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Competitiveness of Renewable Energy Sources on the Liberalized Electricity Market in South Eastern Europe Countries

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ABSTRACT

Although the prices of fossil fuels are at a historically low levels, geopolitics, dependence on fossil fuels, price volatility and environmental issues are among the main reasons behind the continued push for renewable energy sources (RES). We use the levelized cost of electricity to calculate the economic viability of traditional power plants versus RES. The purpose of this paper is to investigate the prices at which the selected power plants produce electricity and to compare it to the wholesale and subsidized electricity price in selected South Eastern Europe (SEE) countries - Slovenia, Croatia, Serbia and Bosnia and Herzegovina. Based on the obtained results we conclude that the RES in SEE are still costly and deviate from the wholesale electricity prices. If SEE countries want to increase the production from renewables, they should be aware that they still cannot operate on the open market without continuous subsidies.

Keywords: Renewables, Electricity Markets, Competitiveness
JEL Classifications: Q20, Q28, Q30

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1. INTRODUCTION

The European Union's energy policy is unequivocally moving towards renewable energy sources (RES), and same as all the other European countries Croatia, Slovenia, Serbia, and Bosnia and Herzegovina (selected South Eastern Europe [SEE] countries) have also ratified the Kyoto treaty, committing to reductions in greenhouse gases (GHG) emissions. Although almost 30 years ago they were the same country and share a lot of common interests and significant trade, two of the countries (Slovenia and Croatia) are EU member states while Serbia and Bosnia and Herzegovina are candidate countries. The Paris 2015 summit on climate changes has further strengthened the push for renewable energy on the global scale, given that 195 countries agreed to try to limit global warming below 2°C compared to pre-industrial period (OECD, 2016).

The development of new technologies, mass production and increased competition have contributed to massive decrease in the cost of producing electricity from RES. PVs are the best example of this since their costs have halved since 2010 and are expected to decrease by further 60% in the next 10 years. These developments have contributed to RES becoming the sweetheart of the both academic and business community, despite the fall in fossil fuels prices.

The issue of the competitiveness of RES in the open electricity market is one of the main issues in the formulation of national energy policies as well as the energy policy of the European Union. This paper analyzes the competitiveness of different types of power plants with respect to capital requirements, operating and fuel costs, as well as wholesale electricity prices and renewable energy subsidies in the selected SEE countries.

To the best of our knowledge, there is only one paper (Pelin et al., 2015) dealing with profitability of small PV plants in the SEE region. To our knowledge there are not any papers dealing with competitiveness of RES versus traditional power plants in the liberalized European electricity market. Although it is possible that in our literature search we missed a paper/study dealing with the RES competitiveness on the EU level there are no published papers dealing with economic viability and competitiveness of different RESs in the SEE countries.

Levelized cost of electricity (LCOE) method of comparing economic viability of different energy sources has a long tradition in energy economics and has been the subject of numerous studies. The average LCOE figures are annually published by various energy agencies (e.g., International Energy Agency, US Energy Information Administration, etc.,) for a number of different power sources and technologies. The reported figures are predominantly for OECD and important non-OECD countries. Since looking from a global perspective the central, east and southern Europe represents a smaller market the comparison of LCOE for different technologies with the wholesale prices and changing fuel prices has not received a lot of attention from the academic community. In Table 1 we present a selected overview of the literature analyzing the economic viability, in light of the liberalized energy prices, of different power plants using RES or natural gas.

The paper that is the closest to our study is Pelin et al. (2015) as they analyze the profitability of small integrated and non-integrated PV plants in Croatia, Hungary, Slovenia and Serbia, while taking into account different technologies and electricity prices. Their analysis deals with net present value (NPV) and a modified version of LCOE. NPV and modified LCOE of PV plants is highest in Slovenia, due to the highest guaranteed purchasing price of electricity from PV. The least profitable country for non-integrated PVs is Hungary and Serbia for integrated systems.

Southeast Europe is an area that is primarily related to the Balkans. Countries that fall into this area are Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Greece, Kosovo, Macedonia, Moldova, Montenegro, Romania, Serbia, Slovenia and Turkey. Southeast European countries, which are analysed in this paper are Croatia, Slovenia, Serbia, and Bosnia and Herzegovina.

Table 1: Selected papers analyzing the economic viability of power plants in the liberalized energy market

Authors	Published	Sample	Power source	Comment	LCOE
Ouyang, Lin	2014	China	Wind farm (onshore), photovoltaic (PV) power station, biomass power plant	LCOE for RES, comparison with feed-in tariffs	Wind farm, 50-200 MW, 60-80 eur/MWh PV, 10-100 MW, 110-180 eur/MWh Biomass, 24-30 MW, 80-90 eur/MWh
Imran, Kockar	2013	USA EU	-	Comparison of wholesale electricity markets in US and EU	
Mari	2014	USA	Nuclear power plant, fossil power plants (coal, natural gas)	Study on variability of capital costs in power plants, focus on nuclear power plants	Nuclear: 61-77 eur/Mwh Coal: 45-52 eur/Mwh Gas: 47-48 eur/MWh
Ueckerdt, Hirth, Luderer, Edenhofer	2013	-		Development of a new LCOE method taking into account integration and production costs	
Hernandez-Moro, Martinez-Duart	2012	Global	PV and concentrating solar power (CSP) plant	Different scenarios of LCOE for PV in 2010-2050 period	PV (2010: 240-350 eur/Mwh, 2050: 90-140 eur/Mwh) CSP: (2010: 197 eur/Mwh, 2050: 90 eur/Mwh)
Parrado, Girard, Simon, Funtealba	2015	Atacama Desert, Chile	PV, CSP and hybrid solar (PV+CSP)	LCOE for three 50 MW PV power plants, scenario up to 2050	PV 2014 (90 eur/MWh), 2050 (64 eur/MWh) CSP 2014 (113 eur/MWh), 2050 (63 eur/MWh) PV+CSP 2014 (111 eur/MWh), 2050 (63 eur/MWh)
Ragnarsson, Oddsson, Unnthorsson, Hrafnkelsson	2015	Burfell (Island)	Wind farm	LCOE calculation	Wind farm 78 eur/Mwh
Chaves-Avila, Wurzburg, Gomez, Linares	2015	Germany Spain	PV, wind farm, biomass power plant	Installed capacities, Electricity prices and feed-in prices for selected EU countries	
Pelin et al.	2015	Croatia Hungary Serbia Slovenia	PV (0,3 MW)	Profitability of various PV technologies	NPV, modified LCOE Rooftop PV: SLO, CRO, SRB, HU Non-integrated PV: SLO, CRO, SRB, HU

Source: Authors, LCOE: Levelized cost of electricity

RES include solar power, wind power, hydropower, wind power, geothermal energy, wave energy, tidal energy, biomass and biogas. The main characteristic of these forms of energy are "reproducibility within a reasonable time." As many authors state, the energy that lasts for about 10 or 100 years is obviously non-renewable and energy that has the potential of supplying us for thousands of years can be viewed as a renewable source of energy. If renewable energy is defined in this manner than we can also consider nuclear energy as a renewable source since the fuel is abundant and at the same time it does not emit GHG. The case of biomass is also borderline since in the case of over-exploitation it can very easily and quickly become a non-renewable source of energy. In this paper we will not focus on the issue of reasonable renewal time and treat RES as it is predominately used in the literature and aforementioned.

According to the SEE Sustainable Energy Policy report (Sustainable energy: How far has SEE come in the last 5 years, 2016) for Croatia, Serbia, Bosnia and Herzegovina, Albania, Macedonia, Montenegro and Kosovo, as well as the Slovenian data (according to Slovenian Energy Agency), Croatia is a regional leader in electricity production from wind, while Slovenia is the regional leader with respect to solar power. In 2014 Croatia produced 35 GWh (0.27%) of electricity from solar power, and 736 GWh (5.5%) of its electricity from wind. On the other hand, Bosnia and Herzegovina has produced only 1% of its electricity from wind power and solar power. Kosovo and Albania have the least diverse energy mix in the region. Kosovo primarily uses coal (97% of total production), while Albania for its production uses only hydroelectric power plant (100%).

Serbia produces 64.8% of its electricity from coal, while Bosnia and Herzegovina produces 60.5%, which is a significant difference from the EU average for 2014 which is 26.3% of electricity generation from coal (Sustainable energy: How far has SEE come in the last 5 years, 2016) (Table 2).

In Slovenia the production from fossil fuels stood at 3.099 GWh, with 9% being produced from gas and the rest from coal.

Production from the nuclear power plant was 6.060 GWh but since Slovenia and Croatia are equal partners in Krško NPP the half of that production belongs to Croatia (Nuklearna elektrana Krško, 2017).

As far as ecological issues are concerned it seems that the analyzed SEE countries are not making the necessary transition towards renewable electricity generation. Since coal is considered the dirtiest fuel we will mention just the planned and realized coal fired power plants in the region. Slovenia plans to continue with electricity generation from coal since in 2015 it started production from the Šoštanj plant block 6 (installed capacity 600 MW). In Serbia the reliance on coal is even more pronounced with Kostolac plant block C (350 MW) opening in 2019 and Kolubara plant block B (750 MW) planned to open in 2020. Besides these two Serbia is also considering Štavalj plant (350 MW) and Nikola Tesla plant new block (744 MW). In 2016/2017 Bosnia and Herzegovina is starting operation in Zenica plant (252 MW), Stanari plant (300 MW) and Ugljevik plant (600 MW). In the period 2018-2022 it plans to start production from Kakanj plant block 8 (300 MW), Tuzla plant block 7 (450 MW) and Banovići 1 (300 MW). Croatia is the only country that does not plan any new coal fired capacities since it scrapped its plans for Plomin plant block C (500 MW) and plans to close the A block in 2018 (120 MW).

The biggest leaps in the electricity production from PV have been made by Slovenia and from wind power by Croatia, while on the other hand, Bosnia and Herzegovina increased electricity production from coal, compared to 2010. Although it seems that Serbia has decreased its electricity production from coal this is only due to heavy floods that hit Serbia in May-June 2014 and forced coal fired thermal power plants Nikola Tesla and Kostolac A to stop production.

In order to catch up to the developed European countries with regards to energy transition and meet the European requirements for electricity production of electricity from RES, SEE countries needed to attract the investors into building RES power capacities. This was done by offering long term purchase contracts with guaranteed and subsidies electricity prices and prioritized to network access. The access priority is a very important factor for investors since all of the produced energy has to be taken by the transmission system operator, disregarding the day ahead plans delivered by the RES producers. The SEE countries opted for the simplest and most investor friendly approach to subsidizing RES electricity prices, that is feed-in tariffs, guaranteeing a fixed price (corrected for inflation) over the contracted period. The guaranteed prices are paid to the investors for all of the produced energy and the funds for this are collected through fees for renewable energy paid by the ultimate consumers of electricity. This system which is implemented in SEE countries has raised concerns among the policy makers and the general public since it is incorrectly set. The system guarantees a purchase price for a period longer than a decade for the entire production and RES producers have no responsibility regarding the electricity balancing energy. The situation is quite strange since the need for electricity balancing (and the associated costs) are directly tied to RES producers. The whole situation becomes surreal when considering that up till

Table 2: Electricity production by power source, 2014 (GWh)

Countries	Coal		Hydro		Oil/gas		Nuclear		Wind		PV	
	2010	2014	2010	2014	2010	2014	2010	2014	2010	2014	2010	2014
Bosnia and Herzegovina	7.869	8.921	7.946	5.821	0	0	0	0	0	1	0	1
Croatia	2.385	2.368	8.435	9.125	3.113	1.131	0	0	139	730	0	35
Serbia	24.999	22.073	12.571	11.617	533	364	0	0	0	0	0	6
Slovenia	5.290	3.019	4.636	5.923	90	309	5381	6060	0	4.2	13	244.6

Source: SEE Sustainable Energy Policy, 2016 and Agencija za Energijo, 2016 recently all the deviations from the production plans were not penalized by any means.

This setup definitively attracted investors but resulted in significant costs for the state and energy consumers. By introducing the system of feed-in premiums (instead of tariffs) and transferring a part of the cost of electricity balancing to RES producers we are witnessing a significant shift in the precision of production planning and a more market oriented and responsible behavior by RES producers. An additional problem is the current public perception of renewable energy. After the initial enthusiasm with anything bearing a green prefix the public began looking suspiciously at the almost exclusively foreign investors in the RES sector importing all of the production plants' building parts. While it was expected that the more sophisticated parts will not be produced locally but imported the policy makers and the public were shocked that even the simplest things such as concrete blocks, metal structures and wiring were not produced locally. In the end it turned out that local community/companies have not experienced and direct economic benefits from RES projects but they are experiencing increased costs due to RES subsidized prices visible in higher electricity bills. A big part of the blame for such public view and disappointment should be attributed to the politicians, journalists and RES enthusiasts unrealistically promising new employment with higher wages, technological advances along with smart and sustainable reindustrialization. All of this promises which can be realized in big, technologically advanced economies are unrealistic for small, technology importing, deindustrialized countries. Due to the lack of any serious initial economic analysis and public pressure Croatia is thinking about introducing a tax on wind power producers due to perceived excessive profits.

In addition to the cleaner environmental, healthier population and strategic benefits for all of the countries the developed countries have additional financial benefits from renewable energy. It is almost exclusively that the most developed countries that have the technology, the business climate, the financing possibilities and a vibrant production sector needed to advance and to fully reap the benefits of RES power transition. The most developed countries dominate the production segments (both hardware and software) used in RES production, and in such cases paying out high incentives to RES producers cannot be viewed as purely financial obligations or a potential misallocation of scarce financial resources since the countries are actually subsidizing their own production sectors, creating new jobs for their citizens and encouraging technological innovation. By taking this holistic view of subsidizing RES producers which creates a self-reinforcing positive loop the fact that RES are still not completely price competitive is not of crucial importance.

The methodology of calculating the LCOE is used by investors, academic community and policy makers as an additional method (besides the NPV, IRR and MIRR) of comparing the cost-effectiveness of a power plant. LCOE is used to determine the electricity purchase price level at which the electricity production i.e., the power plant is profitable. The biggest criticism of LCOE is that it does not take into account the specific market and technological risks (such as uncertainty of fuel prices) and does not take into account such elements like energy interdependence and the need for backup power (Narbel et al., 2014). Each power plant project starts with capital costs. Capital costs include (EIA, 2013):

1. Direct construction costs, as well as preparatory construction costs - various permits, environmental impact studies etc.
2. Indirect costs such as the administrative costs that cannot be classified as direct costs.
3. Equity investment.

The fixed costs of operations and maintenance are present in every plant, but do not depend significantly on the amount of electricity generated. These costs include the following EIA (2013):

- Contracted personnel expenses
- Expenses connected to preventive and regular maintenance of equipment, including the necessary tools for maintenance
- General and administrative expenses
- Maintenance of the premises.

Variable cost of maintenance is the cost associated with the amount of electricity generated and includes the following categories (dependent on the type of the power plant) (EIA, 2013):

- Consumer water.
- Waste and disposal of waste waters.
- Chemicals, catalysts, gas, ammonia (NH3), etc.
- Lubricants.
- Supplies and inventories.

The cost of fuel is expressed in euros per MMBtu. Fuel costs are often referred to in the literature as the most challenging variable to predict in calculating the LCOE. In this study we take the historical prices of fuels (coal, gas, uranium, biomass) and use the average and extreme historical prices in order to calculate the LCOE of the expected, best and worst case scenarios for the power plants.

In this study we use the following lifetimes of power plants (IEA, 2015):

- Wind and solar power plants: 25 years
- Thermal power plants to natural gas: 30 years
- Biomass power plants: 30 year
- Coal: 40 years
- Nuclear power plants: 60 years
- Hydroelectric power plants: 80 years.

Instead of using the lifetime of the plant LCOE uses the economic life of the plant i.e., the period during which we expect benefits from the investment. The economic life of the selected power plants is:

- Wind and solar power plants: 15 years
- Gas fired thermal power plants: 20 years
- Biomass power plants: 20 years
- Coal fired thermal power plants: 20 years
- Nuclear power plants: 30 years
- Hydroelectric power plants: 40 years.

Regarding the discount rate used in LCOE calculation International Energy Agency (IEA, 2015) proposes the use of the following rates: 3%, 7% and 10%. The 3% rate is the social cost of capital which should be used for evaluating the projects of social importance, such as roads, schools, environmental protection etc. The 7% rate represents the market interest rate and a "normal" required return on investment, while the 10% rate represents the required return on investment in the high-risk market. In this paper we used a discount rate of 5%, which represents an average of "social cost of capital" of 3% and market cost of capital of 7%. The logic behind our approach is that in central, southern and Eastern Europe power plants are treated as a quasi-social projects both by the policy makers and the general public. In our sensitivity analysis we consider the highest and the lowest prices of electricity and fuels, and a 10% decrease/increase in costs, capacity factor and the efficiency of the power plants (heat rate).

2. LEGAL FRAMEWORK OF THE ELECTRICITY MARKETS IN SELECTED EUROPEAN COUNTRIES

The movement of wholesale prices in the countries of SEE and surrounding countries are given in the following Table 3.

The data in the Table 4 shows that the highest average wholesale price of electricity was in Montenegro in the fourth quarter of 2014, while the lowest price was in Albania in the first quarter of 2014.

In countries that are the subject of this paper, namely Croatia, Slovenia, Serbia and Bosnia and Herzegovina, prices ranged as follows.

Although there are no data from ERRA for the Slovenia, the base price of electricity on the Ljubljana stock exchange, according to BSP, in 2014 was 40.43 EUR/MWh, in 2015 it was 41.42 EUR/MWh, while in 2016 it was 35.56 EUR/MWh.

As a benchmark for the calculation of the LCOE, in this paper we used ELIX index (European Electricity Index) on the Eurozone level. Since October 2010, European Energy Exchange (EEX) and EPEX SPOT (European Power Exchange) announced ELIX index that is calculated based on the actual aggregate supply and demand for all EPEX SPOT market. ELIX index represents the market price that would be formed if there were no constraints on the electricity market in the Eurozone. France, Germany, Austria and Switzerland make up 36% of the electricity consumption of Europe and their national electricity prices are already using as reference prices throughout the Europe. ELIX index shows how much these prices are really close to the market price of a fully integrated European electricity market (EPEXSPOT, 2016).

ELIX index combines European electricity market, and is therefore selected as the reference price of electricity for the purposes of this paper.

According to ELIX index (data from Bloomberg), the average price of electricity from the 2010 to the end of 2016, amounts to 38.87 EUR/MWh. If we exclude a 5% extreme high and low values, the highest price was 60.29 EUR/MWh, while the lowest price was 16.06 EUR/MWh.

The Table 5 shows that the average price in the neighboring exchanges of electricity are similar to the average price of electricity from ELIX index.

Selected countries of SEE in this paper are Croatia, Slovenia, Serbia, and Bosnia and Herzegovina. The final cost of electricity to consumers vary considerably, and mostly depends on network cost, as well as VAT and other taxes, which percentage is stated in brackets (Table 6).

In the household sector, for 2016, the cheapest electricity had consumers from Serbia, while the most expensive electricity had consumers from Slovenia (Table 7).

In the industrial sector, for 2016, the cheapest electricity had the consumers from Bosnia and Herzegovina, while the most expensive electricity had consumers from Croatia.

Below are set out more detailed information on the organization of the electricity system for each country.

3. LEGISLATIVE SPECIFICS OF THE SELECTED COUNTRIES OF SEE

3.1. Croatia

Since 2013 Croatian electricity market is organized on the model of bilateral market where the electricity trade is done through bilateral agreements. Bilateral agreements for the sale of electricity are concluded between the supplier and the dealer or producer. Market participants on the electricity market in Croatia are producers, suppliers, traders and eligible

Table 3: Wholesale electricity prices in South East Europe (period 2014-2016)

Countries	Wholesale electricity prices, EUR/MWh									
	2016/2	2016/1	2015/4	2015/3	2015/2	2015/1	2014/4	2014/3	2014/2	2014/1
Albania	26.47	26.47	25.72	25.78	25.6	25.67	18.88	18.93	18.85	18.81
Bosnia and Herzegovina	n.d.	n.d.	59.08	54.38	59.46	60.44	68.33	65.42	63.45	69.08
Croatia	65.39	65.19	63.81	63.81	64.41	n.d.	63.81	63.81	64.19	n.d.
Hungary	n.d.	n.d.	45.77	45.96	47.96	51.82	45.54	46.4	48.71	50.48
Macedonia	51.23	51.23	52.03	51.58	51.77	50.38	50.06	50.06	46.93	51.33
Monte Negro	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	89.3	88.7	88.8	88.5
Serbia	n.d.	n.d.	n.d.	n.d.	40.2	40.56	41.82	41.76	42.41	43.17
Slovakia	n.d.	n.d.	43.89	43.68	44.23	44.57	49.86	48.35	48.85	n.d.
Slovenia	n.d.	n.d.	41.42	n.d.	n.d.	n.d.	40.43	n.d.	n.d.	n.d.

Source: Authors based on data from Energy Regulators Regional Association (ERRA) and BSP exchange producers. Official Gazette (2015) on the Croatian electricity market, producer that produces electricity in its own production facilities, can sell the electricity power to the seller or supplier. Supplier in turn can purchase electricity from the producer, trader or another supplier, and can sell it to the end users. A trader buys electricity from the producer, supplier or another trader, and sells electricity to a supplier or another trader. The end customers conclude a contract for the supply of electricity with a supplier who it prefers.

From the 1st of January 2016, as directed by the European Commission, Croatia began to apply market premium as an incentive to build power plants using RES. Market premium is the incentive or the amount of money the electricity market operator pays to the eligible producer of electricity for net electricity delivered in the power network. In this new model, the producers of electricity from renewable sources needs to find a buyer of that electricity at the market price and conclude contract with them, while HROTE (Croatian energy market operator) pays only premium as the difference from the market price and the average manufacturing cost from the renewables (Official Gazette, 2015).

Market premium (TPi) for each manufacturing facility or production unit in the accounting period is calculated as (Official Gazette, 2015):

$$TPi = RV - Tci \quad (1)$$

RV: Reference value of electricity determined by the market premium contract, expressed in HRK/kWh.

Tci: The reference market price of electricity in the accounting period, expressed in HRK/kWh.

According to the new regulation on RES and cogeneration, incentive purchase prices for production plants connected to the transmission or distribution network using RES for electricity generation vary depending on the type of plant. Contract for the market premium is concluded for a defined time period of 12 years. Amount of maximum reference values of electricity (cost of production) and the amount of the reference market price of electricity is determined by the operator of the electricity market. With the new methodology for the calculation of such parameters is prescribed the method of calculating the maximum reference values and the maximum guaranteed purchase prices, which corresponds to the production costs. Values of the maximum reference prices and the maximum guaranteed purchase prices are published by the operator of the electricity market on an annual basis. HROTE also publishes reference market price of electricity on a monthly basis, based on CROPEX's, HUPX and SIPX (e-Savjetovanja, 2017).

It is worth to mention that to this day the Regulation in which are described in detail modes and conditions for acquiring the status of eligible producer, the amounts of maximum reference values of electricity and amounts of market prices of electricity, has not yet been published. Therefore, in this paper we use classes and amounts of incentive purchase price from 2015.

Table 4: The minimum and maximum electricity prices in selected countries (period 2014-2016)

Countries	EUR/MWh	
	Minimum	Maximum
Bosnia and Herzegovina	54.38	69.08
Croatia	63.81	65.39
Serbia	40.2	43.17
Slovenia	35.56	41.42

Source: Authors based on data from Energy Regulators Regional Association (ERRA) and BSP exchange

Table 5: Average electricity prices on different exchanges in 2016

Electricity exchanges	Base average price (EUR/MWh)	Peak average price (EUR/MWh)
Slovenia (BSP)	35.56	39.79
Austria (EXAA)	29.14	32.26
Germany (EPEX-Phelix)	28.98	34.96
Hungary (HUPX)	35.43	40.30
Italy (GME - Nord)	42.78*	

*Data only for average price. Source: Authors based on data from different exchanges, EPEXSPOT (2017), Gestore Mercati Energetici (2017), Hungarian Power Exchange (2017)

Table 6: Average final price of electricity in medium size households, with network costs, VAT and other taxes included, in Euro/MWh

Households	2010	2011	2012	2013	2014	2015	2016
Croatia (30.8%)	115.1	113.7	120.8	137.2	131.2	131.7	131.1
Slovenia (44.8%)	140.1	144.1	154.2	161	163	158.9	161.8
Serbia (29.5%)	n/a	n/a	n/a	56.4	60.7	57.5	64.1
Bosnia and Herzegovina (17.1%)	74.1	74.5	79.8	80.3	79.1	81.2	83.1

Source: Authors based on Eurostat, 2017

Table 7: Average final price of electricity in the medium size industries, with network costs, non-recoverable taxes and levies included, in Euro/MWh

Industry	2010	2011	2012	2013	2014	2015	2016
Croatia (5.9%)	93.2	90	89.2	94.2	90.3	86.9	85.1
Slovenia (22.2%)	91.7	88.9	87.2	83.8	75.4	71.4	67.8
Serbia (7.6%)	n/a	n/a	n/a	56.8	50.7	59.1	61.6
Bosnia and Herzegovina (0%)	62.2	61.3	64.6	65.3	65.2	62.5	61.2

Source: Authors based on Eurostat, 2017

3.2. Slovenia

Participants in the electricity market of Slovenia are producers, traders and suppliers of electricity. They trade on the basis of closed contracts, in which the quantity and the time frame of delivery of the contracted volume of electricity are contracted in advance, so that prices do not depend on the actual implementation of the contract. Any difference between the contracted and delivered quantity of electricity is settled separately. The participants in the wholesale electricity market make contracts through bilateral transactions or through exchanges of electricity in Slovenia or abroad. In order to balance the system, electricity market enable market participants to perform intra-day trading, and trading based on the day-a-head prices. On the retail market, suppliers and consumers are entering into a contractual relationship in which the quantity and the time profile of delivery are not predetermined. End users pay for electricity on the basis of actual consumption calculated based on the meter in homes (Agencija za Energijo, 2016).

Electricity trade is carried out through the BSP, the regional electricity market. The founders of the BSP are Borzen Company Ltd., Slovenian electricity operator, and Eurex Frankfurt AG. By changing the ownership structure in 2010., Eurex Grankfurt AG is replaced by the company Elektro-Slovenia doo (BSP-SOUTHPOOL, 2016).

3.3. Serbia

Similar to the neighboring countries, Serbia had production, transmission and distribution of electricity in the vertically organized companies that were owned and controlled by the state in all aspects and it was considered to be a natural monopoly.

Electric Power Industry of Serbia (EPS), a company established by the Government of the Republic of Serbia, perform the following activities (Elektroprivreda Srbije, 2015).

1. Production of electricity, as well as heat energy
2. Distribution of electricity
3. Lignite exploitation
4. Telecommunications, etc.

With the aim of liberalization and harmonization of the electricity market, and convergence markets to the regulatory and institutional framework of the European Union, Serbia has implemented significant reforms by adopting several of the Energy Law, starting from 2004. Initially, the main task of the market liberalization has been the separation of vertically structured company. For that reason, from Elektroprivreda was separated Elektromreža, whose main task is the transmission of electricity.

In July 2015 is established the stock exchange of electricity in Serbia and Southeast Europe (SEEPEX), which began to operate on February 17th 2016. SEEPEX exchange of electricity was founded by "Electric Power Industry of Serbia" and the EEX EPEX SPOT, and on the first day the price of electricity reached a value of 23.83 EUR/MWh. Trading volume on the Serbian Exchange on the first day was four times greater than the trading volume on the first day on the exchange in Croatia (CROPEX), when in Zagreb was traded with 476 MWh.

On the December 31st of 2016 the base price (baseload, with low demand) of electricity on SEEPEX was 50.33 €/MWh, while peak price (peak load, with high demand) was 55.29 €/MWh (SEEPEX, 2017).

3.4. Bosnia and Herzegovina

The reform of the electricity sector in Bosnia and Herzegovina was based on the introduction of competition and liberalization in the electricity sector. From 2015 all customers can freely choose electricity supplier, thus achieving greater liberalization and harmonization of the electricity market. The largest volume of cross-border exchange is traditionally done with Croatia which has the largest electricity deficit, and with Montenegro, while it has the lowest exchange with Serbia (Državna Regulatorna Komisija za Električnu Energiju BiH, 2015).

Bosnia and Herzegovina is divided into two entities - the Federation of Bosnia and Herzegovina and the Republika Srpska, and one district called Brcko District of Bosnia and Herzegovina. The incentive prices for RES are divided considering the entities, while the Brčko District, at the time of writing this paper, is still working on the adoption of the law on the promotion of electricity produced from renewable sources (Službeni Glasnik Brčko Distrikta BiH, Zakon o Električnoj Energiji, 2015).

Below are given amounts of all feed-in tariffs for selected countries and power plants from RES (Table 8).

Size of power plants on RES that are the subject of this paper are shaded with grey color. The data indicate that, depending on the sizes of selected power plants that generate electricity from RES, wind power plants in size from 50 MW encourage all countries except the Republika Srpska. The solar power plant in size of 20 MW, on the other hand, does not encourage any country. Serbia promotes solar power plants in the country with installed capacity up to a maximum of 6 MW, with feed-in tariffs that significantly stands out in comparison to neighboring countries. Hydro power plants of 20 MW stimulate all countries except Slovenia and the Republika Srpska. Biomass power plants with the size of 200kW stimulate all countries. Given the incentive price, it is clear that the main objective of the countries in the region is to stimulate small power plants using RES.

4. THE ECONOMIC VIABILITY OF POWER PLANTS ON RENEWABLE AND CONVENTIONAL SOURCES IN MARKET CONDITIONS FOR SELECTED COUNTRIES OF SEE

LCOE are mostly dependent on the capital construction cost, the price of fuel, and the capacity factor that shows us the efficiency, i.e., working hours a year (Table 9).

The largest initial capital cost per kW has a biomass power plants, while the lowest capital cost has gas power plants. Except for solar, wind and hydro power plants that all have no fuel costs, on average the most expensive fuel, expressed in euro/MMBtu,

Table 8: Incentive (feed-in) the purchase price of electricity from renewable sources for selected countries, in Euro/MWh

Types of renewable power plants	Croatia	Slovenia	Serbia	Bosnia and Herzegovina	
				Federation of BIH	Republika Srpska
Wind power plant					
2-23 kW				189.7	
23-150 kW				113.1	
150 kW-1 MW				96.7	
1-10 MW				81.9	
Up to 10 MW					84.5
10-230 MW				75.4	
up to 300 MW	70	95.38	92		
Solar power plant					
Up to 10 kW	249				
2-23 kW				316	
10-30 kW	221				
23-150 kW				241.9	
30-300 kW	200				
above 300 kW	70				
150 kW-1 MW				201	
Roof systems					
Up to 30 kW			206.6		
Up to 50 kW		94.27			173.7
50-250 kW					150.6
30-500 kW			209.41		
250 kW-1 MW					120.5
up to 1 MW		86.2			
Ground systems					
Up to 50 kW		88.57			
Up to 250 kW					139.8
250 kW-1 MW					111.1
Up to 1 MW		81.59			
Up to 6 MW			162.5		
Hydropower plant					
2-23 kW				148.4	
Up to 50 kW		105.47			
23-150 kW				93	
Up to 200 kW			124		
Up to 300 kW	139				
200-500 kW			137.27		
50 kW-1 MW		92.61			
150 kW-1 MW				70.3	
500 kW-1 MW			104.1		
Up to 1 MW					87.7
300 kW-2 MW	121				
2-5 MW	114				
1-5 MW		82.34			67.8
Above 5 MW	70				
5-10 MW					63.6
1-10 MW			107.47	63.2	
Above 10 MW				54.04	
10-30 MW			73.8		
Biomass fired power plant					
2-23 kW				159.9	
Up to 50 kW		Seperately			
23-150 kW				127.7	
Up to 300 kW	203				
150 kW-1 MW				123	
50 kW-1 MW		224.35	132.6		215.3
300 kW-2 MW	195				
2-5 MW	187				
1-5 MW		167.43			
Above 5 MW	70				
1-10 MW			138.2	116	115.5
Above 10 MW			82.2		

Source: Authors based on RES LEGAL Europe

has a biomass power plants, while the cheapest has a nuclear power plant. Fuel was especially hard to calculate and to make it comparable, considering the prices are denominated in different values. In order to make it comparable, different conversion factors had to be applied. Capacity factor is the best in nuclear power plants, while this indicator is the worst for solar power plants.

The capital cost for wind and solar power plants is lower than for other power plants (except coal power plants), and if it is known that they have no fuel costs, it might be expected that the LCOE for these two types of power plants is among the lowest. However, very low capacity factor makes these plants uncompetitive on the open market, given that wind power plant works only when there is wind, and solar power plant only when there is sun. Such property makes it extremely unreliable in the planning of electricity production and market alignment (Table 10).

Due to the high cost of CO2, coal and gas power plants have higher levelised cost of electricity than the wholesale price of electricity on the SEE an market. From power plants on non- RES, only nuclear power plant can produce electricity in the range of wholesale electricity price on the SEE market.

Power plants on renewable sources have even more pronounced difference between LCOE and wholesale market price of electricity. For this reason, many countries have introduced feed-in tariffs or other forms of incentives to build power plants on non- RES, thereby further reducing the cost of electricity and introducing an imbalance in the electricity market (Table 11).

From power plants on renewable sources, closest LCOE to the market price of electricity has hydropower, followed by wind power and solar power, and at least competitive is biomass-fired power plant. The Table 11 presents selected power plants on RES

Table 9: Capital cost, fuel cost and capacity factor for analyzed power plants

Types of power plants	Capital cost (€/kW)	Fuel cost (€/MMBtu)	Capacity factor (%)
Coal power plant (500 MW)	2355	2.69	79.9
Gas power plant (450 MW)	942	6.43	87
Nuclear power plant (1500 MW)	4894	0.19	90
Hydropower plant (20 MW)	4398	-	46.8
Wind power plant (50 MW)	1476	-	29
Solar power plant (20 MW)	1262	-	14.6
Biomass-fired power plant (200 kW)	6146	7.64	86

Source: Authors

Table 10: LCOE of power plants on non- RES with associated wholesale electricity prices in selected countries, as last available price from ERRA (EUR/MWh)

Types of non-renewable power plants	Croatia		Slovenia		Serbia		Bosnia and Herzegovina			
							Federation of BiH		Republika Srpska	
	Wholes market	LCOE	Wholes market	LCOE	Wholes market	LCOE	Wholes market	LCOE	Wholes market	LCOE
Coal power plant 500 MW	65.39	80.2	41.42	80.2	40.2	80.2	59.08	80.2	59.08	80.2
Gas power plant 450 MW	65.39	64.8	41.42	64.8	40.2	64.8	59.08	64.8	59.08	64.8
Nuclear power plant 1500 MW	65.39	54.7	41.42	54.7	40.2	54.7	59.08	54.7	59.08	54.7

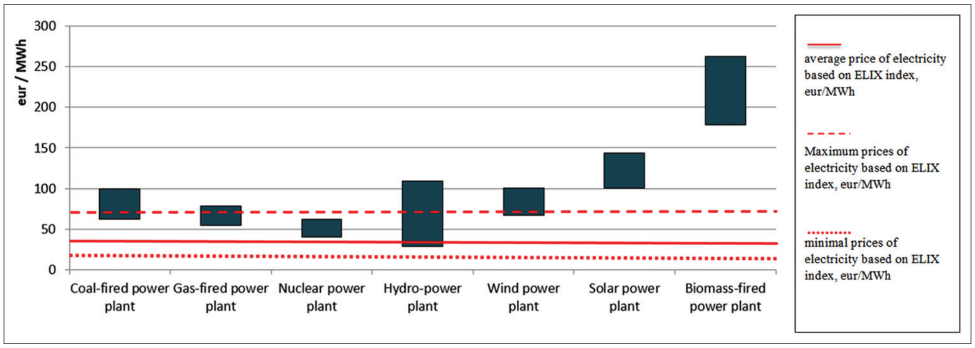
Source: Authors, LCOE: Levelized cost of electricity

Table 11: LCOE of power plants on RES with the associated wholesale prices of electricity, as well as feed-in tariffs in selected countries (EUR/MWh) in eur/MWh

Types of renewable power plants	Croatia			Slovenia			Serbia			Bosnia and Herzegovina					
										Federation of BiH			Republika Srpska		
	Wholes market	Feed-in	LCOE	Wholes market	Feed-in	LCOE	Wholes market	Feed-in	LCOE	Wholes market	Feed-in	LCOE	Wholes market	Feed-in	LCOE
Wind power plant 50 MW	65.39	70	83.18	41.42	95.38	83.18	40.2	92	83.18	59.08	75.4	83.18	59.08	-	83.18
Solar power plant 20 MW	65.39	-	120.46	41.42	-	120.46	40.2	-	120.46	59.08	-	120.46	59.08	-	120.46
Hydro-power plant 20 MW	65.39	70	67.29	41.42	-	67.29	40.2	73.8	67.29	59.08	54.04	67.29	59.08	-	67.29
Biomass-fired power plant 200 kW	65.39	203	217.13	41.42	224.35	217.13	40.2	132.6	217.13	59.08	123	217.13	59.08	215.3	217.13

Source: Authors, LCOE: Levelized cost of electricity

Graph 1: The maximum and minimum levelized cost of electricity for selected power plants in Europe, with market price of electricity on the basis of ELIX index



with the wholesale market prices of electricity and feed-in tariffs for selected countries.

With light green color are marked the most competitive countries with respect to the feed-in tariffs in SEE by each power plant. Wind farm power plant of 50 MW is most profitable to build in Slovenia, which gives an incentive of 95.38 euro/MWh. Big solar power plant of 20 MW has no state incentives, but given the wholesale price of electricity, which is the highest in Croatia, Croatia is a country in which can be expected to invest in a solar power plant of these dimensions. Hydro power plant of 20 MW is most profitable to build in Serbia, as well as the biomass-fired power plant with size of 200 kW.

While wind power plants, hydro-power plants and a small biomass-fired power plants are cost-effective with the state incentives, it is not profitable to build large solar power plant in any country of SEE, since their LCOE is higher than the market wholesale electricity price. As mentioned earlier, SEE countries are encouraging the construction of only small power plants using RES.

Below are given ranges of LCOE for all types of power plants with a price trends in the European electricity market based on ELIX index.

Blue Bar Graph 1 show the ranges of LCOE for each type of plant, based on capital costs, operation and maintenance costs, fuel costs, and the efficiency of power plants. The red lines represent the range of the wholesale price of electricity on the market in the Eurozone, obtained based on historical movements of ELIX index.

5. CONCLUSION

In this paper we analyze the market wholesale prices, incentive purchase price of electricity and levelised cost of electricity for various types of power plants. The necessary variables for calculating the levelised cost of electricity are obtained by empirical method, based on the existing power plants in Europe.

Energy planning is far more than a mere calculation of profitability. Some plants that are less profitable are essential for the energy system of a country due to energy stability. Since consumption varies both through the day and through the years, it is necessary to always have some kind of power that is less profitable, but so provides security of supply.

Various approaches are used when calculating the cost and profitability of power plants. The most famous among them are the NPV, real options, and levelised cost of electricity. As a preferred method for this type of analysis we used the levelised cost of electricity, or LCOE, which takes into account capital costs, operating costs and maintenance, capacity factor (as working hours per year), discount rate, life span of power plants, and fuel costs, which is usually the most difficult definable element in the formula. Through historical fuel prices, and the available data on the costs of power plants, we calculated LCOE for the best, worst and most likely scenario.

Wholesale electricity prices are also calculated based on historical data, both for Europe and for selected countries.

Taking all this into account, the power plants on RES are non-competitive with today's market price of electricity. Countries in South-East Europe mostly subsidize small power plants using RES.

Power plants on non- RES are competitive in the market, but much depends on the price of CO_2 certificates, which, for example, makes coal fired power plant at least competitive. Although the most expensive in the beginning, nuclear power plant proved to be the most stable and the most competitive power on non- RES. Hydro-power plant is the only power plant on RES that can be considered a competitive on open market, but due to the high dependence on water resources and the differences in capital costs, the best and worst case scenario varies significantly.

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