly at regulated prices. Plans to create common market between Albania and Kosovo. |
| **Bosnia and Herzegovina** | Wholesale market mainly functioning on bilateral and over-the-counter basis. Lacking liquid trading platform. |
| **Bulgaria** | In 2013 third of the trade in liberalized markets. IBEX and Nord Pool Spot working towards Day-Ahead power market planned to be in operation Q4 2015. |
| **Croatia** | Market functioning on bilateral basis and prices are freely negotiable. CROPEX and Nord Pool Spot working towards Day-Ahead power market planned to be in operation at the end of Q4 2015 |
| **FYR of Macedonia** | Most of the market still regulated because of ELEM's dominant position. Eligible customers can trade at freely negotiated prices. New electricity market rules came into force in 2014. |
| **Kosovo** | Low amount of available generation resources in the area. Fully regulated market where KEK is obligated to provide KEDS the required electricity. Also smaller producers with over 5MW capacity need to sell to KEK. |

| | |
|---|---|
| | Kosovo and Albania planning to create common energy market to increase liquidity pool. |
| **Montenegro** | COTEE functioning as market operator. Prices for customers connected to the transmission network not regulated. Customers connected to distribution network have to purchase their electricity at regulated prices. Price for non-eligible customers regulated and the electricity provided by EPCG as public service. |
| **Serbia** | EMS functioning as market operator. EPS has dominant position but all participants can trade with freely negotiable prices. EMS and EPEX Spot working towards Day-Ahead power market, SEEPEX, planned to be in operation at the end of 2015. |

# 5 Regional power market

As part of the regional electricity market opening process, establishment of a regional power market is natural and beneficial step. In this chapter the importance and benefits of the regional power markets are explained. In addition, an overview to the optimal market model for SEE area is given.

## 5.1 Integration dimensions

Regional integration can be divided into three dimensions: infrastructural, regulatory and commercial integration. In order to fully integrate a well-functioning regional power market, all of the integration dimensions should be in place. Fully integrated infrastructure means that there is regional transmission system in operation and the areas in region are well interconnected. Opposite to this are isolated national power systems or some minor cross-border transmission capacity allocation. Fully integrating infrastructure naturally requires cooperation between national TSOs and some investments in the transmission system to allow sufficient electricity flows between the areas. In addition, infrastructural integration includes coordinated transmission and investment planning. The second dimension, regulatory integration, requires regional regulatory agency. This means shifting from independent national level regulation to centralized decision making and regulation for electricity sector. The centralized regulation should cover standards, market rules and market surveillance. (Pineau et al. 2004)

The third dimension of regional market integration is commercial integration. When integrating commercial aspects the jurisdictions need to move from national markets with local ownership structures to cross border trading and further to regional spot markets. This dimension especially includes designing regional market where the electricity can be traded. To achieve this goal, also some level of harmonization of the market rules between national power exchanges need to happen. Full commercial integration can also gain benefits from an open regional financial market which can facilitate the risk management in the electricity markets. (Pineau et al. 2004)

## 5.2 Benefits and effectiveness of regional power market

Multiple benefits can be gained from integrated power markets. For this study four distinctive benefits are introduced and first one of them is specialization and exchange in

integrated markets. When the markets are fully integrated, it is possible to generate electricity anywhere within the region where the marginal costs for production are least and thus leading many times to environmental friendly production. Full integration also provides more security when higher level of fuel diversification can be gained due to the wider and integrated transmission network. The second distinctive benefit is the reduction of the market power of single market participants. In small national markets big generators often have ability to dominate the market and determine the price level. However, since there usually are multiple actors and several big generators in the integrated electricity markets, also the market power is much more evenly balanced. The third distinctive benefit is improved economic signals for the market. Regional power market is able to provide transparent and reliable area prices for electricity in the region, which further can be used to evaluate electricity sector investments. Fourth benefit connects to commercial integration. When full commercial integration has been accomplished, there is less need for national level institutions. Therefore, regional power market can reduce costs generated by many layers of institutions performing similar tasks within the region. (Pineau et al. 2004, Price, Pham 2009, Karova 2011)

These four explained benefits are the main impact areas of closer integration in power markets. However, together they can further have effect on other aspects of the markets and electricity sector. One such follow-up effect can be cost reductions in many parts of electricity sector. With full commercial and infrastructure integration, the cross-border trading becomes easier and more economical. Thus, the one cost reduction object can be the transaction costs for electricity traders. Secondly, the full infrastructural integration and joint planning among the TSOs leads to more efficient capacity allocation and joint grid operations, reducing operational costs. In addition, creating joint and cooperated institutions for market activities naturally eliminates the overheard costs created by otherwise required duplicate institutions. (Price, Pham 2009)

The effect of the full integration might have two-sided effect on the market prices. Assuming that also the infrastructural integration is in place and that the electricity can flow freely in the interconnected network, then prices try to balance out in the area. This means that the electricity importing (deficit) areas might now see lower electricity prices whereas the exporting (excess) areas may see prices going up. However, even though the

price might rise in excess areas, the excess area might still gain more benefits since they have opportunity to specialize and take advantage in their electricity generation and grown activity on electricity export business. (Price, Pham 2009)

Transmission security is also one of the important benefits resulting from the electricity market integration. A good example of this is Nordics where the TSOs are cooperating to balance the transmission network. They operate joint balancing power market and activate frequency controlled reserves in jointly manner (Fingrid 2015). This is not only cost effective but also releases some amount of generation capacity to the free markets which would otherwise needed to be kept as ancillary service. In regional markets the increased and economically optimized cross-border trading also naturally balances the power system.

The fulfillment of the expected benefits can be measured by observing the economical effectiveness of regional electricity market. Zhang et al. are discussing the effectivity measures and they divide the effectiveness to short and long term efficiency. Short-term efficiency refers to the market operation efficiency and the increase in the social welfare. Therefore, it is affected by the market structure and by the behavior of the market players. Furthermore, because of the nature of the electricity markets and eventually the physical delivery of the electricity, the power grid restrictions can influence the short-term market efficiency. These three points form the three efficiency metering classes based on Zhang et al. article: the rationality of the market structure, the effectiveness of the market orders and market efficiency. The structure of the regional electricity market has major impact on the market operation and short-term efficiency. Factors influencing the structure are well aligned with the potential benefits. Firstly, the structural efficiency is affected by the amount of big players in the markets. Related to that, the concentration of the market power and the monopolization degree needs to also be taken into consideration when measuring the structural efficiency. Thirdly, the diversity of the production possibilities per fuel type needs to support the market model and in addition there has to be ability to meet the need of electric demand in the region. Finally, the structural efficiency relies on the degree of the interconnectivity in the region. (Zhang Yubo et al. 2008)

The second short-term efficiency metering class, the effectiveness of the market order, measures how well the market functions when different participants pursue different interests. Generation companies typically aim to maximize their revenues while transmission system operators need to also consider the interests of the whole market and the safety of the power system. In addition, regulators need to take into consideration also the social welfare on top of the aforementioned interests. In order to achieve truly effective operation in regional market such market model needs to be adopted where these partly conflicting interests can co-exist and do not harm the effectiveness of the market. For example, in order to retain the credibility of the market at all times the regulators need to have sufficient power to recognize and prevent harmful electricity trading actions. Furthermore, regulators need to be able to ensure equal and fair competition situation in the markets to keep it efficient. Correspondingly, transmission system operators need to be able to maintain security and stability in the transmission network to enable efficient market operations and physical delivery. Third short-term metering class focuses on the overall market efficiency. However, measuring overall market efficiency can be a complex tasks and thus usually focuses primarily on social welfare. (Zhang Yubo et al. 2008)

## 5.3 Recommended market model for SEE area

There are several possible market design options when considering competitive regional electricity markets. These market designs have each different kind of strengths and weaknesses. This study focuses on the European model which is the recommended design by World Bank's study to be adopted to enhance the wholesale market opening in South East Europe region.

In the World Bank's study, four possible market models were considered: PJM (USA regional market between Pennsylvania, Jersey and Maryland), the European model, bilateral classic and bilateral with auction. All four options were evaluated based on eight different criteria: Security of Supply, Enhancing Investment Climate, EU Mainstream, Efficient Utilization of Transmission Grids and Generation, Market Price Reference, Integration of Renewables, Transparency and Implementation Costs. Each criterion in each market design option was evaluated from 0 to 10 and then multiplied with specific weight factor depending on the importance of the criterion. The results of the study show

that the European Model would fit best the SEE region since it scored highest almost in all criteria. The result of their analysis can be seen in Figure 10. (World Bank 2011)

The security of supply got equal score for all models since it is assumed to be transmission system operator's responsibility. The enhancement of the investment climate means the attractiveness of the markets for the investors. Therefore, possibility for liquid financial market and possibility for low risk operations in the market affect this category greatly. European Union mainstream criterion estimates how well the market model aligns with the existing European model. Since SEE area is part of Europe and the long term vision of EU is common pan-European market, it is worthwhile considering that aspect already when considering the regional market model. Effective utilization of transmission grids and generation represents the way market model supports transmission capacity allocation and the activation of the different generation types. For example, European model scored high here because of the merit order activation illustrated earlier in the Figure 4. Market price references measures the quality of the prices as investments signals to markets. Transparent prices representing well the zonal market situation are valuable signals towards the markets. Integration of renewables measures how the respective market model supports the activation of the renewable energy sources. In addition, it takes into account how the market model can adapt the generation fluctuation caused by the unpredictability of the renewable generation. Transparency is scored based on the level of access to different parts of price formation e.g. cost data of generation. Finally, the implementation cost category is self-explanatory since it estimates the cost of implementing the market model as regional electricity market solution.

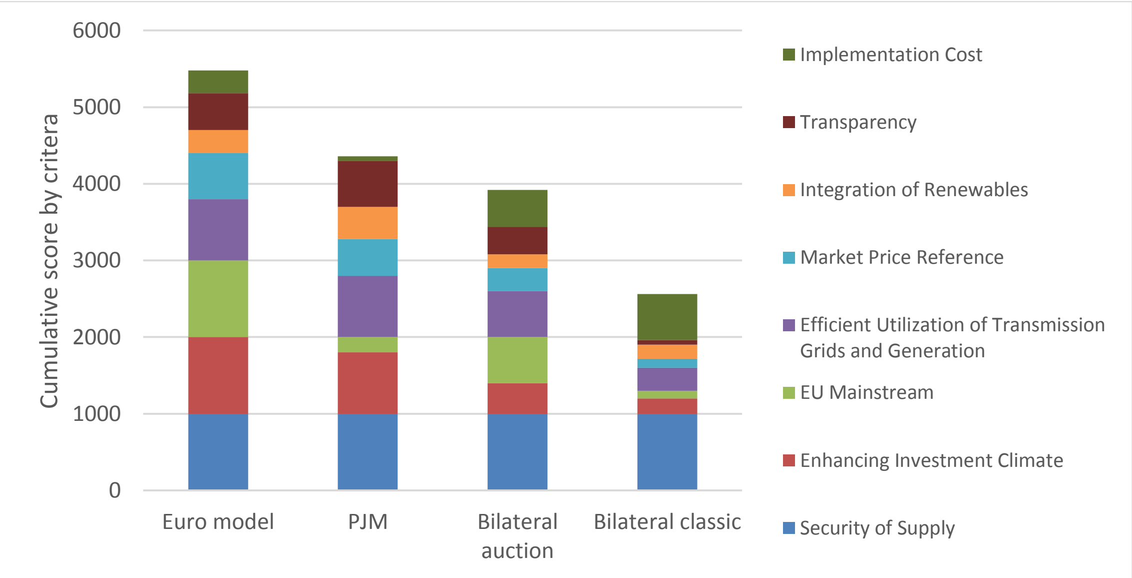


**Figure 10. Evaluation on different market models. (World Bank 2011)**

## 5.4 Regional Day Ahead market concepts

The European market model was briefly described earlier in the chapter two using Nordic markets as example. The scope of this study limits on the Day Ahead part of the European market design. In the Day Ahead electricity markets supply and demand are the two most important factors for determining the electricity price. Demand describes the willingness to buy some utility which consumer can afford. The law of demand states that while other factors stay as constant, the higher the price of the product is, the less demand there is for it. Other way around, the lower the price is, the more there is demand for it. Demand curve is typically descending due to the fact that the consumer received benefit from new unit of product is always less than the gained benefit from previous unit, which is called the marginal utility. (Parkin et al. 2005) In electricity markets demand originates from the electricity consumers such as factories or retail sellers. Demand is affected by electricity consumers desire to maximize their benefit with their available budget. In addition, demand is affected by the variable and fixed costs of the production and by the delivery obligations. Eventually, the aggregated demand curve is compiled by summing up all the demand curves of the single consumers. However, usually demand in electricity markets is quite inelastic due to the essentiality of the sufficient electricity supply. In other words, demand is not affected much by the market price and consumers are willing to buy electricity almost at any price. Therefore, in this study demand is simplified to be entirely inelastic.

Supply describes the willingness of selling utility and the possibility to gain profits from the sales. The law of supply states that while other factors stay as constant, the higher the price of the utility is, the more utility is produced. Following the same logic, the lower the price is, the less there is willingness to produce the utility. Opposite to demand, supply curve is typically ascending as each incrementing utility provides less profit. In other words, the production costs are increasing for each additional produced unit. (Parkin et al. 2005) In the electricity markets supply originates from power producers. Supply is affected by multiple factors such as production method and fuel prices. Also free competition in the markets affects the pricing of the supply. Eventually, the aggregated supply curve for the market is compiled by summing up all the individual supply curves of each power producer.

In the Day Ahead electricity markets the aim is to daily find optimal price and traded volume for electricity for every hour of the next day. In perfect market situation the optimal situation is always found at the intersection of the supply and demand curves, at market equilibrium (Parkin et al. 2005). The price at this point is called equilibrium price and the volume as the equilibrium volume. If the price of the utility is too high, there is more willingness to supply it than there is demand for it. Similar, if the price is too low there is more demand for it than willingness to supply the utility. In both described cases, over supply and over demand, the markets are not functioning efficiently and thus the situation is not beneficial for the suppliers or for the consumers. Therefore, the markets automatically move towards the market equilibrium to maximize the overall welfare. (Parkin et al. 2005)

World Bank's study recommends that the regional market should work in decentralized manner where each jurisdiction has their own local power exchange. The local power exchanges are responsible for collecting the electricity production and consumption offers in their local market area. Each local power exchange needs to then further compile all the received orders to aggregated supply and demand curves. These curves will then be further sent to the regional market operator. Regional market operator will then use the received aggregated supply and demand curves to calculate area prices for the respective areas, taking into account available transmission capacities between local power exchange areas. World Bank's study proposes that the available transmission capacities should be allocated and sent to the regional market operator by so called coordinating auction office. This entity is cooperatively operated by regional TSOs. (World Bank 2011)

The Nordic electricity market operated by Nord Pool Spot is following the European market model. Even though the market price is formed in common European solution, the market price is formed by finding the intersection of the aggregated supply and demand curves as described earlier. All the market participants, both producers and consumers settles with same price. This price is called Marginal Price. Due to the market model, producers typically offer their production based on the short-term marginal costs. Therefore, the production units with lowest the marginal cost of the production are activated first. As result, the economically most efficient production units will earn the

most. (Nielsen et al. 2011) Figure 4 in the chapter in two illustrates the logic behind the marginal price from the merit order point of view.

In the regional markets, the transmission capacities are allocated in so called implicit auction. In the implicit auction, the day-ahead transmission capacities are taken into consideration already during the price formation process in order to maximize the overall social welfare for the whole region. Thus, the flows between the market areas are always based on the current status of the interconnected network and local markets. As results of such auction, the area prices for electricity reflect both the cost of the electricity production in each bidding area and the cost of the congestion in network. Furthermore, implicit auction ensures that the electrical electricity flows from surplus area to deficit areas. In other words, the electricity flows from low price areas to high price areas and thus balances the price differences between the unbalanced areas. As opposite to implicit auction, in the explicit auctions the transmission capacities are allocated separately and independently detached from the marketplace where the physical electricity trading is taking place. The capacities may be auctioned through annual, monthly and daily auctions. However, since the capacity auction is not subjected to the market forces, the result may end up providing less social welfare, less price convergence and more frequent adverse flows. (Nord Pool Spot 2014a)

### 5.4.1 PCR and MRC

The theory background for the regional power market cooperation was given earlier in this chapter. The theory has already been put into practice in two European projects: Price Coupling of the Regions (PCR) and Multi Regional Coupling (MRC). Basically, MRC is successor of PCR after more areas have joined the pan-European electricity market cooperation since the establishment of the PCR. Even though the explained framework for the regional power markets and the regional integration dimensions are steering towards a closely coupled market operations, the approach for the local control with regional cooperation should be emphasized.

The World Bank’s study recommends such regional market design where the national or multinational electricity sector actors retain the local responsibility over all of the trading processes, procedures and trading platforms. Then in addition to the local operations, the electricity market cooperation can extend to the coupling of the multiple local Day Ahead

markets as regional market. (World Bank 2011) This operational framework is well adopted in the PCR and further in MRC solution. PCR framework includes three main principles, single price optimization algorithm, robust operation and individual local power exchange accountability. Single common algorithm and robust operations provide the required level of regional cooperation and the benefits described also in this study. Common algorithm for the whole region guarantees fair and transparent way of determining the day ahead electricity prices across Europe and optimal cross border electricity flows. In order to facilitate this common price calculation PCR relies on decentralized sharing of data and on the robust market operations and procedures. However, in the PCR framework each market area still holds their local control by having local power exchanges, transmission system operators and national regulatory authorities. (Nord Pool Spot 2015d) As can be seen from the PCR framework, the regional market solution does not necessarily require a centralized regional entities. Instead, regional markets and joint operations can also be achieved by retaining the local control and authority of the national market operators and further does not mean that all of the market activities need be implemented in one place.

# 6 Regional market simulations

The need for the regional markets and its expected benefits are discussed in the previous chapters of this study. In addition, the South East Europe electricity sector was introduced and evaluated earlier. Based on the presented background information, this study investigates if the expected benefits could be achieved in the South East Europe region by carrying out day ahead market simulations. This chapter lays the base for the simulations and thus firstly describes the required additional simulation parameters. Secondly, a brief overview is given to the optimization algorithm Euphemia which is used to carry out the simulations. Next, the logic behind the input data and market topology is explained and finally the simulation procedure is briefly elaborated.

## *6.1 Parameters for the simulations*

The most important values for the simulations, demand and available production capacities in the selected SEE market area were described earlier in this study in chapter three. However, these alone are not sufficient for a realistic simulation and thus also the network transmission capacities, the pricing of the generation methods and the capacity factors are required.

### 6.1.1 Network transmission capacity

Hourly network transmission capacity represents the maximum electricity flow that can occur in a transmission cable in one hour. Hourly network transmission capacities between selected jurisdictions are shown in Table 6

**Table 6. Day-ahead hourly network transmission capacities in MW. Datasource: ENTSO-E**

| FROM/TO | AL | BA | BG | HR | FYROM | ME | RS&XK |
|---|---|---|---|---|---|---|---|
| Albania (AL) | | | | | | 142[2] | 250[1] |
| Bosnia and Herzegovina (BA) | | | | 750 | | 500 | 600 |
| Bulgaria (BG) | | | | | 300 | | 600 |
| Croatia (HR) | | 700 | | | | | 600 |
| Former Yugoslav Republic of Macedonia (FYROM) | | | 100 | | | | 300 |
| Montenegro (ME) | 289[2] | 500[3] | | | | | 700[4] |
| Serbia and Kosovo network area (RS&XK) | 250 | 600 | 350 | 600 | 700 | 700 | |

[1]Assuming Albania -> Serbia is same as Serbia -> Albania
[2]No data for DA NTC in ENTSO-E database, using highest flow from 2014 based on ENTSO-E data
[3]Assuming Montenegro -> Bosnia is same as Bosnia -> Montenegro
[4]Assuming Montenegro -> Serbia is same as Serbia -> Montenegro

The data for network transmission capacities is extracted from ENTSO-E database for Day Ahead Network Transmission Capacities (NTC). However, since only part of the interconnection data for Albanian and Montenegrin is provided in this database some assumption are made to cover the missing NTC values. For closest realistic estimation, electricity flows which occurred during 2014 were extracted from ENTSO-E database and the maximum hourly value of the occurred flows is used as transmission capacity between Albania and Montenegro. In addition, NTC values for both directions between Montenegro and Serbia and Kosovo network area and between Montenegro and Bosnia and Herzegovina are not explicitly given. Therefore, it assumed in this study that the same capacities are available for the both directions for these connections. Similar to these interconnectors, NTC value from Albania to Serbia and Kosovo network area was given also only for one direction. It is assumed that the same capacity is available also to the other direction i.e. from Serbia and Kosovo network area to Albania.

### 6.1.2 Pricing of the generation types

Generally electricity producers' pricing methods are affected by multiple factors such as variable costs of production, shutdown and starting costs of the power plants, investment and fixed costs, emission trade prices and weather. However, the most affecting factor is the generation type and the marginal cost of production related to the specific production type.

Levelized cost of electricity (LCOE) is generally used to benchmark and compare different generation technologies. Basically LCOE is the average price for the electricity needed to reach a net present value (NPV) of zero when the cash flow of the generation unit is discounted. It should be noted that this method does not include the value of the risk or different financing methods for the technologies. In addition, all the technologies are evaluated equally and same economic analysis is used. Therefore, the assumptions made when calculating LCOE have high sensitivity and may have high influence on the calculated LCOE values. Furthermore, in case of electricity generation the costs and the possible generation amounts can vary based on location, capacity, efficiency, operation and other similar parameters. These variables are usually not accounted in LCOE calculations. (Branker et al. 2011)

Levelized cost of electricity is calculated based on the cost for investment, operations and maintenance, fuel, carbon emissions and decommissioning provided by OECD countries. The equation may vary for some parts depending on a study but in most cases the equation (1) is used (IEA 2010). Nomenclature for equation (1) is presented in Table 7.

**Table 7. Levelized cost of electricity equation nomenclature.**

| Nomenclature | Explanation |
|---|---|
| **$Investment_t$** | Investment costs in year "t" |
| **$O\&M_t$** | Operations and maintenance costs in year "t" |
| **$Fuel_t$** | Fuel costs in year "t" |
| **$Carbon_t$** | Carbon costs in year "t" |
| **$Decommisioning_t$** | Decommissioning cost in year "t" |
| **$Generation_t$** | The amount of electricity produced in year "t" |
| **$(1 + r)^{-t}$** | The discount factor for year "t" |

$$LCOE = \frac{\sum_t (Investment_t + O\&M_t + Fuel_t + Carbon_t + Decommisioning_t) * (1+r)^{-t}}{\sum_t (Generation_t * (1+r)^{-t}} \qquad (1)$$

Norwegian Water Resources and Energy Directorate (NVE) has done a study early 2015 evaluating the recent LCOE values for common generation methods in Nordics. The values in NVE's study are presented in NOK/kWh units. According to European Central Bank exchange records, on average one Euro equaled to 8,354 Norwegian crowns throughout the year 2014. (Europea Central Bank 2015). This exchange rate was used to convert the LCOE values into EUR currency for this study. The converted LCOE values based on NVE research are presented in Table 8.

As discussed already earlier in this study, in the European market model the electricity price is heavily based on the marginal costs of production. In other words, the producers tend offer their production at price reflecting their costs to produce electricity. Levelized costs goes beyond the marginal costs taking into account also the investment costs. In addition, the LCOE values calculated in the NVE study are for brand new power plants. In reality, in the SEE region many of the power generation units are older and the investment might already be paid back which makes the LCOE values too high and

inaccurate to be used in the simulations. Therefore, since the European model is recommended for the SEE region, the marginal costs are used as pricing mechanism in the regional market simulations giving more accurate representation as pricing method. The marginal costs in the Table 8 are extracted from the NVE study. The operation costs for standalone solar energy are estimated to be 2,5% of the investment costs. The study shows that yearly investment costs for standalone solar photo voltage installations were around 12MNOK/MW. The marginal costs are calculated based on these two values. In addition, the marginal costs for wind power are representing the costs for on-shore wind power. It should be also noted that nuclear power production waste treatment is not included in the marginal costs shown in the Table 8. Finally, natural gas generation is expected to be mainly combined cycle production.

**Table 8. Levelized cost of electricity and marginal cost for different generation types. (Norges vassdrags- og energidirektorat 2015)**

| Generation type | Marginal (EUR/MWh) | LCOE (EUR/MWh) |
|---|---|---|
| Solar PV | 4.1 | 147.2 |
| Hydro | 4.8 | 29.9 |
| Wind | 18.0 | 48.6 |
| Nuclear | 22.7 | 50.9 |
| Conventional Coal | 36.4 | 50.9 |
| Combined cycle (natural gas) | 64.2 | 71.7 |
| Peak load diesel generator (oil) | 306.2 | 312.2 |

Nuclear is mainly used as basic load in power markets due to its stable nature. It is relatively low cost and easy to run but shutdown down and startup of the nuclear power plant is expensive. Thus, nuclear generation is assumed to be inelastic in reference to price. In other words, electricity is generated by nuclear power plants regardless of the marginal costs. Hydro power has one the lowest marginal costs of production. Furthermore, it is relatively easy to decide when to produce electricity with hydro power. Usually some amount of hydro power needs to be generated in order to keep the river system balanced. For these reasons, the pricing of hydro production is usually a complex task. In Nordic markets the pricing of hydro production usually relies on the opportunity cost of production i.e. whether the power should be produced today or tomorrow. Therefore, hydro production usually reflects the year-ahead future prices of electricity announced in the financial markets. However, in this study based on the production mix

in the SEE region, it is expected that the coal production is the cap in merit order and therefore pricing of hydro power won't affect much the simulations as long as its price remains lower than the marginal cost of conventional coal.  Thus, to avoid unnecessary complexity the hydro power capacity is fully priced based on the marginal costs in this study. Wind and solar power are usually produced based on the weather conditions. Since electricity is challenging utility to store and producing with low marginal costs plants is supported by European market model, both production types are expected to be inelastic in this study. Rest of the production methods are priced in reference to marginal costs. As result, generation type is activated if marginal price is higher than the respective marginal cost of production.

### 6.1.3 Capacity factor

Capacity factor compares the actual electricity produced by power plants to the electricity which could have been produced if the power plant would have ran at full rated power over the given time period. In case of hydro power, capacity factor depends on the water potential in the plant site and further on the yearly hydro reservoir level. In addition, the capacity factor is affected by the power curve of the utilized production unit. (Kaldellis et al. 2005, Pazheri et al. 2014)

In this study it is expected that the fossil and the nuclear power plants can operate at maximum rate during the selected days. Thus, the capacity factor for these generation units is 100% and does not affect the net maximum capacities described earlier in the chapter three. In reality the capacity factors of the conventional generation units are usually affected by fuel costs, electricity prices and plant availability time (U.S. Energy Information Administration 2015b). However, these factors are not considered in this study to avoid unnecessary complexity and thus it is expected that suppliers provide all their available conventional capacity to markets regardless of the market situations.

For the renewables the situation is slightly different since the potential generation amounts are affected by the available fuel amount, i.e. the water situation in the region as well as solar radiation and wind conditions. In addition, the capacity factors for renewable sources are usually considerable lower than for conventional fossil generation and nuclear power. Therefore, renewable and hydro power capacities are subjected to capacity factors in the performed simulations. United States Energy Information Administration (US EIA)

has calculated average capacity factor of 37,5% for conventional hydropower, 33,9% for wind and 27,8% for solar photovoltaic in 2015 (U.S. Energy Information Administration 2015a). Pazheri et al. estimates that hydro power plants have capacity factor of 30-60% whereas onshore wind has 20-40% and ground-mounted photovoltaic have capacity factor of 15-27%. In addition, Kaldellis et al. have used capacity factor of 46,7% in their calculations for small hydro power in Greece (Kaldellis et al. 2005). From European point of view Eurelectric study from 2011 estimates capacity factor for hydro power to be 30-80%, for wind 20-40% and finally for solar 10-20% (EURELECTRIC 2011). Based on these sources the average capacity factor for hydro power is close to 40%. Thus, it seems that the monthly capacity factors provided by EIA are close to this average value. These monthly capacity factors are applied to hydro and renewable production in the typical days of each month in this study to cover the seasonal variation. The capacity factors are shown in Table 9.

**Table 9. Capacity factors (CF) from different sources and monthly values by EIA. (EURELECTRIC 2011, Kaldellis et al. 2005, U.S. Energy Information Administration 2015a, Pazheri et al. 2014)**

| Source | Hydro CF | Wind offshore CF | Solar PV CF | Renewables CF |
|---|---|---|---|---|
| **US EIA** | 33,7 % | 33,9 % | 27,8 % | - |
| **Pazheri et al.** | 30-60 % | 20-40 % | 15-27 % | - |
| **Kaldellis et al.** | 46,7 % | - | - | - |
| **EURELECTRIC** | 30-80 % | 20-40 % | 10-20 % | - |
| **Average** | 40,0 % | 30,0 % | 30,0 % | - |
| **January** | 36,3 % | - | - | 40,4 % |
| **February** | 32,5 % | - | - | 34,4 % |
| **March** | 41,3 % | - | - | 39,6 % |
| **April** | 44,6 % | - | - | 43,1 % |
| **May** | 45,3 % | - | - | 34,5 % |
| **June** | 45,8 % | - | - | 36,1 % |
| **July** | 41,9 % | - | - | 26,7 % |
| **August** | 33,9 % | - | - | 22,5 % |
| **September** | 28,0 % | - | - | 26,0 % |
| **October** | 29,0 % | - | - | 31,5 % |
| **November** | 33,0 % | - | - | 42,2 % |
| **December** | 38,4 % | - | - | 30,4 % |

The share of the renewable energy resources in the regional generation capacity mix is small. Therefore, all renewable sources are grouped together as one generation source in the simulations. Since the capacity factors for wind and solar are close to each other and there is considerably more wind power capacity than solar capacity in the region the wind power capacity factors are applied for this grouped renewable generation cluster. Table 9 shows that there tends to be more hydro capacity available for electricity production during spring and early summer months than during the winter months. Keeping in mind the yearly variation in demand shown in Figure 9, it can be seen that during the high demand months there is also less hydro capacity available. Other way around, during the summer months when there is generally less demand for electricity in SEE region, the capacity factors for hydro power production are also higher. Therefore, it is expected that due to the decreased availability of the relatively low price hydro power production there will be some price differences between winter and summer months. In addition, since there is less hydro production capacity available during winters, it may need to be compensated with other higher price methods such as coal and gas fired production.

## 6.2 Euphemia

Nord Pool Spot's Day Ahead market systems were used to carry out the simulations in this study. In core of the price formation process is Euphemia algorithm. Euphemia algorithm was created as part of the Price Coupling of the Regions (PCR) project to be able to calculate electricity prices jointly across whole Europe. The aim is to maximize socio-economic benefits and increase market transparency. (EPEX Spot et al. 2013)

In Euphemia model the market can be divided in bidding areas. Bidding area represents the smallest entity where orders can be submitted. Therefore, in the price formation each bidding area will get clearing price based on the orders within the respective area. In order to link bidding areas to each other Euphemia uses so called Available Transfer Capacity (ATC) model. In the ATC model each bidding area is connected to other areas in respect to the actual underlying network topology. Electricity can flow between the areas using these ATC lines and the amount of the flow is limited by capacity allocated for the ATC line. There can also exists bidding areas without ATC connections to other bidding areas. These areas are called island areas. ATC model is illustrated in Figure 11. (EPEX Spot et al. 2013)

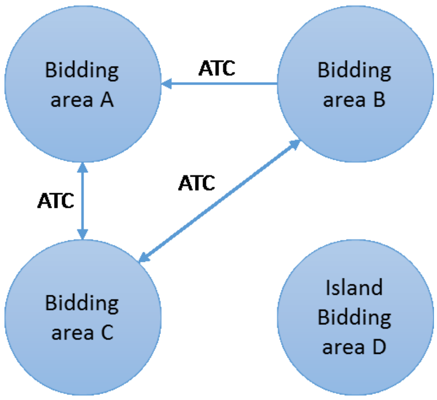


**Figure 11. Connected bidding areas in ATC model.**

In the PCR Day Ahead auction process the two base values for Euphemia calculation are the order books and the network data files from each European Power Exchanges. These order books contain aggregated supply and demand curve for each bidding area and complex order types such as block orders. The aggregated curves further include each individual supply and demand offer announced to the markets by electricity generators and consumers. Aggregated curves can be linear, stepwise or hybrid curves. Linear curves do not contain such curve points which have same price, whereas stepwise curve may contain consecutive points which always have either the same price or the same quantity. Hybrid curves are composed by both types of curves. The other fundamental input required for the price formation is the network topology data describing the ATC lines and bidding areas of the market. It also contains restrictions in the network such as allocated capacities for each ATC lines. (EPEX Spot et al. 2013) Nord Pool Spot is using also so called System Price plugin for Euphemia during the PCR Day Ahead auction process which performs such calculation where the network topology restrictions are ignored. As result, Nord Pool Spot will receive the System Price results.

The calculation problem given to Euphemia algorithm is quite complex due to the order types and the amount of data. Thus, Euphemia runs combinatorial optimization process based on the modeling of the market coupling problem. The algorithm is designed to solve welfare maximization problem, also referred as master problem. It also searches optimal solution for three sub-problems to complement the result. Master problem solving aims to search the intersection of the supply and demand curves and optimal set of accepted complex orders which would result in the maximal socio-economical welfare for the

region. The sub-problems then further search for feasible price according to submitted orders and given price caps. The other two sub-problem calculations solve solutions for more complex orders. The basic solving logic of the Euphemia algorithm is illustrated in Figure 12. (EPEX Spot et al. 2013)

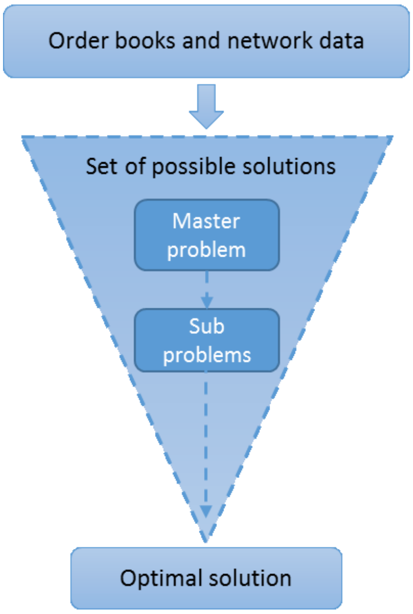


**Figure 12. Euphemia problem solving using master and sub problems.**

## *6.3 Orders for calculation*

In the European price coupling the price caps for single hourly orders are harmonized. Minimum price cap is set to -500€ and maximum price cap is set to 3000€. (Nord Pool Spot 2013) Price caps are used to determine the value field where the aggregated supply and demand curves need to intersect. If the intersect is not found within this area, then one of the curves is cut depending if the it is maximum or minimum price situation. Same price caps are used for this study simulation to align the simulation results for the SEE regional area with other Europe.

Hourly demand profiles for each country are shown earlier in chapter 3 Figure 9. The profiles contain values for demand for each hour in each typical day for each month of a year. Using this data, jurisdiction specific demand offers are compiled. During recent times, real time demand response has increased as effective mechanism to balance price differences. However, demand response is not modelled as part of this study simulation since inelastic demand is more traditional case. Negative volume represents selling volume whereas positive volume represents purchasing volume. Inelastic demand offer

contains only minimum and maximum price steps with the same demand amount in megawatts (MW) for both price steps. Example of a demand singly hourly order for Croatia representing typical day in January can be seen in Table 10.

**Table 10. Single hourly order for total demand in Croatia for D1.**

| Hour / Price | -500 EUR | 3000 EUR |
|---|---|---|
| 01:00 | 1681 MW | 1681 MW |
| 02:00 | 1547 | 1547 |
| 03:00 | 1476 | 1476 |
| 04:00 | 1445 | 1445 |
| 05:00 | 1456 | 1456 |
| 06:00 | 1551 | 1551 |
| 07:00 | 1805 | 1805 |
| 08:00 | 1977 | 1977 |
| 09:00 | 2103 | 2103 |
| 10:00 | 2184 | 2184 |
| 11:00 | 2207 | 2207 |
| 12:00 | 2244 | 2244 |
| 13:00 | 2222 | 2222 |
| 14:00 | 2147 | 2147 |
| 15:00 | 2077 | 2077 |
| 16:00 | 2041 | 2041 |
| 17:00 | 2153 | 2153 |
| 18:00 | 2397 | 2397 |
| 19:00 | 2417 | 2417 |
| 20:00 | 2410 | 2410 |
| 21:00 | 2332 | 2332 |
| 22:00 | 2333 | 2333 |
| 23:00 | 2179 | 2179 |
| 24:00 | 1927 | 1927 |

Supply offers are constructed based on the net production capacities shown in chapter three Figure 8. In the chapter 6 it was discussed and reasoned why wind, nuclear and other renewables are considered to be inelastic in this study simulation. Therefore, such inelastic productions have similar flat single hourly orders as shown in Table 10 for demand side. However, the productions methods which are priced against the marginal cost of production include an additional price step at marginal costs to adapt the activation level for each production method. The theoretical production amount is expected to be same for all hours in respect to the net maximum production capacity throughout the year. However, capacity factors for hydro and renewable generation varies depending on month. The orders for price calculation are built so that each jurisdiction has one demand

offer based on the demand profile and multiple generation offers to cover the different fuel types representing the available production capacities in the jurisdictions. The possible supply offers are Coal, Gas, Hydro, Nuclear, Oil, and Renewables. Due to the relatively small amount of other renewables than hydro in the region such as wind and solar they are all included in one and same inelastic order. Example of a supply offer for conventional coal power in Croatia is shown in Table 11.

It should be noted that even though the jurisdictions in the region have different currencies in use, the regional market simulations are done in euro currency. The price optimization algorithm requires all orders to be in same currency in order to be able to calculate the market equilibrium. Therefore, Euro is currently used in the Price Coupling of Regions. If national power exchanges want to offer local currency trading for their customers, they must handle the currency exchange calculations in their own trading systems before and after the common price calculation.

**Table 11. Single hourly order for Croatian coal-fired production.**

| Hour / Price | -500 EUR | 36,4 EUR | 36,5 EUR | 3000 EUR |
|---|---|---|---|---|
| 01:00 | 0 MW | 0 MW | 1505 MW | 1505 MW |
| 02:00 | 0 | 0 | 1505 | 1505 |
| 03:00 | 0 | 0 | 1505 | 1505 |
| 04:00 | 0 | 0 | 1505 | 1505 |
| 05:00 | 0 | 0 | 1505 | 1505 |
| 06:00 | 0 | 0 | 1505 | 1505 |
| 07:00 | 0 | 0 | 1505 | 1505 |
| 08:00 | 0 | 0 | 1505 | 1505 |
| 09:00 | 0 | 0 | 1505 | 1505 |
| 10:00 | 0 | 0 | 1505 | 1505 |
| 11:00 | 0 | 0 | 1505 | 1505 |
| 12:00 | 0 | 0 | 1505 | 1505 |
| 13:00 | 0 | 0 | 1505 | 1505 |
| 14:00 | 0 | 0 | 1505 | 1505 |
| 15:00 | 0 | 0 | 1505 | 1505 |
| 16:00 | 0 | 0 | 1505 | 1505 |
| 17:00 | 0 | 0 | 1505 | 1505 |
| 18:00 | 0 | 0 | 1505 | 1505 |
| 19:00 | 0 | 0 | 1505 | 1505 |
| 20:00 | 0 | 0 | 1505 | 1505 |
| 21:00 | 0 | 0 | 1505 | 1505 |
| 22:00 | 0 | 0 | 1505 | 1505 |
| 23:00 | 0 | 0 | 1505 | 1505 |
| 24:00 | 0 | 0 | 1505 | 1505 |

## 6.4 Regional market area setup

A fictional regional market area was created in the trading systems for the simulations. The created topology matches the electricity transmission network topology existing in the region in reality. This regional market is illustrated in Figure 13. Jurisdictions connected to each other with cross-border transmission capacities are also shown in the Figure 13, the NTC values are presented earlier in Table 6. In the Nordic electricity markets there are also additional limitations in addition to the transmission capacities such as network losses and ramping restrictions. Ramping restrictions are mainly used between asynchronous networks and the limitation aims to restrict the maximum amount of power flow direction change within an hour (Nord Pool Spot 2014c). However, in this study only available transmission capacities are used as restriction parameters in the price calculations since the regional network is synchronous.


**Figure 13. Simulated regional market area.**

Figure 13 shows that the SEE area is quite well interconnected. One main advantage is that the Serbia and Kosovo network area is connected to all neighboring jurisdictions enabling power to flow fluently horizontally and vertically throughout the region if needed. In addition, almost all jurisdictions have interconnection lines to all neighboring

countries providing promising base for free electricity flow in the area. However, Albania and FYR of Macedonia border does not have ATC line. This will cut the full loop from Bulgaria to Croatia where electricity would not pass by Serbia and Kosovo network area, reducing the possible flow patterns. The transmission lines connecting outside of the regional market area are not considered here since the yearly net flow outside of the selected regional area is quite small and thus not considered in the market simulations.

## 6.5 Simulation procedure

Simulation in this study consists of twelve delivery days where each day represents a typical day in each month of a year. Since the electricity generation capacities are expected to remain same throughout the whole year all twelve delivery days have the same supply orders for all other generation methods expect hydro and renewables. Capacity factors for hydro and renewable generation vary depending on the month, which then changes the available production capacities and further the supply offers. Furthermore, demand is varying for each day to match the average situation in each month. The only limiting parameters in the calculation are the available network transmission capacities. The amounts of available transmission capacities vary during a calendar year in real life due to the maintenance and failure situations. However, these abnormal situations are not taken into consideration in the high level simulation performed in this study and thus the available transmission capacity values are also expected to remain same throughout the year.

The simulation process used in study follows the proposed regional market method. Thus, firstly multiple supply orders were created for each jurisdictions to reflect the available generation capacities. Inelastic supply orders create a flat supply curve whereas price depended generation units create linear supply curves. Next, one demand curve is create for each jurisdiction to represent the total hourly demand in the area. In addition, available transmission capacities are added in the system. In the next step the aggregated supply and demand curves are generated for each network area by adding up the individual supply and demand curves created for the respective area. Finally, the order book containing the aggregated curves per network areas is generated, as well as the network data file containing the regional topology and capacity values for each connection line. The order book and network data file is given to Euphemia algorithm which then performs

the optimization calculations and determines the optimal area prices for each network area. Furthermore, Euphemia algorithm determines the optimal electricity flows between the network areas as implicit auction. The area prices and network flows are further passed to Nord Pool Spot's post processing tool where the results for each portfolio are calculated based on the received area prices. In other words, the last phase of the simulation determines how much electricity is generated by each of the available generation units.

One reference scenario was ran to complement the actual simulation. The same supply and demand curves were used in the reference scenario for each of the typical days but the available network capacities were set to zero in all hours. In other words, the reference scenario shows how the market situation would be in the region if the market operations were performed in each network area independently in islanded markets. However, this is slightly apart from real life since the explicit auctions for capacities and the results of the explicit auctions are not estimated on top of the reference case results. Currently, to balance out the demand and supply the network areas do some level of cross-border trading with explicit auctions as explained in the chapter four.

# 7 Results and analysis

The aim of the simulation was to analyze in high level if the benefits of the regional market could be achieved in SEE region. Real underlying data was used in the simulation in order to provide realistic results. The simulation provided three important indicators to evaluate if the benefits could be achieved: generation utilization pattern, prices for the region and flows between the simulated market areas. The results are further elaborated in this chapter and conclusions are drawn to evaluate if the expected benefits could be obtained.

## *7.1 Generation utilization*

The simulation results for the fictional SEE regional electricity market provided valuable data showing how generation units would be utilized if a common electricity market was efficiently operated in the region. The analysis of the production utilization results is further broke into different levels, starting with the overall production pattern in the region, shown in the Figure 14.

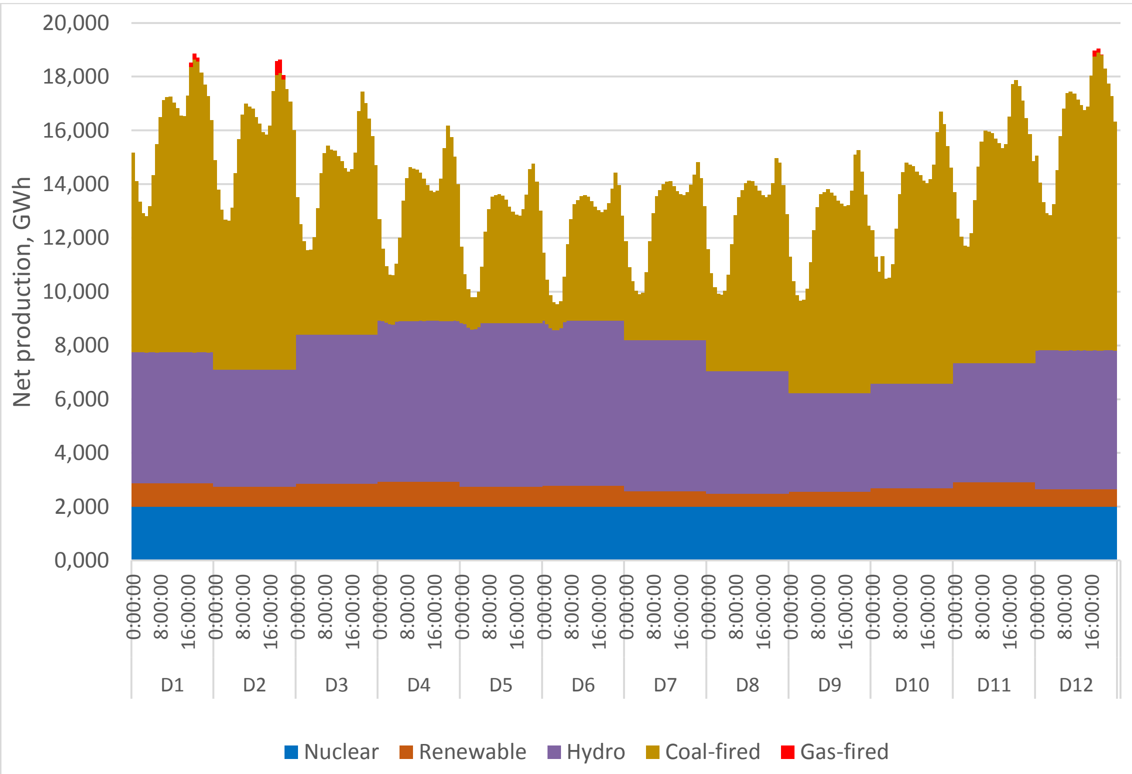


**Figure 14. Expected regional net production during the typical days.**

As expected, nuclear and renewable production are run at maximum level during all of the simulated days. Nuclear and renewable production were set to be inelastic i.e. electricity could be produced regardless of the price. This result reflects well also real life where nuclear energy is widely used as baseload in the generation mix. Figure 14 also shows that the next economical production method, hydro production, is run at maximum level during all simulated days. However, there are some fluctuations in the production amounts due to the capacity factors used in the simulations to take into account the variation in the yearly availability of the hydro generation capacity. The amount of electricity produced by hydro power is at highest level during the typical days in April, May and June. On top of the hydro production there are varying amounts of coal-fired production throughout the simulated time interval. Figure 14 shows that the coal production profile follows tightly the regional demand profile illustrated earlier in chapter 3 Figure 9. Thus, the results clearly indicate that the coal-fired production units are activated to generate the remaining electricity needed after nuclear, renewable and hydro production to meet the regional demand. The regional production profile matches the identified seasonal and hourly variations of the demand. It should also be noted that small amounts of gas-fired production is required in typical days of January, February and December when the demand is at highest. In addition, the results show that there is no need for oil-fired production in any of the simulated days. Peak load generation units are usually used only in extreme cases when something unexpected occurs in the markets or region. Averaged approach naturally smooths off such extreme cases from input data and thus it was expected that heavy peak load hours might not occur during the simulations. Oil-fired production would act the similar way as the gas-fired production does in the results and would generate the required addition electricity for the peak load hours.

Since the averaged days were created to represent a typical day in each month, these days are now used to generalize the whole month. Therefore, the production amount for a typical day shown in results is multiplied by the days in the respective month to cover the whole month. This way the expected yearly production amounts can be investigated. Figure 15 illustrates the calculated expected yearly production rates per fuel type for each jurisdiction. Results show that the expected yearly production pattern in the region is very similar to the one which occurred in 2013.

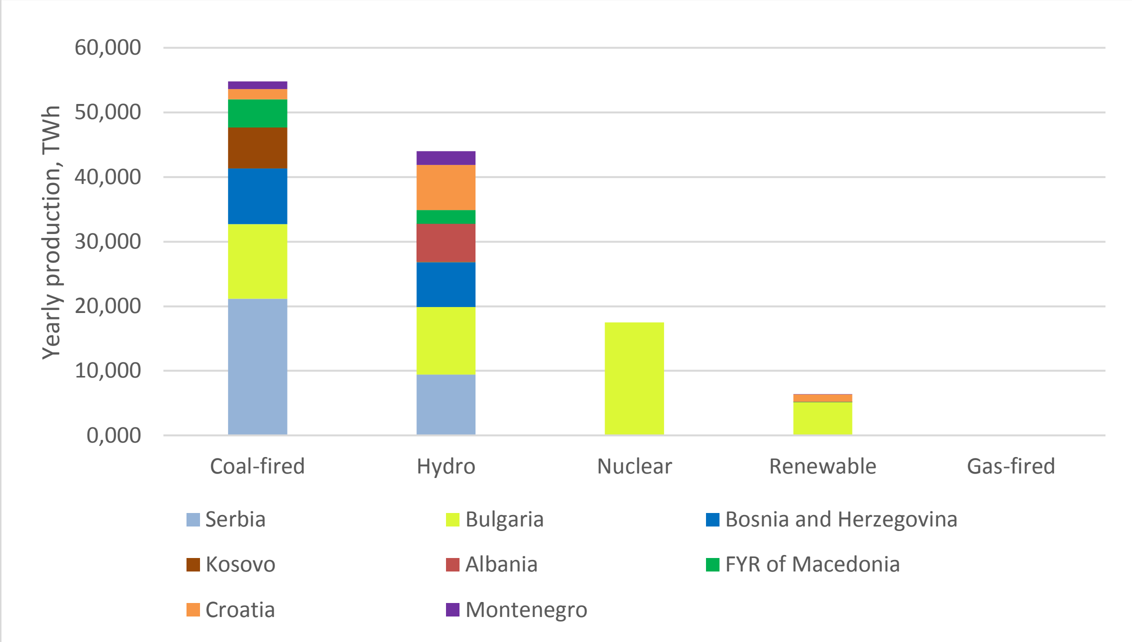


**Figure 15. Expected yearly electricity production rates.**

Figure 15 shows that most of the electricity would still be produced with coal-fired units if all regional production capacity was subjected to regional day ahead market. The next biggest production cluster would be hydro, followed by nuclear. However, the gap between coal-fired production and hydro production amounts would be considerably smaller than in the 2013 values shown in Figure 7. In the simulations 45% of all electricity was generated by coal-fired units and 36% of all production was hydro power. In 2013 the respective shares were 52% for coal-fired and 31% for hydro. Thus, the simulation results indicate a clear increase in the hydro production amounts as well as a clear decrease in coal-fired production amounts. Indeed, it seems that the SEE regional day ahead market would have allocated the production capacities in more cost efficient way. The shares of the renewable and nuclear productions are quite the same in the simulation results as what was actually realized in year 2013. The explanation for the similarity can be found from the inelastic nature of the production methods: both methods tend to produce electricity regardless of the price and market situation. The similarity between these two production amounts in Figure 14 and Figure 7 indicates also that the simulation was realistic and reflecting well the real life. Interestingly, the simulation results show that there was considerably less gas-fired and oil-fired production than what occurred in 2013. The expected decrease in these production amounts can originate from two things. Firstly, the averaged approach using typical days does cut the extreme cases where gas-

and oil-fired productions are mostly used. Secondly, due to the implicit capacity auction used in the simulation, the market situation in the power system is much better handled and thus the extreme cases might not even occur if a regional market would be established in the area. Finally, the total regional production amount was close to 123TWh in the simulation results. Keeping in mind that the real occurred production amount in the region was close to 135TWh in 2013, it can be seen that the amount in simulation results do not match one to one to that. However, the total electricity export outside of the simulated region was around 11TWh in 2013. Electricity exports outside from the region naturally directly increases the production amounts inside the region and are included in the production statistics. However, the required export amounts were left out from the simulations due to the complexity restraints. Thus, after subtracting the given export amount from the 2013 regional production amount the 2013 regional production amount actually ends up to 124TWh, which is almost identical to the amount in simulation results. Again, this similarity in the simulation results and the real life data indicates successful and realistic simulation results.

One reference case was ran in addition to the actual regional day ahead market simulation. Same regional market topology, same production capacity amounts and same supply and demand offers were used in the reference case. However, all available transmission lines between bidding areas were removed by setting the available capacities to zero. In other words, each jurisdiction was an isolated area and had to match their demand with their own installed production capacity. Figures 16 and 17 illustrates the results from this reference simulation.

The reference case results show that without a regional market and implicit auctioning of cross-border capacities the nuclear and renewable production amount remain identical compared the actual SEE regional market simulation. However, the amount of coal production is reduced almost by 13% because it was not possible to produce electricity more economically in other areas and transfer it to deficit areas. Instead, the deficit areas need to cover some of the production with gas-fired and oil-fired units. Furthermore, the hydro production profile has changed since surplus areas cannot transfer the excess to neighboring areas. The biggest deficit areas were Albania, Croatia and Montenegro. This production pattern also resembles the one which occurred 2013. Therefore, the results

from reference simulation back the statement that regional day ahead electricity markets in SEE region would have allocated better the available production capacities.

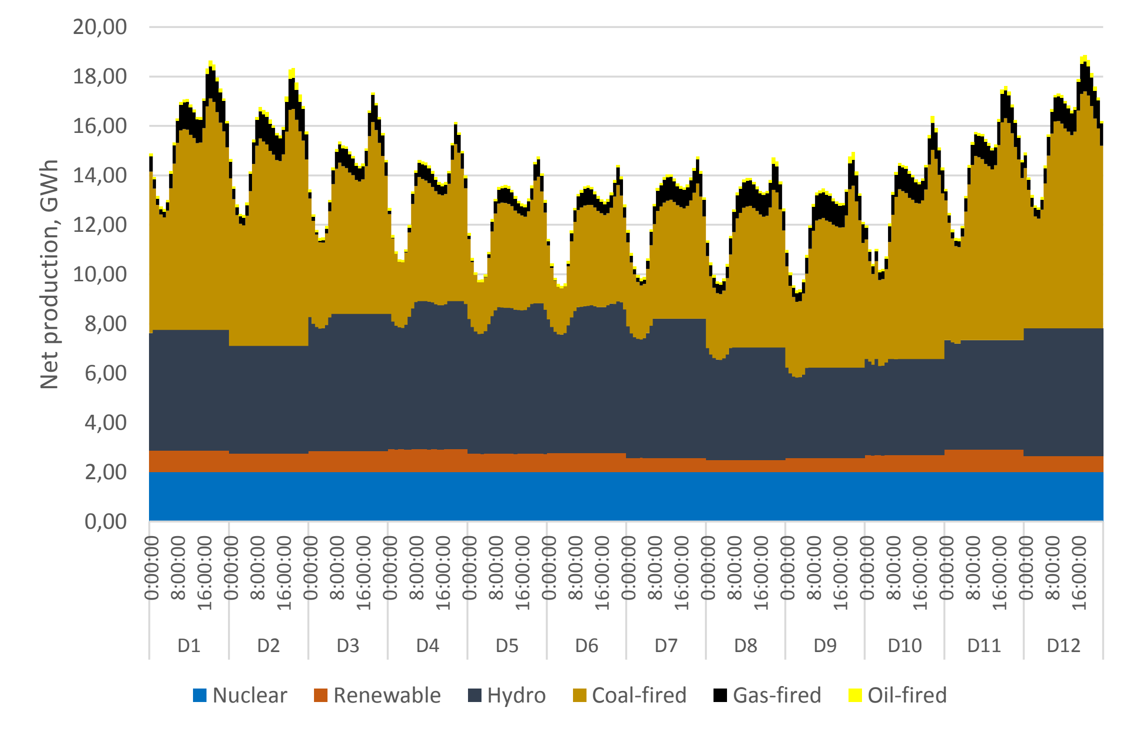


**Figure 16. Expected regional net production without transmission capacities.**

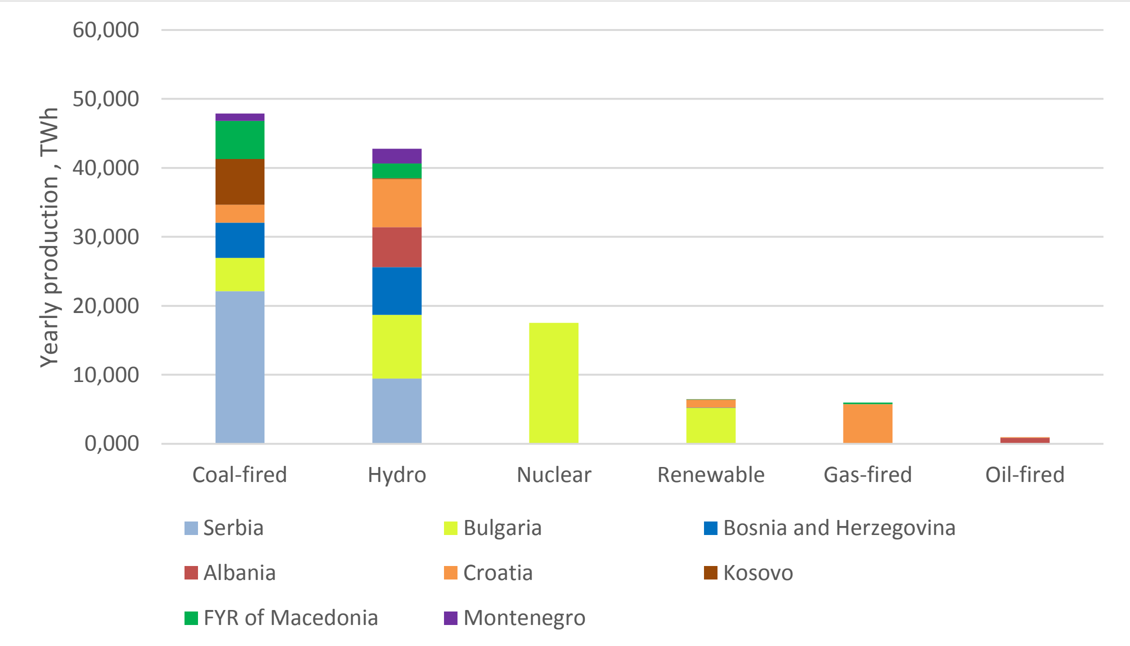


**Figure 17. Expected yearly electricity production rates without transmission capacities.**

## 7.2 Prices

Simulations provided two kind of prices as result: Area price and System price. Area price is specific price for each bidding area. Area prices for each bidding areas can differentiate from each other based on the demand and supply situation within each area. Thus, it represents the marginal price for each bidding area. In Nordic electricity markets, the physical trading takes place based on the Area price and thus both producers and consumers settle with the same price. Area price is calculated so that available transmission capacities are taken into account. Therefore, congestion in certain transmission lines can lead to price differences between the bidding areas. On the contrary, System price is calculated so that transmission capacity limitations are ignored and thus it represents the price in pure market equilibrium. In other words, System price takes into account only the demand and supply offers in the whole region and calculates the price at their intersection. As results of this, the system price is always the same for all bidding areas throughout the whole region. In the Nordic electricity market System price is mainly used in financial markets. (Nord Pool Spot 2014b) However, in this study System price is used as a reference price to illustrate such situation where there would be enough available transmission capacity in the region to host perfectly functioning markets with most efficient flow of electricity.

System price results for the simulated twelve days are illustrated in Figure 18. Keeping in mind that the marginal cost for conventional coal production was 36,4 EUR/MWh, it can be seen that the system price settles quite close to this for each of the days and hours. This means that in perfect market situation where there would be no congestion between the bidding areas, the coal fired production is the last generation type needed to be activated in order to meet the demand. Some minor variation can be observed from the results. The system price varies between 36,41 EUR/MWh and 36,5 EUR/MWh due to the interpolation for the supply curve. When comparing the demand profile and the seasonal and hourly variation in the System price, it can be seen that the minor variation in the System price follows the same pattern as demand does. Therefore, the results indicate that at the seasonal level the System price is lowest during the low demand months and highest at the winter months which are the high demand periods. Similar, at daily level the system price usually is highest during peak hours 17:00 – 19:00 and lowest during night hours.

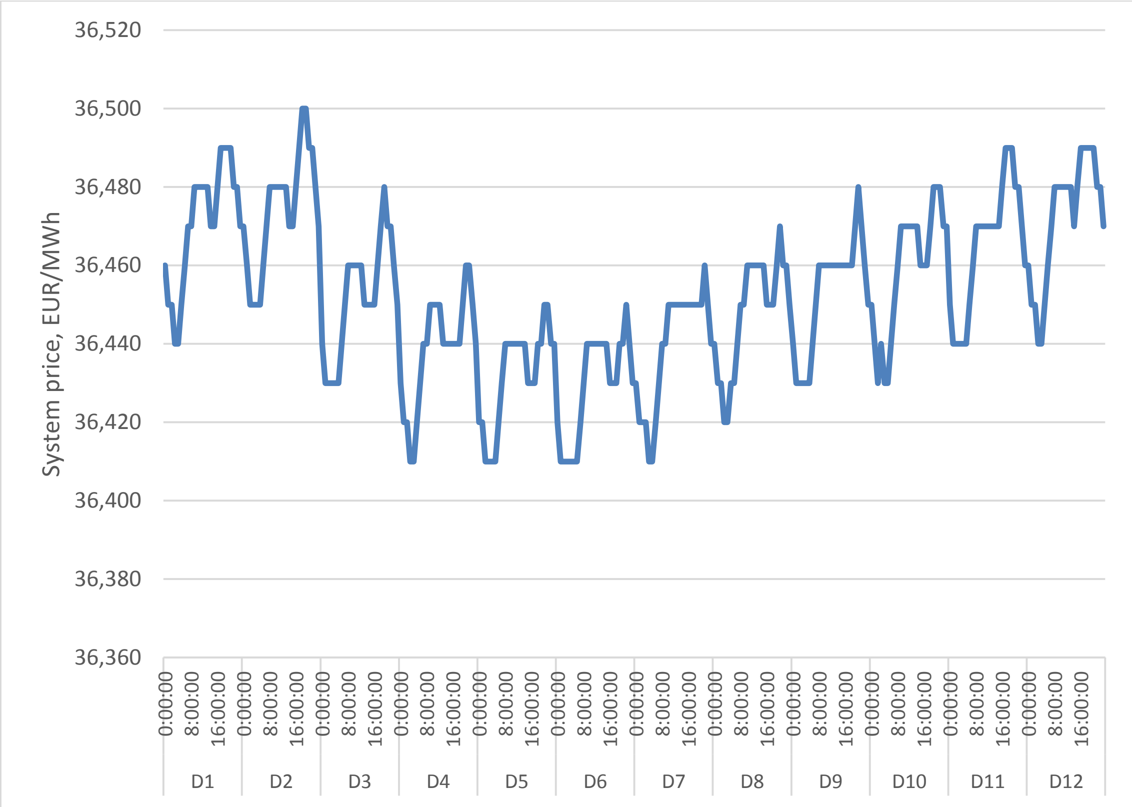


**Figure 18. System price in simulated region.**

The available transmission capacities were shown earlier in the chapter 7 Table 6. That data elaborated that the SEE region is well interconnected. In addition, based on that data it seems like there is also quite a lot of available capacity between SEE jurisdictions. This situation is reflected well in the Area price results. In fact, Area prices were almost identical to the System prices in all bidding areas throughout the twelve simulated dates, as illustrated in the Figure 19. The results show that electricity was able to flow between areas so freely during the simulated days that all other jurisdictions than Bulgaria had identical prices for all hours of the simulation. These results indicate that the regional market would perform extremely effectively if all network capacity was allocated for the regional Day Ahead market and implicit auction.

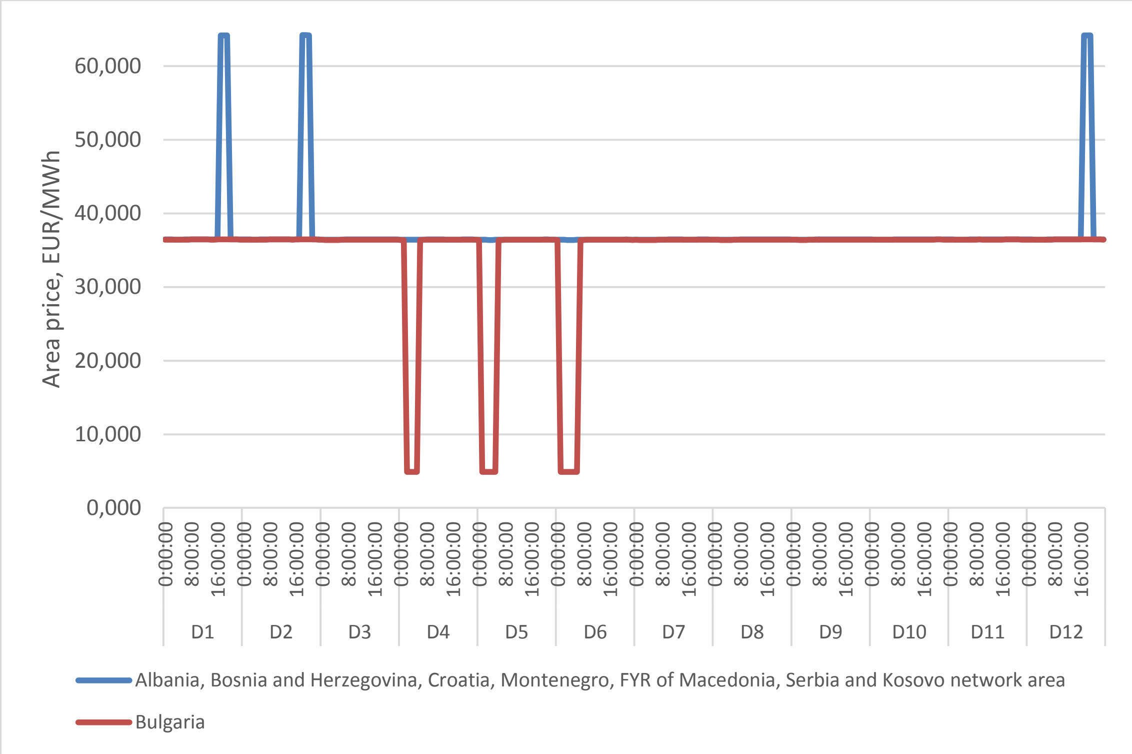


**Figure 19. Area prices in simulated region.**

Figure 19 shows also six distinctive price peaks. First two price peaks are at the peak demand hours in typical day in January and typical day in February. During these peak hours the area price has risen to 64,2 EUR/MWh in all other areas expect in Bulgaria. The marginal cost of the gas-fired production was also defined to be 64,2 EUR/MWh in the simulation. Therefore, the price results back up the fact that some gas-fired production had to be activated to meet the high demand in the peak hours in the winter months. In addition to the peak demand, also the capacity factors for hydro production were below average during these days, which further explains the need for gas-fired production. The amounts of the activated gas-fired production can be seen in Figure 14. Figure 19 shows identical peak also for few hours in typical day in December which can be explained with the same reasoning. However, Figure 18 does not show this kind of peaks for the System price. Therefore, it seems like there are congestions in Bulgarian borders. In other words, Bulgaria would have capacity to produce more electricity to cover the peak demands in other jurisdictions of the region but there is not enough transmission capacity to physically transmission the required electricity to the deficit areas. However, this also means that Bulgaria can easily meet its own demand and thus the price remains lower than in rest of the region. Three remaining price peaks are below the average price level

and occurring only in the Bulgarian bidding area. These occur during low demand hours 01:00 – 05:00 in typical days in April, May and June. The demand profile in Figure 9 shows that demand is lowest during these months. In addition, the capacity factors for hydro production are at highest during these months, meaning that there is more hydro production available than in other months. Again, due to the congestion in Bulgarian interconnection lines the low price peaks are occurring only in Bulgaria.

The reference simulation without any transmission capacity clearly shows the benefits of regional electricity market in SEE area. Figure 20 illustrates this situation, note that the scale of the figure is logarithmic due to the high variation in the price values. In this case, almost all bidding areas end up in different area price and the price seems to be much more volatile.

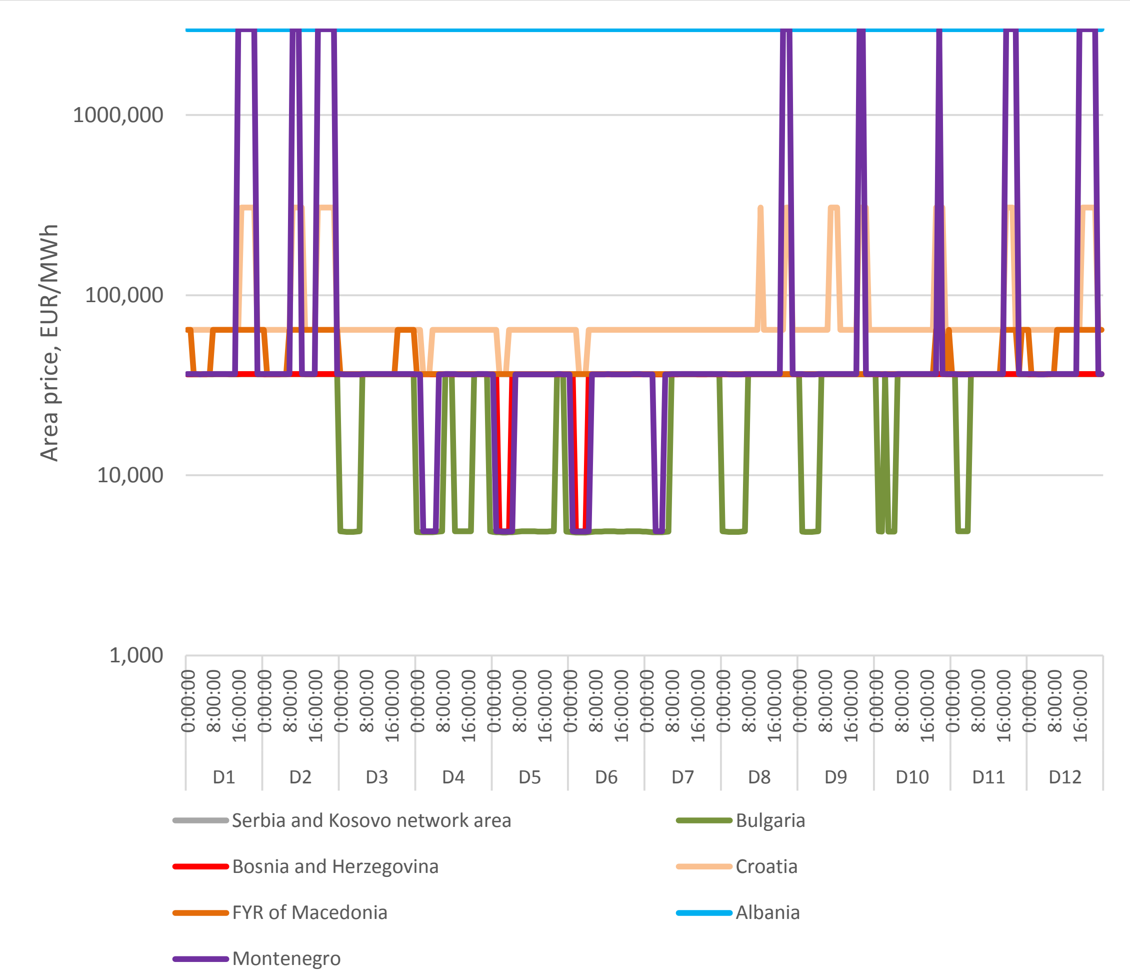


**Figure 20. Area Prices without transmission capacity in logarithmic scale.**

Figure 20 shows that Bulgaria has the lowest area prices and can produce electricity with only nuclear, renewables and hydro at the marginal cost of hydro productions for several hours. However, in reality the lowest prices might be somewhat higher if the hydro production would be priced against the opportunity cost of production rather than marginal costs. Similar to Bulgaria, the Area price in Bosnia and Herzegovina is also at low price around 4,9 EUR/MWh for few hours while the maximum price stays still only at 36,46 EUR/MWh. Third lowest price level in the reference case is in Serbia and Kosovo network area where the area price is close to 36,5 EUR/MWh throughout the whole simulation interval. Other jurisdictions clearly suffer from not having cross-border flows and price balancing between the neighboring areas. FYR of Macedonia has to active gas-fired generation units during winter months and peak demand hours and thus the area price rises to 64 EUR/MWh, whereas during low demand periods the local demand can be met mainly with hydro and coal production and the price stays close to 36 EUR/MWh. Croatia has to active not only gas-fired units but also oil-fired production for several hours during the simulated dates. Therefore, the base level of Croatian area price stays around 64 EUR/MWh but can rise all the way to 306 EUR/MWh during the peak load hours. The most volatile area seems to be Montenegro where the price of the electricity fluctuates between 4,88 EUR/MWh and the maximum price of 3000 EUR/MWh. This means that during the high demand periods there is not sufficient amount of production capacity in Montenegro to satisfy the local demand but on the other hand during the low demand periods hydro production alone can cover the demand. Figure 20 shows also that Albania suffers the most from the situation where there is no transmission capacity between bidding areas. The Area price in Albania stayed at maximum price 3000 EUR/MWh for all simulated hours. Basically there is not enough production capacity in Albania to meet the demand in any of the hours during the year. Thus, the demand needs to be curtailed to meet the level of production capacity. Keeping in mind that the Albanian Area price was around 36 EUR/MWh in the regional market simulation for almost all hours, it seems that having an effective regional electricity market with implicit capacity auctioning would be highly beneficial for Albanian electricity sector.

Comparing the simulation price results to the current price level in the SEE region is challenging since any of the countries do not yet operate transparent day ahead electricity spot markets. Thus, the price information available may include regulation and other price

components such as transmission fees. Nevertheless, Eurostat provides electricity prices excluding taxes and levies for industrial consumers with annual consumption between 20 000 and 70 000 MWh. Even though the given price does not perfectly match the day ahead market spot prices, they provide some indication of the current price level in the region. These prices are illustrated in Figure 21. The price information for FYR of Macedonia is from 2013 since 2014 data is marked as confidential. In addition, Albanian prices are not provided by Eurostat.

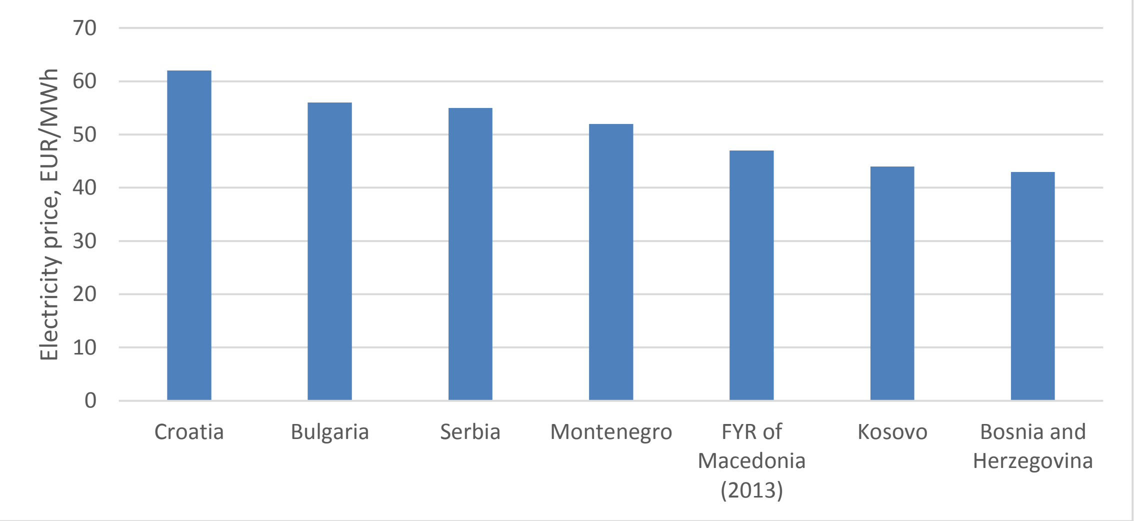


**Figure 21. Electricity price for industrial consumers in 2014. (Eurostat 2015b)**

Figure 21 shows that Croatia has the highest price level having electricity prices around 62 EUR/MWh. Also Bulgaria, Serbia and Montenegro have price levels above 50 EUR/MWh and further rest of the jurisdictions have prices above 40 EUR/MWh. The simulation results in this study indicate that the electricity spot price would set close to 36 EUR/MWh for nearly whole year if calculated in effective regional day ahead electricity market. All of the jurisdictions have currently higher electricity price level, Bosnia and Herzegovina being closest with 43 EUR/MWh. Especially consumers in Croatia would gain notable benefits if their electricity would be traded through regional electricity market. Currently the price differences in the region are quite reasonable. However, the difference between Croatia and Bosnia and Herzegovina is as much as 19 EUR/MWh. Simulation results show that all jurisdiction in the region would have close to identical prices throughout the year if regional electricity market would operate in the area. Equal electricity prices would further benefit the area in terms of electricity sector investments.

## 7.3 Flows

The third part of result analysis concentrates on the expected electricity flows in the region. In the regional electricity market the price is determined by taking into account the available transmission capacities. Therefore, in order to gain maximal socio-economic benefit for the region there usually occurs some electricity flows between the areas. This way electricity can be produced on site where it costs least. Simulation results provide flows between bidding areas for each simulated hours. The flows during the typical days of each month are treated as average case for the whole month. Thus, the hourly flows are summed up to total daily flows between bidding areas and further multiplied by the amount of days in the respective month. This way the expected yearly export and import amounts are achieved. The expected yearly exports and imports between simulated areas are shown in Table 12.

**Table 12. Expected yearly flows between bidding areas in GWh.**

| FROM/TO | AL | BA | BG | HR | ME | FYROM | RS&XK | Export |
|---|---|---|---|---|---|---|---|---|
| AL | | | | | 0,0 | | 0,0 | 0,0 |
| BA | | | | 3279,8 | 674,4 | | 174,7 | 4128,9 |
| BG | | | | | | 2628 | 5256 | 7884,0 |
| HR | | 0,0 | | | | | 0,0 | 0,0 |
| ME | 1893,0 | 1,5 | | | | | 19,7 | 1914,2 |
| FYROM | | | 0,0 | | | | 1269,6 | 1269,6 |
| RS&XK | 232,1 | 616,9 | 0,0 | 3535,3 | 1134,8 | 9,6 | | 5528,6 |
| Import | 2125,0 | 618,3 | 0,0 | 6815,1 | 1809,2 | 2637,6 | 6720,0 | |

Table 12 shows that Albania, Croatia, FYR of Macedonia and Serbia and Kosovo network area were net importers of electricity whereas Bosnia and Herzegovina, Bulgaria and Montenegro were net exports of electricity. The trend of power flows seems to be similar to what actually occurred in 2013 with one distinctive exception. During 2013 Serbia and Kosovo network area was clearly net exporter. However, the simulation results indicate that in SEE regional electricity market that area would be net importer instead. The change originates from the fact that simulation didn’t take into account any flows outside of the region. In addition, when calculating the electricity prices and flows jointly in implicit auction the regional system dynamics change compared to explicit auctions. Even though all of the interconnectors have clear dominant flow direction, there are flows occurring in both directions for almost all lines. This indicates that the jurisdictions in the region are able to support each other in cases where deficit and excess areas are varying.

Furthermore, this kind of behavior is indicating that many of the power systems are complementary to each other. In other words, the production capacity fleets in different jurisdiction can operate smoothly together if the allocation and activation is done in jointly manner.

The flow results are in line with the price and production utilization results. The reference simulation without transmission capacities showed that Albania and Croatia were the biggest deficit areas. Therefore, it is natural that they are also the biggest electricity importers. Imported electricity will increase the supply in the jurisdictions and therefore lowers the prices. In addition, the reference simulation results show that Bulgaria can produce electricity at low price all around the year. Thus, when transmission capacity is introduced in the price optimization, Bulgaria naturally ends up as net exporter. Serbia and Kosovo network area has high figures for both export and import. This is due to the key location of their network area, locating in the center of the region. Hence, Serbia and Kosovo network area would probably function as transit area in SEE regional markets.

The flows in each cross-border links are netted together to see in which direction the net flow is expected to occur. This will further give a better view on the flow dynamics in the region. The expected net flows based on the simulation results and actual net flows from 2013 are illustrated in Figure 22.

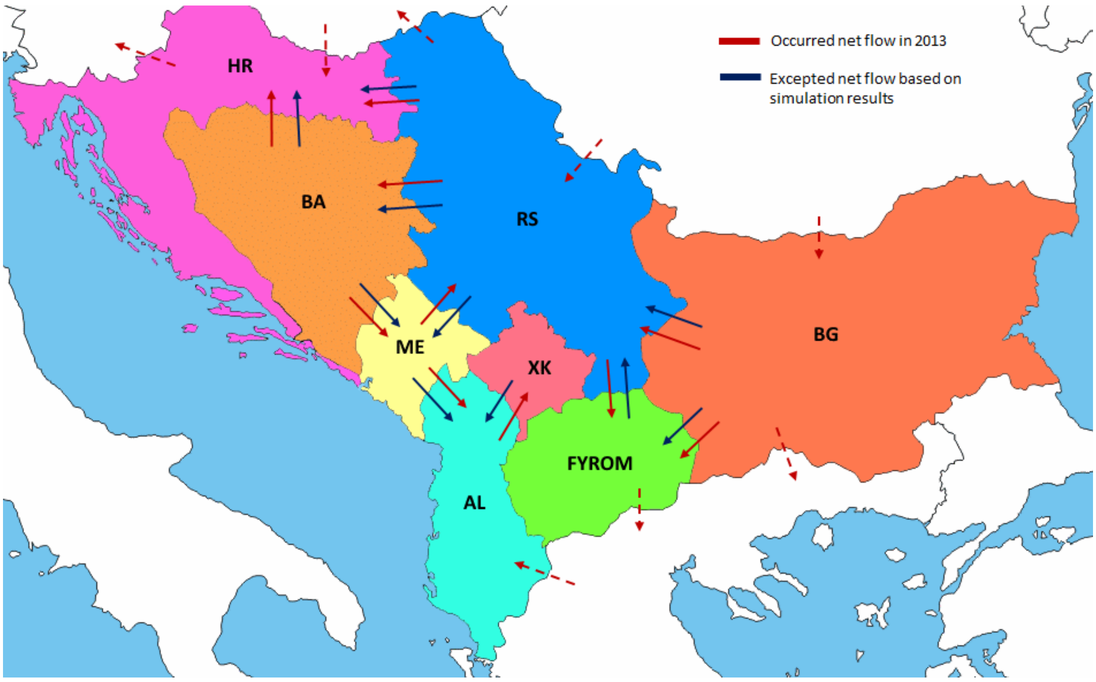


**Figure 22. Excepted net flows from simulation and occurred real flows in 2013.**

As can be seen, the trend is similar in both cases. Some of the Serbia and Kosovo network area dynamics have changed since the directions of net flows between Montenegro, Albania and FYR of Macedonia and it have changed. The simulation results display that in cases when Bulgarian and Serbia and Kosovo network area border is congested, some of the Bulgarian excess electricity is transferred also through FYR of Macedonia. Generally, the flows are pointing to the deficit areas Croatia and Albania. In both cases Serbia and Kosovo network area is functioning as transition area.

## 7.4 Conclusions

The most important benefits which can be achieved from the efficient regional electricity market cooperation were discussed previously in this study in chapter six. Four distinctive benefits were introduced: specialization, reduction of the market power of a single market participant, improved economic signals for the markets and finally the costs reductions from elimination of the overlapping institutions. Regional Day Ahead market simulation and the reference simulation with isolated areas performed in this study gave a high level implications whether these benefits could be achieved in the South East Europe region within the selected jurisdictions.

Results show that there would be a change in the regional production utilization pattern. It seems that less coal-fire production would be needed due to the better allocation of the hydro power production. This is a clear sign of improved specialization i.e. with regional electricity market cooperation the selected jurisdictions could produce electricity in the most economical and profitable way. This kind of specialization in the electricity production business would have further impact also on the electricity prices by leveling them out since the electricity flows between jurisdictions would be allocated with implicit auction in the regional market solution. In addition, the reference simulation implies that without a regional market cooperation and explicit auctions some amount of the production capacity would not be utilized at all, resulting in not optimal market result.

Simulation does not explicitly reveal if the market power of the single market participants would be reduced in the SEE region due to the fact that the ownership structures of the production capacities are not investigated closer in the scope of this study. However, in

the simulation all the production capacities in the region were aggregated and thus the overall market shares of the big national producers are naturally reduced. In addition, the SEE electricity sector outlook showed that none of the jurisdictions possess major share of the total production capacity in regional scale. Therefore it is reasonable to say that the benefit of spreading the market power could be achieved with regional electricity market cooperation in South East Europe.

Simulation results provided almost identical prices for the whole selected region. On the contrary, there are some differences in the electricity prices currently in the region. Furthermore, the results show that the expected system price would be quite stable throughout the whole year. Consequently, less volatility in the price provides safer climate for electricity sector investments. Thus, the benefit of the improved economic signals towards the market could also be realistically achieved. Finally, the fourth benefit, the cost reductions from eliminating the overlapping institutions, remains somewhat unanswered in the scope of this study. The performed simulations do not take into account the required institutions needed to establish an efficient regional electricity market neither does this study give any recommendations for market operations other than what was already provided in the presented World Bank's study. However, the overview to current market opening statuses in the selected jurisdictions revealed that the region is already moving towards jointly operated institutions such as Coordinated Auction Office. Thus, achieving the fourth benefit seems to be also reachable for the region.

The electricity flow results point out that especially the border between Bulgaria and Serbia would be congested in peak situations. Thus, it would be beneficial for the region to increase interconnection capacity on this border in order to retain the market efficiency and equal regional prices also during the peak situations. In addition, Albania and FYR of Macedonia do not have cross-border capacity between them at all. If regional market would be operating in the region, then introducing interconnectors into this border would further increase the possibilities for electricity flows in the region. Thus, it would also ease the Bulgarian border congestion situations and increase the effect of the possible benefits. In addition, the better the region will be interconnected the better the regional network reliability will be and the liability of the electricity deliveries will increase.

# 8 Summary

This study researched the benefits of regional cooperation in the South East Europe area including the jurisdictions of Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Former Yugoslav Republic of Macedonia, Kosovo, Montenegro and Serbia. At first, the theory background behind electricity market liberalization was introduced by discussing the change from bilateral trading to power exchange based trading. It was pointed out that power exchanges provide more security, lower trading costs and increased competition for the market participants. In addition, electricity trading in power exchanges is more transparent and provides better price signals for the markets. Also a brief outlook to European Union energy policy was given, providing information about the Energy Packages which are the driving forces for the reforms in the electricity sectors.

Chapter three concentrated on the South East Europe electricity sector by providing key values for the selected jurisdictions. The electricity sector review showed that in regional level the demand has been quite constant during the past four years. In 2013 the regional electricity consumption was close to 100TWh. The largest shares in the regional consumption belong to Bulgaria and Serbia since both had their final electricity consumption around 27TWh in 2013. On the production side, the regional yearly production amount was close the 135TWh in 2013. Most of the electricity is produced by coal-fired generation and hydro power production. Rest of the production is covered by nuclear, gas-fired, renewable and oil-fired generation. Out of the selected set of jurisdictions Albania, Croatia and FYR of Macedonia were net electricity importers in 2013 whereas rest of the jurisdictions were net exporters. Jurisdictions in SEE also trade electricity with neighboring areas. Finally, the demand profiles in each jurisdiction were investigated by using averaged approach where a typical day for each month was calculated. Some seasonal and hourly variations were identified in the demand profiles.

In addition to the electricity sector outlook, also market opening status outlook was given in chapter four for each selected jurisdiction. Vertical and horizontal unbundling of the electricity sectors were investigated along with the electricity market statuses and eligibility thresholds. It was found that there has been quite stable and well progress in the reforms. However, the reforms are in quite difference phases in different jurisdictions. Serbia and Bulgaria seem to be furthest with their reform processes and both jurisdictions

have plans to establish local Day Ahead electricity markets through power exchange. Croatia is slightly behind the two aforementioned jurisdictions since the vertical unbundling is not fully finished. However, also Croatia has ongoing project for local Day Ahead market with power exchange. Rest of the jurisdictions are more behind from the full market liberalization.

Chapter five introduced the concept of regional power market and discussed the expected benefits. Three dimensions of the regional integration were identified: infrastructural, regulatory and commercial integration. These three dimensions describe the level of cooperation required in the electricity market field to gain the possible benefits. However, it was also pointed out that regional integration does not necessarily require centralized entity where regional market equals to regional solution. Instead, regional cooperation and local control approach was emphasized and the example of the PCR cooperation was introduced. Four distinctive benefits were introduced: specialization, spread of the market power, improved economic signals and costs reductions by eliminating overlapping institutions. In addition, it was noted that regional cooperation in electricity markets can lead to increased network safety and can also create cost reductions due to the more cost efficient market operations. Finally, European Market Model was discussed as it is identified as optimal market model for SEE area by World Bank's study.

Regional Day Ahead market simulation for the selected region was also carried out in this study to investigate if the expected benefits could be achieved in the selected jurisdictions. Real underlying data of the region was used as input for the simulation. In addition, a reference simulation was carried out where otherwise identical input data was used but all transmission capacities between the jurisdictions were removed. Simulation result analysis was broke into three parts: generation utilization, prices and electricity flows. The results showed that with the regional market most of the electricity would still be produced with coal-fired production. However, the simulation results indicate that the coal-fired production amount from total production amount would decline by 7% while hydro production share would increase by 5%. Therefore, the results show that the generation utilization would be allocated more efficiently with a regional day ahead market. The reference simulation results backed the statement since in these results the more expensive gas-fired production had to be activated. In addition, reference simulation

resulted in deficit situations in some of the jurisdictions. The expected regional yearly production amount in simulation results was 123TWh while it was 124TWh in real life in 2013. Thus, the simulation was deemed to be quite realistic.

Price results contained two type of prices: System price and Area price. System price illustrates an optimal situation where there are no restrictions in the market area whereas Area price reflects the market situation in each specific area. Results show that the System price reflects the merit order of activation as expected in European Market Model. System price stayed between 36,4€ and 36,5€ in all of the simulated days. This was expected since in the optimal situation the coal-fired production is always the last required generation unit in the selected region. Also Area price results indicated stable prices for the whole region. However, due to the transmission line congestions in the peak situations few price peaks were identified, giving a lower price for Bulgaria and higher price for the rest of the region. Again, the reference simulation showed that a Regional Day Ahead market would provide benefits for the region since in these results the Area price was quite volatile in all of the jurisdictions due to the seasonal and hourly variation in the demand. The current electricity price level in the region is somewhat higher than the expected price level based on the simulation results.

Lastly, the electricity flow results show that Albania, Croatia and FYR of Macedonia would be net importers whereas rest of the jurisdictions would end up net exporters of the electricity. This trend is quite similar to the real life values from 2013. Flow results also reveal some congestion especially in Bulgarian borders. Overall, the simulation results indicate that the benefits of regional a cooperation in the electricity markets could be achieved in the region. Stable prices and change in production patterns indicate better specialization in electricity production. In addition, stable prices across whole one year would provide safe environment for electricity sector investments and further reform.

A natural way of increasing regional cooperation in the SEE area would be to continue electricity sector reforms and establish local power exchanges after which the jurisdictions can apply to join PCR/MRC cooperation and thus couple their electricity markets in respect to the European market model. Investigations how to achieve and roadmap this cooperation development process remain as further research theme.

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