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A comparative analysis of Renewable Energy Potentials and Policies in Denmark and Serbia: What can Serbia learn from Denmark?

Danica ANTONIJEVIC

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Danica ANTONIJEVIC

CENTRAL EUROPEAN UNIVERSITY

ABSTRACT OF THESIS submitted by:

Danica ANTONIJEVIC

for the degree of Master of Science and entitled: *A comparative analysis of Renewable Energy Potentials and Policies in Denmark and Serbia: What can Serbia learn from Denmark?*

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Towards reaching low carbon emission goals, European Union (EU) policy makers had focus on renewable energy production and have established targets for the replacement of fossils (Lund, 2008). Energy transition in Denmark presents one of the most noteworthy and well-known examples of effective change from usage of imported fossils to highly growing share of different forms of renewable energy (Mey and Diesendorf 2017). According to International Energy Agency data, Denmark presents one of the world leaders in the renewable energy consumption and aims to be a low carbon society independent of fossil fuels by 2050, and dependent on renewables for more than a half of total energy consumption by 2030. Yet, in Serbia, exploitation of RES for energy production is far under their potentials (Golusin et al, 2010). Having in mind that Serbia has adopted Kyoto protocol and became a part of Energy Community, development of renewable energy sector has become obligatory activity (Golusin et al, 2010). Substantial renewable energy resources that Serbia obtains (Golusin et al, 2010) are making this analysis easily justifiable for identification of challenges and opportunities for implementing the Danish model in Serbian energy sector which faces many barriers to its growth. Focusing on national energy transitions to data collected via a literature review and interviews conducted in Serbia, this thesis is striving to identify important solutions in the field of renewable energy from Danish experience and give specific proposal and suggestions for further development of Serbia in this field.

Key words: comparative analysis, renewable energy potentials, solutions, renewable energy policy, Denmark, Serbia

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List of Abbreviations

DEA	Danish Energy Agency
CPS	Central Power Station
GDP	gross domestic product
GDP PPP	gross domestic product based on purchasing power parity
GFEC	Gross final energy consumption
GHG	Greenhouse gases
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power
HPP	Hydro power plant
EE	Energy efficiency
EU	European Union
EnC	Energy Community
EC	European Community
FiT	Feed in Tariff
IPA	Instrument for Pre-Accession Assistance of the European Union
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ktoe	Kilotonne of oil equivalent
NREAP	National Renewable Energy Action Plan
OPEC	Organization of the Petroleum Exporting Countries
RE	Renewable energy
RES	Renewable energy sources
PPA	Model power purchase agreement
RE	Renewable energy
SEEA	Serbian Energy Efficiency Agency
SHPP	Small hydropower plants
TPES	Total Primary Energy Supply

UNDESA	United Nations Department of Economic and Social Affairs
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

1.1 Background

Countries all over the world are striving for reduction of fossil fuel dependency for sake of reducing environmental damage to the Planet we live on. Combustion of fossil is main cause of greenhouse gases emission which is further leading to many other environmental issues such as global warming and ozone depilation followed by natural disasters (Jovanović *et al.* 2014). However, with the worldwide growth of population, energy demand is rising, while 1.3 billion of people still don't have approach to conventional energy (Zafir and Keivanfar 2017). Luckily, factors such as oil price increase, scarcity of fossils and environmental issues are obliging legislators of both developed and developing countries to predominantly focus on switch over renewable energy sources (Cuellar-Bermudez *et al.* 2015). Current availability of fossil resources is not sustainable over the long-term (Smil 2000). Yet, one of the greatest professional in the energy field, Smil (2000), states that the reason for their depletion in future will not be physical but rather finally unsatisfactory costs. However, combustion of fossils is proved to be world biggest emitter of greenhouse gases (Smil 2000) which is leading to drastically environmental issues as one of the most popular topics nowadays globally. After big energy crises in 1970s and raising awareness of the Climate Change reality in the last decade of 20th century, worldwide eagerness for environmental protection was uprising and focus of many policy makers was concentrated towards renewable energy development (Fischer and Preonas 2010). Intergovernmental Panel on Climate Change (IPCC) record from 2007 states that, in order to mitigate Climate Change effect, key target must be decline of fossil fuels dependency (Fischer and Preonas 2010). For that to be accomplished, energy transition from fossils to higher utilization of renewable energy sources is crucial step forward. According to International Energy Agency definition, renewable energy is the one obtained from "*solar, wind, biofuels, geothermal, hydropower and ocean resources, and biofuels and hydrogen derived from renewable resources"* (IEA 2010). These energy sources are, to a lesser or greater extent, available all over the world. Thoroughly achievement of Paris Agreement target will be possible only through successful policy and planning measure for development of renewable energy sector (IRENA *et al.* 2018). This thesis will explain difference in terms of policies and utilization in renewable energy sector of two analyzed countries, Denmark and Serbia. Denmark is given as an example of the country with high degree of utilization of their renewable sources. On the other hand, Serbia, although rich in resources, is facing many barriers for increase of energy production from renewable energy sources. Additionally,

through literature review and interviews, advantages of RES utilization and policies in Denmark will be recognized and some ideas for renewable energy progress in Serbia will be proposed.

1.1.1 Denmark

The Kingdom of Denmark is presented with three main territories: Denmark, Greenland and the Faroe Islands (Danish Minister for Energy, Utilities and Climate 2017). Population of the whole country in 2016 was 5.7 million (World Bank 2018a). Denmark covers 43,000 km2 of surface area from which 61% is utilized for agriculture, 13 % covered by forests while remaining area presents cities and natural zones (Danish Minister for Energy, Utilities and Climate 2017)**.** Denmark became a part of NATO in 1949 and European Union in 1973, respectively (Ogden 2017) while has ratified UNFCC in 1993 and the Kyoto protocol in 2002 (Danish Ministry of Energy, Utilities and Climate 2017).

Starting from the oil crises back in 1970s, Danish energy policies were focused towards development of renewable energy sector which have helped country to sustain same primary fuel consumption for over three decades, although the GDP has increased for 70 percent (Lund 2007). During this period, almost 15 % of fossils consumption was switched to renewables (Lund 2007). Danish Energy Agency oversaw research for RES potentials as a part of "Energy 21" plan back in 1996 (Lund, 2007) which helped Danish policymakers to target specific resources which accelerate RES usage. This high development of energy sector is proven by the fact that 30 years after the oil crises, when energy supply was 90 percent depended on oil, almost half of the electricity is produced from renewable sources (Lund 2007).

Government of Denmark in 2005 set a goal of phasing out fossil fuels by 2050 and be (Jørgensen *et al.* 2017). From the beginning of 1990s, growth of Danish economy has been significant (Sands 2013). From that period till now, own energy production of the country has been doubled (Sands 2013). Nowadays, Denmark present self-sustainable country, totally independent on other countries imports and even exporter of electricity and fuels (Sovacool and Tambo 2016). This is due to availability and utilization of their oil and gas reserves in North Sea, mixed with the general increase in renewable energy investments and policy measures, especially in wind sector (Sands 2014). Although every energy transition takes sometimes even decades (Smil 2010), this above mentioned fast development of renewable energy sector, gives hope that aspiring goal 2050 is most likely to be achievable. Affirmation of the fast transition to clean energy is the fact that in 1990 for every kWh of produced electricity amount of 1 kilogram of CO2 was release in the atmosphere while 20 years later the amount drastically declined to only 200 grams (Sovacool and Tambo 2016).

For this reason, Denmark is used for comparison as one great example of county which is focusing its effort of both policy makers and engineers to achieve highest possible turn to clean energy sources provided by nature.

1.1.2 Republic of Serbia

The Republic of Serbia is a country located on the Balkan Peninsula in Southeaster Europe. According to the World Bank data from 2016, population of the country is 7.06 million which makes Serbia highest populated ex Yugoslavian country. Serbia borders Hungary on her north, Romania and Bulgaria to the east, Macedonia to the south, Croatia, Bosnia and Herzegovina, Montenegro to the west and contend a border with Albania through the controvert territory of Kosovo. In 2016 GDP per capita was 5.348 USD (World Bank 2018b). The economy development of the country is hardly comparable with Danish economic situation. Serbia has suffered strongly from UN sanctions back in 1990s and material damage after NATO bombing in 1999. This has left huge consequences on both social and economic situation and lead to long stagnation of the country.

Serbia has ratified United Nations Framework on Climate Change (UNFCCC) in 2001 (Ivezić *et al.* 2013) and the Kyoto protocol in 2007 (Tešić *et al.* 2011). Stated in the Intended Nationally Determined Contribution (INDC) of the Republic of Serbia, national target of GHG emission reduction is 9.8% by 2030 using 1990 as a base year. There is a controversy about Serbia, as well as other Balkan countries, for using 1990 as a base year for GHG reduction goals. The reason is that back in 90s, due to the war crises and decrease in industry production, GHG emission were not representative. That period for Serbia (Yugoslavia at that time) was not reliable enough as a true worth of emissions due to the low industry development because of tough political situation of the country and the region. Serbia obtained European Union (EU) candidate status since March 2012. Serbia, as all the neighboring countries on Balkan peninsula, has valuable RES potentials which in order to achieve EU membership need to be under much higher exploitation in coming years (Karakosta *et al.* 2012).Nevertheless, the importance of general need for the higher utilization of renewable energy sources is the fact that in 2015 79.4% of total GHG emission was from energy sector in Serbia (Ministry of Mining and Energy of Serbia 2016). This high share of the sector in GHG emission is explainable by combustion of low quality lignite and use of old technology.

GDP of the country scientifically decreased in the 90s due to the political situation, however, since the beginning of 2000s, noteworthy growth has been noticed (Karakosta *et al.* 2012). Serbia's energy

production and carbon intensity per GDP is far from the average of developed countries in Europe (Karakosta *et al.* 2012). However, Serbia is a country with high future prospective for economy growth due to its richness in resources, arable land and other natural resources (Karakosta *et al.* 2012). To achieve higher energy efficiency and utilization of renewables, unsuitable policies in Serbia should be changed. For this reason, thesis is dedicated to investigation of how the Serbian energy sector can overcome barriers to its growth and what can be implemented from well-developed based on insights from the Danish case study.

1.2 Research Questions and Aims

The main question this research will attempt to answer is:

How can Serbia strive to achieve current development of Danish policies and renewable energy utilization with the capacity and resources they obtain?

For sake of comprehensible explanation, research question was disunited in three parts:

1) Comparative Analysis of RE potentials in Denmark and Serbia

2) Comparative Analysis of RE related Policies in Denmark and Serbia;

3) Based on the research about main drivers and policies that brought Denmark to current development of energy sector, which steps can be taken in Serbia for overcoming barriers and better utilization of RES?

After concentrating on review of comparative analysis of Danish and Serbian potentials and policies, possible recommendations will be provided for Serbia's renewable energy capacity utilization based on previous findings. Those findings may help overcoming poor utilizations or renewable energy sources in Serbia and show what is the main obstacle in implementation of the policies.

1.3 Organisational Structure

First Chapter of the thesis is giving short background of examined countries and the main aims and objectives of the research that is further described during the writing of chosen topic. In the next chapter, Chapter 2, a review of the literature delineates both Danish and Serbian energy transition, renewable energy potential and summarize main targets and policies of the countries in energy sector. Chapter number 3 holds methodology part which describes method used for data collection through literature review and interviews with stakeholders and further discuss content analysis as the second part of the section. In the 4th Chapter results of the intereviews of different stakeholders in Serbia are

described. In the Chapter number five is starting with comparative analysis of both potentials and policies of Denmark and Serbia. Ddiscussion is further outlined by answering research questions, giving a policy recommendation for the Republic of Serbia based on the finding during the literature review and interviews. Finally, suggestions for future researchers interested in this field is given. In the last Chapter, conclusion is provided through short summary of outcome of thesis findings.

2 Literature Review

2.1 Introduction

This part of the thesis consists of the general overview of renewable energy sector and policies of two comparing countries. Using existing academic articles and official articles from the Governments, different institutions and International organizations, is given the idea of the two countries renewable energy potential and legal framework as well as insight in energy share and richness of the country in terms of renewable energy potential. The literature of the mentioned topics for Denmark is robust with many written documents on the European Union (EU) level as well as records made by different Danish energy agencies and academic articles. Due to the high development of Danish renewable energy utilization and policies there was enough data to do the overall review of the country profile. Nevertheless, the Serbian renewable consumption is on the emerging path and since Serbia is on the way to become EU member state in the future, many new written documents are appearing in the past years. Therefore, literature review provided valuable data and analysis in the field of both Danish and Serbian Renewable Energy capacities and policies. Intention of this chapter is to provide foundation for the comparison of two countries capacities and policies as well as suggestion of implementations of Danish ideas and policies in Serbia.

2.2 Global Energy Transition

Even Thomas Malthus, far back in 1798, in his "Essay on the Principle of Population" (Malthus 1960) recognized the high interdependence of the population and environment. Malthus claimed that exponential growth of the population leads to higher exploitation of natural resources and degradation of environment on many levels (Cropper and Griffiths 1994). Charles Darwin was inspired by Malthus's book which he read in 1838, before his 40,000 mile long Beagle trip around the world (Young 1969). Thanks to the Malthus description of high growth of the human's population and overall limited natural resources of the planet Earth, Darwin managed to get to the idea of the limitation factor, something that will maintain "stronger ones" in the population. That's what inspired him to create notion called *natural selection* as principal evolutionary mechanism (Young 1969) that later became the main concept of his Evolutionary Theory.

From agricultural and technological aspect each human has a negative impact on the environment as a consumer of both renewable and nonrenewable sources on the world (Ehrlich and Holdren 1971). The relationship between energy and population is tight. Giving example, during the period from 1940 to

1969 population of the world have increased 53% followed by the growth of energy use for 38 percent (Ehrlich and Holdren 1971). Ehrlich and Holdren in their paper about Impact of Population Growth are outlining the formula describing that population growth is directly equal to energy and resource consumption per capita and directly related with per capita impact on environment. The total world population in 2015 was 7.3 billion while expectations for 2030, 2050 and 2100 are 8.5, 9.7 and 11.2 billion respectively (UNDESA 2015). Therefore, there is a legitimate reason to be worried for the fact that world's population is emerging and energy demand consequently and rapidly increasing.

A country that is going through energy transition needs to go through all existing phases created as inspiration to Elinor Ostrom's framework: techno-economic, socio-technical and political perspectives (Cherp *et al.* 2018). These three perspectives co-evolve between each other but can also develop autonomously (Cherp *et al.* 2018). However, every energy transition is happening with large time scale. Going from one dominant fuel to other usually takes from 50 to 60 years (Smil 2014) wood to coal, caol to oil, coal and oil to natural gas and finally transition to renewable is not happening any faster (Smile, 2014). For instance, changes can be faster in some countries due to the significant technology development or remarkable policy changes. Yet, time when renewable energy will become dominant source of energy globally is expected to be far since the demand for energy worldwide is ascending (Smil 2014) and currently renewable energy technology doesn't have potential to prevail in many countries. However, numerous developed countries nowadays are on the good way to achieve high share of renewable energy sources in total energy production. Country that is flowing path to phase out fossil fuels by 2050 and rely over 50 percent on renewables for their energy needs by 2030 (Greenpeace 2014), Denmark, is taken for this comparison as a great example of fast energy transition and highly developed energy policies. On the other hand, Serbia is used as an example of the country which is on the very beginning of the long way to achieve significant renewable energy utilization.

The usage of renewable energy sources (RES) is becoming unavoidable due to the scarcity of fossil fuels reserves that will not manage to maintain the demand of above mentioned growing population for many reasons. It is estimated that coal reserves will be obtainable till 2112 while both oil and gas are expected to be gone by 2042 approximately (Singh and Singh 2014). Besides the lack of the long-term possibilities for utilization of fossils, nowadays more countries worldwide are targeting Climate Change goals and reduction of GHG which is only doable if the switch towards renewable energy sources starts increasing and dependence on fossil fuels drastically drops. To achieve Paris Agreement goal of keeping temperature grow well below 2 degrees Celsius comparing to pre industrial time, renewable energy

utilization needs to be more than 6 times faster (IRENA 2018). Given the above, discussion about this crucial topic of RES is on demand and politician worldwide need to undertake drastic measures so we can leave the Planet livable for the coming generations.

2.3 Denmark

2.3.1 Energy transition in Denmark

Production of energy from obtainable sources on Earth became a popular and important topic in previous years. Some of the countries are on the very beginning with their utilization while some of them are already for decades focusing their strategies and policies towards a greater consumption of renewable energy. One of them is Denmark whose story started over 40 years ago when roots of transition started after the oil crises.

Going back to the history, in the 1950s world oil industry (without USSR and USA) was controlled by the group of big oil companies well-known as “Seven Sisters” totally controlling market and prices (Chalabi 1997). The emergence of free market and development of new, independent companies, especially in US and Western Europe, was big threat to dominancy of Seven Sisters. To prevent further cut in the oil prices and bring stabilization of oil industry, in 1960 Organization of Petroleum Exporting Countries (OPEC) was founded in Baghdad (Chalabi 1997). OPEC diverse group with countries from different part of Middle East, Africa, and South America (Algeria, Angola, Ecuador, Gabon, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela) (Ogden 2017). Over 80% of total crude oil reserves in the world are under control of OPEC power. However, well-known oil crisis was the result of U.S. support for Israel in the Yom Kippur War when many member countries from OPEC decided to put embargo on U.S. and all the countries supporters of Israel (Denmark was one of them) (Chalabi 1997). At that time Denmark was dependent over 80 percent of mainly imported oil (Sovacool 2013). To overcome disagreeable situation, rescue plan for building nuclear power plant was proposed by electricity companies in Denmark (Greenpeace, 2014). In the end of 70s already, many anti-nuclear citizens demonstrate against this idea while in the mid of 80s, thanks to many scientists, citizens movements and other influencing people, nuclear power was deleted from energy plan and Government focused on providing subsidies of 30% for investments to wind turbines (Greenpeace 2014). Thanks to this kind of support from government through subsidies, energy efficiency and renewable usage were increasing without bad affect on economy of the country. After the oil crisis, Danish focal points were, as mentioned, avoiding nuclear building and increasing amount of usage of renewable energy which was highly supported by Danish Government. Thanks to the finding of large

sources of natural gas in Slochteren in north, Denmark used it for producing 80% of electricity after the crises and nowadays 60 precent of produced gas is exported in other countries (Kooij *et al.* 2018). Therefore, stated by IEA data, fossil fuels have started decreasing in that time, mostly coal which was replaced by RE in heat and electricity generation (IEA 2017). In the same period, wind energy has increased two fold while biofuels and waste increase grew for over 50% in total primary energy supply (TPES) (IEA 2017). This fast reaction of policy makers after the oil crises helped to overcome almost 10 percent of both unemployment and inflation as a result of oil crisis (Kooij *et al.* 2018).

In the Figure 1. we can clearly see those changes. Figure is showing Denmark's total primary energy supply right after the oil crises till 2015. To avoid the crises and dependency on the oil, Denmark started with energy production from their own reserves of natural gas as well as higher utilization of renewable energy sources. This is obvious on the Figure below where brown color shows significant increase in natural gas utilization. Besides that, light green and blue colors are showing growth of renewable usage from biofuel & waste and wind.

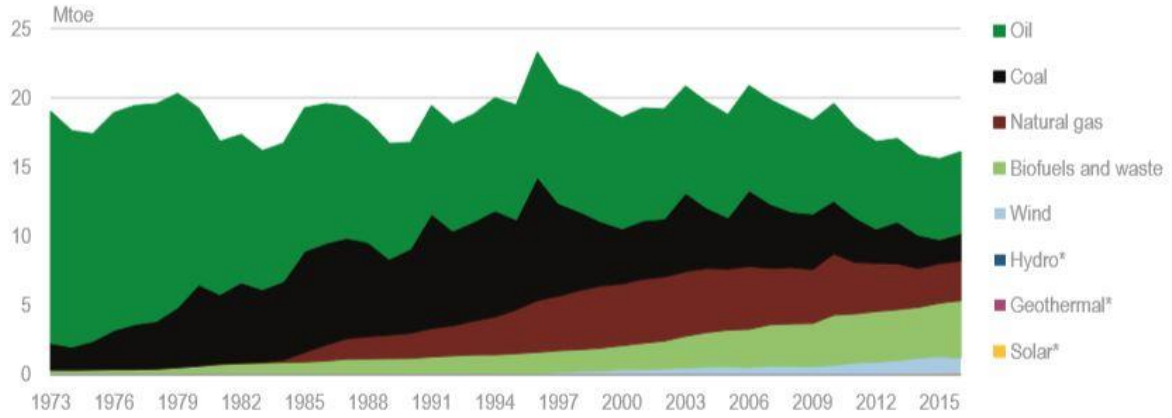

Figure 1. Denmark's total primary energy supply in Denmark (1973-2015), Source: IEA 2017.

The second Figure is showing total energy production of the country from 1973 till 2015, where is noticed that coal is not in the share of domestic production. Therefore, after the oil crises when Denmark was heavily depended on import, domestic utilization of oil and natural gas was needed for overcoming energy sources shortage in electricity production that country was facing. Thanks to the high reserves that country has on the northern parts, Denmark managed to overcome first effects of the crises without investments in nuclear power plant. To clarify, besides domestic natural gas and oil usage, in both Figure 1 and Figure 2 can be noticed that ascending curve of wind and biofuels & waste utilization started to grow in 70s which was caused by great choices of government and policy makers to turn their focus towards available energy sources on Earth. Comparing those two figures (Figure 1. and

Figure 2.) we can see that on the first graph oil curve is declining over time while on the second graph related to Danish domestic production, oil curve is increasing. That is for the above-mentioned reason of beginning of utilization of domestic oil after the crises and decreasing reliance on import.

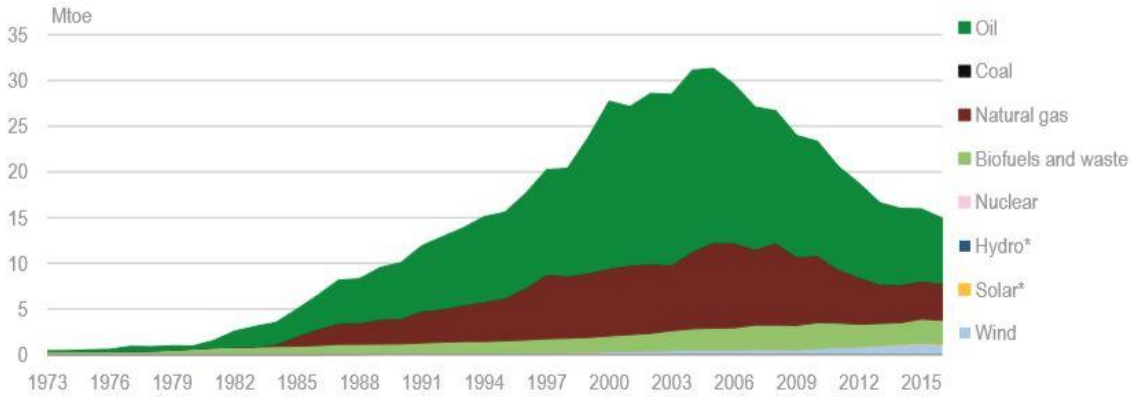

Figure 2. Total energy production by Source in Denmark (1973-2016), Source: IEA 2017.

True proof of development and Danish transition towards renewable energy sources is shown in comparison of two maps below, one from 1990 and second from 2014. As mentioned before, Government of Denmark focused on domestic fossil utilization while on the other hand they concentrated towards renewable sources usage mainly in the wind power generation and to some extent solar energy. Besides installation of wind turbines and solar panels, local combined heat and power (CHP) installations using natural gas, biomass and waste started widely spreading as it can be seen on the maps (IEA 2017). As shown on the left map in 1990 in Denmark existed 15 Central Power Station (CPS) which increased to number of 20 till 2014 (IEA 2017). In regards of new RE constructions it is visible on the right map that many changes appeared in this time frame. New built capacities were 5,175 Wind Turbines, 670 Local CHPs, 90,000 Solar PV (IEA 2017).

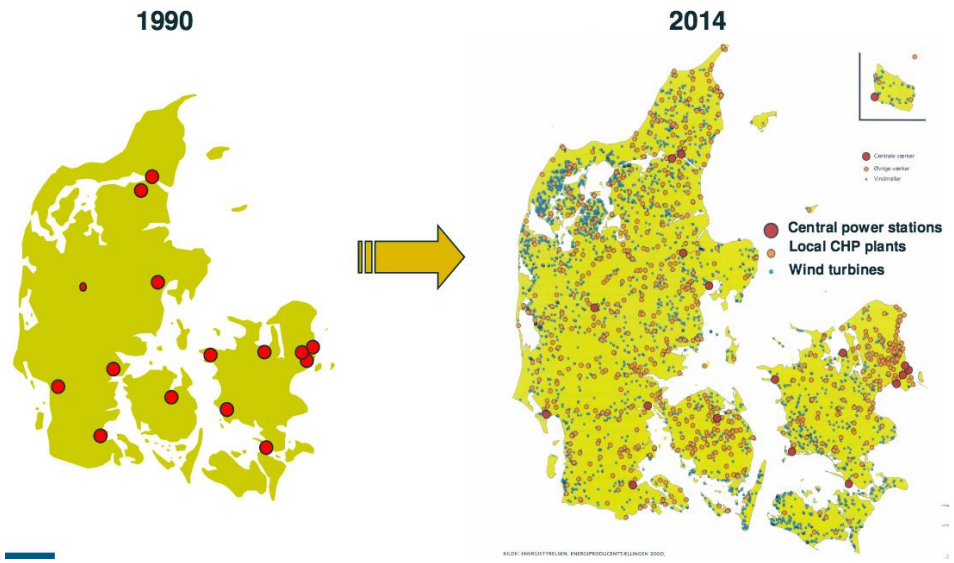

Figure 3. The transition from central planning to distributed generation; Source: (Energinet.dk, 2015)

The goal of total phase out of fossils comply with an “Energy Strategy 2050” of Denmark which has several key points: RES in transportation sector, further development of both off shore and near shore wind facilities, energy efficiency and further investments in research (Sovacool and Tambo 2016). Although rich with oil reserves, yearly decrease of reserves is almost 7 percent and therefore, 2050 plan, which would also make Denmark zero CO2 emitor will be needed for total phase out of fossil fuels (Sovacool and Tambo 2016). Baseline year for Danish CO2 emission reduction is 1988 (Odgaard 2000). Renewable energy is the key solution for CO2 reduction, regarding to a fact that for 1 percent of its utilization increase, half percent of national CO2 emission is decreasing (Odgaard 2000). Core for beginning of spreading green energy market in Denmark is producer’s priority for entering a grid and receiving green certificates (Odgaard 2000) after the oil crisis. Although the country itself is not rich in hydroelectric resources, good enforcement and development of the policies for utilization of other renewables drove Denmark to current highly developed level (Liu and Lund 2014). Growth in using alternatives for energy production was also the key strategy for reducing CO2 emission in Denmark (Odgaard, 2000). Country started producing oil more than 40 years ago, at 1972, with a peak production in 2004, and decline after 2016. Besides that, following oil production, export of crude oil peaked in 2014 and decline in 2016. (IEA 2017). Danish natural gas reserves are good enough to make itself sustainable and also export it to neighboring countries like Sweden Netherlands, Germany and Norway (IEA 2017). The consumption of coal has dramatically fell for two thirds in the period from 2006 to 2016 after the extensive policy of fossil phase-out, imported mostly from Russia (IEA 2017).

Nevertheless, when talking about energy sector, Denmark is thought to be one of the world leaders in energy efficiency and security with 121% energy self-sufficient in 2010 (Sovacool 2013). National Energy Policy of 1976 presented energy taxes and alternative energy plan in Denmark (Ogden 2016) with a focus on domestic reserves exploitation and building nuclear power as a solution for overcoming crisis (Sovacool 2013). To conclude, although energy transitions are time consuming processes, Denmark is good example of the country which managed to merge development of the crucial sectors, political, social and technological, for sake of faster prosperity.

2.3.2 Renewable Energy Sources in Denmark

Denmark has aspiring targets for future in their energy sector. In the last decades, there is a good trend of switching to renewables (mainly biofuels and waste) in the total primer energy supply, and to wind power generation in electricity sector (IEA 2017). In the Figure 4. Below we can see high increase in RE usage which put Denmark on the fifth position of IEA countries with the highest share of RE in total primer energy supply, after Norway, New Zealand, Sweden and Austria (IEA 2017).

By the end of 2016, total production of energy in Denmark was 14.9 Mtoe (IEA 2017). Of total energy production oil stood for 4,6%, natural gas 27.1 % while renewable such as biofuels and waste, wind and solar for 17.1%, 7.4% and 0.7% respectively (IEA 2017). As an outcome of oil and natural gas downturn in Danish domestic production for over 50%, the energy produced from renewable sources boost for 29% in the same period, from 2005 to 2016 (IEA 2017). On the figure below, noticeable growth is seen in biofuel and waste sector followed by wind. Energy production from biomass is appear for over two thirds of total renewable production in Denmark, including transportation and heating sector (DEA 2017). In the past years many plants for fossil combustion are changing to wood pellets, wood chips or straw usage (DEA 2017). It is believed that till 2020, the amount of biogas produced will increase three times comparing to 2012 (DEA 2017). Importance of biomass capacity of Denmark, and other countries in general, is huge. Biomass significance is justified by the fact that it's not depended on the weather conditions as in case of both solar and wind energy while the electricity storage in big quantity is still overpriced (DEA, 2017). Regarding utilization of solar energy, Denmark is using both solar panels for heating purposes and solar cells for electricity (DEA 2017). Electricity produced from solar cells in 2015 amounted for 2.2 percent (DEA 2017) which shows notable growth. According to Danish Energy Agency (2017), solar potential in Denmark is significant, however, there is a big difference between summer and winter isolation. Therefore, solar energy is currently not reliable option unless storage technology develops fast and price drop in coming years.

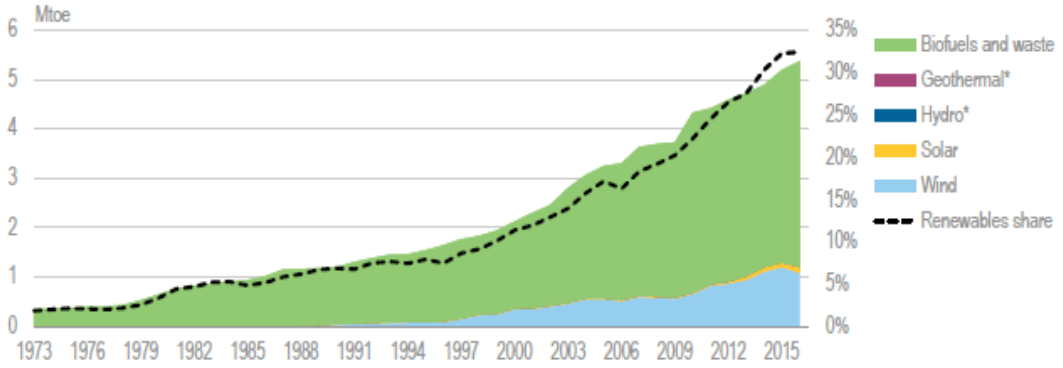

Figure 4. Renewable energy and waste in TPES, 1973-2016 Source: IEA 2017.

Besides total energy production, electricity share from renewables in 2016 stood for amazing 63% which is high above the 24% average of other countries that are part of International Energy Agency (IEA 2016). In this electricity share leading sources were wind, biofuels and waste and solar energy accounting for 43%, 18% and 2%, respectively as it is shown in the Figure 5. What can be noticed from the Figure 5. as well is prevailing of renewable energy sources over the fossils, which is positively changing over the years. Currently, for electricity production is used only 29% of coal (IEA 2016), while, just for comparison, in 1984 it had over 95% share in Danish electricity production (World Bank 2018a).

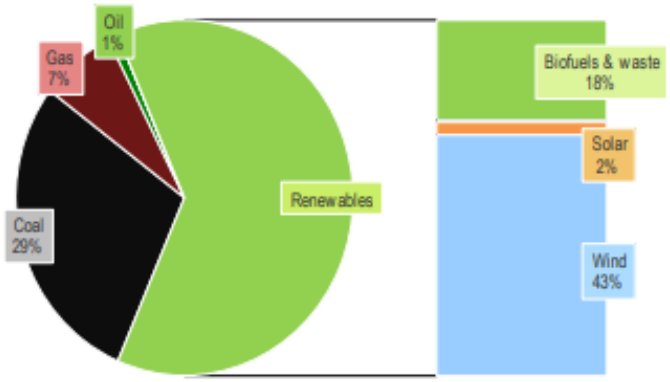

Figure 5. Electricity generation in Denmark by source in 2016; Data: IEA 2016.

Denmark is country located on temperate zone where heating is needed during many days over the year and as manufacturing country with developed economy energy supply is high (Sands 2013). Danish location itself together with climate is giving great potentials for wind energy utilization. Since it's a flat country, Denmark is not rich in hydro renewable energy sources but presents good climate for both onshore and offshore wind production (Sands 2013). In 2015 Denmark was a world leader in wind

energy production per capita (Mey and Diesendorf 2017) while it present forth country in the world in terms of installed wind capacity (Bolinger 2001). Its energy market is small but closely bonded with Germany and Nordic countries which are rich in hydroelectricity and can cover up electricity shortage if needed (Friesenbichler 2016). Offshore potentials of the wind are half time more efficient in terms of energy productiveness than the onshore (Ogden, 2016). Offshore wind production has the lowest cost for electricity production, for 50% cheaper than current costs of natural gas and coal (Roberts 2016). Besides that, wind power is also utilized in mountains regions, especially in the area between two mountain (Society 2012). For this reason of enormous wind capacity, main policies and supportive schemes after oil crises were focused towards reaching higher exploitation of this renewable energy source. In 2014 total capacity of wind was 4,890 MW, over two thirds from onshore production ("Wind Energy -The Official Website of Denmark" n.d.). Background of this amazing success is justified by the fact that country itself presents world leader in wind technology production, installation and all following services ruled by numerous companies (DEA 2017). Besides that, already from the period of oil crises, huge investments were concentrated towards universities, researchers and engineers from the wind energy production field (DEA 2017). Outcome of above mentioned achievements is shown in table below (Table 1.) where significant growth of wind share in electricity generation in Denmark is noted from 2001 till 2011. As seen in the table, wind share in electricity in 2001 was 12.3% while 10 years later it increased over two times while according to Figure 5. in 2016 it achieved amazingly high 43%.

Table 1. Share of Wind Energy as percentage of total electricity consumption in Denmark; Sources: IRENA 2012, IEA 2016.

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
12.3%	14.0%	16.0%	18.8%	18.7%	17.0%	19.9%	19.3%	19.4%	22.0%	28.3%

Also, worth mentioning is geothermal use in Denmark. Geothermal energy from hot water which is used for district heating in Denmark is exploited from the levels usually above 1000m depth, ideally around 700 meters (DEA 2017). Currently three geothermal power plants are operating in Denmark (DEA 2017). Besides that, geothermal heat pumps are utilizing heat from upper underground layer, no more than 250 meters deep (DEA 2017). DEA oversees issuing permissions for individuals or companies willing to invest in heat production from geothermal pumps.

2.3.3 Renewable Energy policies in Denmark

Energy Strategy 2050 was introduced by the government in 2013 which had two key point, phasing out fossils by 2050 and achieve 30% RES share of total energy demand (IRENA 2012). Nevertheless, the

newly elected government in 2013 had additional proposals for targets in the field of energy and climate change mitigation. According to Greenpeace report from 2014, Denmark is one of the leading countries that have energy policies following 2050 climate targets of total phase-out fossils. As noted in the the report, the goal is not only reaching fossil independence but also substitute it with totally green and safe renewable without nuclear power or carbon capture and storage (CCS). The table below shows that the Danish target for just two years from now will be half of the all electricity production to be met by wind renewable and that coal will not be used anymore by 2030. Five years after that, Danish plan is to totally rely on renewable for electricity and heating. Finally, as already mentioned, the main goal is to be totally depended on safe energy from renewables without any percent of usage of fossil fuels by 2050 (Greenpeace 2014). Danish Energy Plan from 2006 already suggested those high targets. Many authors argue that this policy plan is too optimistic. Yet, giving in fact stunning rise of country's self-sufficiency from 5 to 121 percent in the time of 1980 to 2010, it gives a hope that this is possible (Ogden 2016). Sovacool (2013) is stating that this kind of society, taking in the consideration the history after the oil crises has justified expectations to achieve those victorious goals.

Table 2.Denmark energy and climate targets. Source: Greenpeace 2014.

Denmark energy and climate targets	
100% renewable energy	2050
100% renewable energy in electricity and heating	2035
A complete phase-out of coal	2030
40% reduction of domestic greenhouse gas emissions from 1990	2020
50 % of electricity demands met by wind	2020

Danish Government have focused on two main areas during the policy making and regarding achieving long term energy and climate change targets: electricity generation from renewable and using biomass for district heating as well as replacing natural gas and oil with RE in individual heating (IEA 2017). According to IEA report from 2017, crucial point for reaching 2050 target need to be changes in heating sector, and to focus in both district heating and individual heating sector. Energy transition in Denmark has led to the switching from fossils to biomass and municipal waste usage in remarkable quantity when talking about the heating sector with a great help of zero taxation for biomass (IEA 2017).

Main responsibility for development of energy policy in Denmark have The Ministry of Energy, Utilities and Climate while The Danish Energy Agency (DEA) have a role in implementation, especially energy efficiency policies and regulations (IEA 2017). As already mentioned before, Danish energy transition towards renewables started since the oil crisis. From that period till now, 4 main policies regarding renewable energy were introduced:

1) *First Energy Plan, (Dansk Energipolitik): 1976*

This plan was developed after the high influence of Oil Crisis on Danish energy shortage related to their high dependence on the oil imports. The main targets of the plan were to increase energy efficiency, decline energy consumption and turn oil power plants to coal and nuclear power (IRENA 2012). This plan stood for self-production increase and reduction of imports reliance (Ogden 2016). With the help of multiply energy supply, reliance of imports of oil decreased (Sands 2013). Together with introducing Energy Plan, government proposed *energy taxes* which were supporting the usage of renewable energy sources which utilization at that time was moderate. Taxation in energy sector in Denmark was introduced as a fiscal policy with idea to increase energy efficiency and decline necessity of fossil fuel consumption (IEA 2017) where obviously higher taxes on gasoline would make people turn to biodiesel car consumption.

This Energy Plan was devoted to material investments for further research about RES and finally Ministry of Energy was created 3 years after the first energy plan (IRENA 2012). Although part of this plan, nuclear power plant construction was phased out after over a decade long campaign against it lead by antinuclear movement (OOA) (IRENA 2012). Many people were part of the protest against the nuclear construction. Nonetheless, it was not only protest itself, but also alternative was given by engineers and scientists (IRENA 2012). Alternative was elaborated in “Sketch for an energy plan in Denmark” 1976 and seven years later in “Energy for the future: alternative energy plan” presenting wind utilization as a key alternative (IRENA 2012).

During this period of First Energy Plan, special development of wind partnerships helped Denmark to overcome the crises. The initiative and willingness of the people to concentrate their savings into investment in renewable energy production was main drive force for this country after the oil crisis. Besides peoples initiatives, good outcome was a result of support by government providing 30 percent investment of complete costs of project (Bolinger 2001). However, those investment subsidy was

declining by years and completely revoke in 1989 (Bolinger 2001). At the start of wind turbines purchase period, investors were obliged to obtain a house in the circle of 3km around the turbine (Bolinger 2001). This limitation was enlarging over the time and spreading to 10km in 1985, to all Denmark in 1999 ending with all Europe in 2000 (Bolinger 2001).

2) Second Energy Plan (Energiplan81): 1981

In this policy plan, government still had nuclear power plant construction action point which was finally rejected by government 4 years later (IRENA 2012). Plan was concentrated towards natural gas and oil usage from Northern Sea and introduction of subsidies for biomass and wind utilization (IRENA 2012). Due to the taxes that citizens needed to pay additionally for coal and oil, renewable energy market started increasing as well as the competition (IRENA 2012). That was a good initial step for the beginning of green energy transition. During the time when Second Energy plan was on force, government was supporting citizens ready to invest in RES by tax incentives which was very popular all the way through 80s (IRENA 2012).

As mentioned before, after oil crisis plan of the government was building nuclear power plant for sake of increasing self-sufficiency. However, thanks to the social impact and revolt, plans switched from nuclear option, to much better alternative, massive renewable utilization. Focus of renewable usage at that time was wind, specifically emphasised in this Energy Plan of 1981 (Odegon 2016). On the other hand, in this legislative plan some measures of lower energy consumption were proposed. One of them was car free Sundays (Odgen 2016). People were not generally happy with these measures but were eager to sacrifice their own needs to bring something good for the country and the society as a whole (Odgen 2016).

3) Third Energy Plan (Energi 2000), Feed-in tariff: 1990

This plan was the first one that officially revoke nuclear power plant construction. Besides that, plan announced goal of 10 % of electricity generated from wind till 2005 and CO2 reduction for 20 % with the same target year while using 1988 as a base year (IRENA 2012). It made it the first policy to set up the targets for GHG emission and additionally expanding carbon energy taxes (Odgen 2016). Since 1993, fixed feed-in tariff supportive scheme was established with defined price of 85 % of transportation and building costs with reimbursement (IRENA 2012). More precisely, it was functioning through obliging utilities nearby to buy energy for lower general price while CO2 tax and energy tax would be refund to the partners that invested their savings into the wind turbines and sold energy to utilities (Bolinger 2001). More precisely, *Feed---In Tariff Systems (FiT): that gives* financial compensation

for connecting electricity produced by renewables into public grids. These tariffs are usually given for the longer periods of time in order for investors and producers surely get back the stake (Schaffer and Bernauer 2014).

4) Fourth Energy Plan (Energi 21): 1996

Lastly, policies introduced in Fourth Energy Plan were proposing new targets. Out of total energy consumed, renewable sources should cover 12-14% and 35% till 2005 and 2030 respectively (IRENA 2012). Further goals were later puted forward for offshore wind farms while main body in charge of implementation of renewable energy policies was Danish Energy Agency (DEA) (IRENA 2012). Besides that, one of the governmental goals during the 90s in Denmark was developing of sustainable energy sector (Sands 2013). Moreover, "Energy 21" was targeting further growth of taxes and giving more strategy plan in energy sector (Odgen 2016).

Besides those crucial policies, few more legislative steps were undertaken afterwards which helped reaching better share of renewables. Firstly, in the period from 1999 till 2008, *electricity market liberalisation* was proceeding (IRENA 2012). This liberalization of the enrgy market in Denmark both for the large companies and consumers startet in 2000s (Kooij et al. 2018). The idea to liberate electricity market by 2002 was proposed by government (IRENA 2012). To increase competitiveness in the market, feed-in tariff (FiT) system was replaced by renewable portfolio standard (RPS) (IRENA 2012). Payment for investors was based on market price while they were getting additional premium which set up the highest possible amount that producers can get (IRENA 2012). Unfortunately, this policy mechanism didn't show up well. Distinct decrease in wind power usage was noticed after phasing our FiT and implementation of this new policy (IRENA 2012). Later on, from 2009, as a part of energy supportive scheme, tenders were introduced (IRENA 2012) which additionally helped market liberalization and increased competitiveness among interested companies. In 2002, as a part of this Energy policy, green certificate system was introduced (IRENA 2012). In general, this policy instrument, which is quantity-based, together with FiT, that is price-based, are believed to be the key changers in renewable energy sector (Schaffer and Bernauer 2013). The main incentives for bringing up green certificates have been mainly GHG emission reduction and air pollution decline (Schaffer and Bernauer 2013). Increase in renewable energy consumption and lower prices for RE technologies are according to many analysts, outcome of these policy instruments (Schaffer and Bernauer 2013).

Danish energy policy is represented by so-called Energy Agreements (IEA 2017) that are reviewed in every 5 years approximately. Accordingly, some years after market liberalization, Special Energy

Agreement was created by Danish government in 2008 which brought plan of constructing two 200MW offshore and to onshore wind parks with 75MW capacity (IRENA 2012). As a part of the agreement two main goals were proposed. Firstly, decrease of energy consumption from 2006 base year to 4% by 2020 and reach 20% of RES share in total energy consumption (IRENA 2012). After the economy crises in 2010, Denmark started rethinking of the importance of RES which at that time were not economically profitable and nuclear power generation started to be mentioned again. Nevertheless, through energy agreement in 2013 supported by many people from different spheres tax deduction from renewable energy consumption was introduced. (Kooij et al. 2018)

There are more additional policies proposed by government that help promotion and development of renewable energy market. For example, public service obligation (PSO) which every household in Denmark is paying as a part of electricity bills is amount of money for different renewable energy projects (IEA, 2017). Nevertheless, as a part of National Energy Efficiency Action Plan 2017, Denmark plans to spend huge amount of money for helping developing countries in their energy plan enhancement (IEA 2017). Worth mentioning, electricity sector went through many changes since the oil crisis, especially in the last two decades. Total generation of electricity has declined while renewable took over the major share in production. In 2016, over two third of total production was from renewable sources, while over 40 percent was generated from wind power (IEA 2017). Thanks to all those measures of RES utilization and decrease in overall energy consumption, satisfactory levels were achieved. For example, In the previous years, population as well as economy of Denmark was having ascending path (IEA 2017). However, thanks to diverse policies, the total final consumption decreased (TFC) due to the energy efficiency measures and policy focus (IEA 2017).

2.4 Republic of Serbia

2.4.1 Energy transition in Serbia

Energy sector have huge influence on different branches such as economy, technological and society and presents core for development of countries (Ministry of Energy and Mining of Serbia 2016). To be more specific, energy represents base for both economic and social growth of the society (Harayshat, 2007). Assured energy supply and availability with high sustainable measures are being in focus to a greater extent in the past years. Still, main way of using renewables in Serbia is traditional biomass and hydro. In 2016 20.1 (Ministry of Energy and Mining of Serbia 2016). Essence of the problem in energy sector of Serbia is low efficiency and lack of technology to support new renewable energy consumption

(Ivezic et al. 2013). In the two figures bellow, we can see overabundance of brown colour which is unluckily representing coal share in energy production (Figure 6.) and total primary energy supply (Figure 7.)

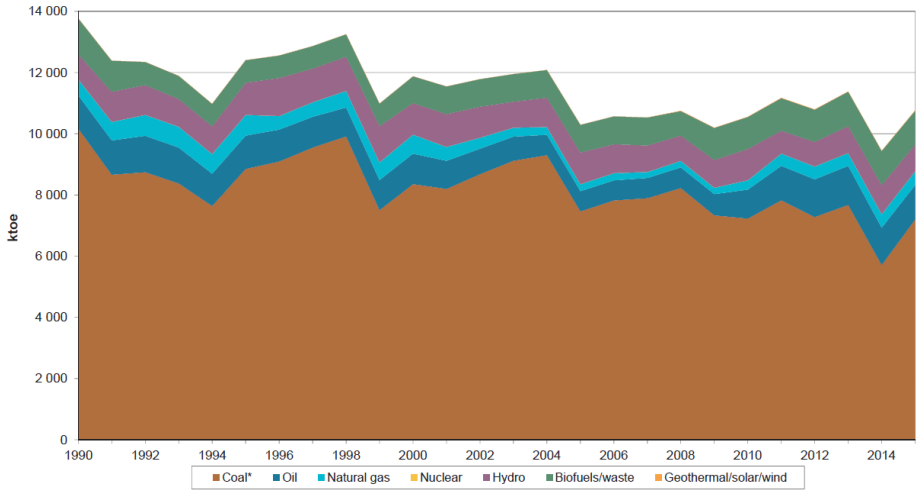

Figure 6. Energy Production in Serbia, Source: IEA 2016.

Coal is generally the most harmful source of energy for air pollution when talking about greenhouse gasses emissions (Vasumathi *et al*. 2012). Additionally, the amount of ash created during the combustion is causing more environmental problems and need for more infrastructure dedicated to coal cleaning (Vasumathi *et al*. 2012). Having in mind that Serbia produce electricity from cheap lignite while using overaged power plants, necessary measures for climate change mitigation achievements is to gradually develop utilization of renewable sources provided by naturally rich Serbian land. Besides that, law against building nuclear power plant in Serbian is still on force. This law was implemented in 1995 while Serbia was part of Republic of Yugoslavia.

Renewable resources usage for energy production in Serbia is at very beginning except hydro and traditional way of biomass utilization for heating. Therefore, Serbia is on the long way of introducing to society other options and possibilities for energy reduction and confessing the importance of their utilization in future. Serbian fossil reserves were counted by Self-sufficiency (SS) measures which are presented by total domestic reserves and yearly consumption (Pavlović and Ivezić 2017). Result given in the paper of Pavlović and Ivezić is not so promising by having coal reserves for next 149 years, oil for 8.3 and natural gas 7 years. Therefore, transition to renewable energy sources consumption is mandatory for Serbia to reduce future dependency on imports. What is debatable in relatively good reserves of coal is their

efficiency. Energy efficiency of transformation energy from coal in existing thermal plants in Serbia is way lower from European standards, going below 30 percent in the final outcome (Pavlović and Ivezić 2017).

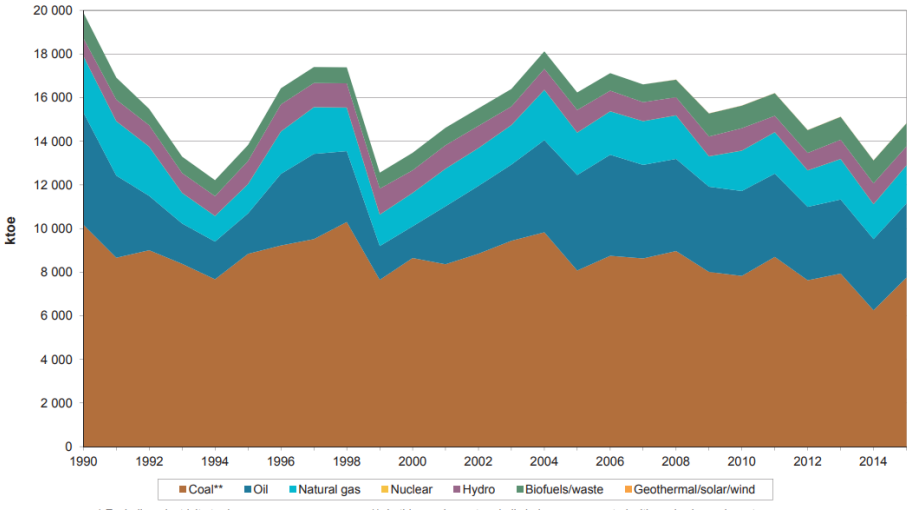

Figure 7. Total primary energy supply in Serbia, Source: IEA 2016.

In 2010, one third of energy used was relying on imports (oil, petroleum and natural gas mostly) which doesn't make Serbia exception comparing to many European countries (Ministry of Energy and Mining of Serbia 2016). According to some authors there is a fear of Serbia becoming even more dependent on the imports due to the developing industry due to recovery after economic crisis. The negative thing about fast growing industry can be deadlock of electric power plants construction (Ministry of Energy and Mining of Serbia 2016) which would result that Serbia won't be able to cover demand of energy during the expected industry development. Having in mind the potential of the country for renewable energy utilization, production of energy till 2050 should be focused on using locally obtainable RES and implementation of clean technologies with low-ranking GHG emissions (Ministry of Energy and Mining of Serbia 2016).

Therefore, one of the key area of focus is increasing Energy efficiency. On the Figure 8. below two scenarios for electricity consumption in Serbia in future are shown. Predicted increase in electricity production from 1990 till 2030 is over 16 percent without taking any measures (Ministry of Energy and Mining of Serbia 2016) which is presented with blue line on the graph. In case of taking energy efficiency measures, consumption would decrease for significant amount shown with green line on Figure 8. Stated in the Energy Sector Development Strategy by 2025, measures given by Law on Efficient Use of the Energy can help country with lowering consumption, decreasing losses of final energy (in transport),

declining energy loss with modern and renewed technologies etc. Law on Efficient Use of Energy was received in 2013 has for the biggest goal, increasing efficiency in the building sector which spends 40 % of total consumption of energy (PKS 2018).

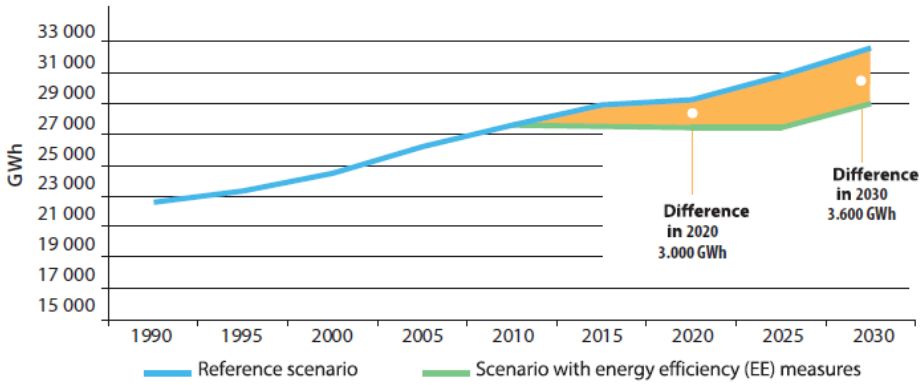

Figure 8.Projection of electricity consumption. Source: Ministry of Mining and Energy of Serbia 2016.

2.4.2 Renewable Energy Sources in Serbia

According to Energy Balance of Republic of Serbia, the share of renewables in total energy production in 2017 was 18, only 0.5 % higher than the one in 2015. Although the percentage differs from document to document. As stated in both reports, 2020 Serbian goal is to achieve 27% share of renewables in total final energy production. However, in current structure, almost 60 percent stands for solid biomass, while biogas, wind, solar and geothermal energy participate with less than 1 percent in total (Ministry of Energy and Mining of Serbia 2016, 2017).

Except the high utilization of hydropower and biomass, other renewables are in initial phase of development in Serbia (Ministry of Energy and Mining of Serbia 2016). Serbia is country wealthy with energy from water sources, though only 60 percent of the current capacity is exploiting (Tešić *et al.* 2011)As stated in the Energy Sector Development Strategy of the Republic of Serbia, entire potential of the country in terms of renewable energy sources is 5.65 million toe per year. This significant potential could ideally stand for half of the total energy production in Serbia (Ivezić *et al.* 2013). In the table below, using official data from Ministry of Energy and Mining report, it can be seen that 1.054 million toe of biomass and 909 000 toe of hydro is already in use. On the other hand, for potential utilizing solar, wind and geothermal energy is still equal zero due to the small amount of installed capacities which still are not high enough to be reflected in the final results. On the table besides potential in use, available potential is shown together with unused potential. To conclude, in Serbia only one third (35

percent) of possible potential of RES is in use (Pavlović and Ivezić 2017) and according to some authors, potential of RES can cover nearly half of the total production (Tešić et al. 2011).

Table 3. Overview of technical usable potential of RES (from 2012) Data source: Ministry of energy and Mining of Serbia 2016.

Type of RES	Available technical potential in use (million toe/per year)	Unused available technical potential (million toe/per year)	Total available technical potential (million toe/ year)
BIOMASS	1,054	2,394	3,448
HYDRO ENERGY	0,909	0,77	1,679
WIND ENERGY	≈0	0,103	0,103
SOLAR ENERGY	≈0	0,24	0,24
GEOTHERMAL	≈0	0,1	0,18
Total from all RES	1,968	3,682	5,65

The pie chart below (Figure 9.) also shows share in obtainable potential of Serbia's renewable energy sources. Chart is divided in 5 main renewable sources where hydropower potential is presented only with small hydro power plants (SHPP). Matching the results in the table above, biomass potential drastically prevails over other resources.

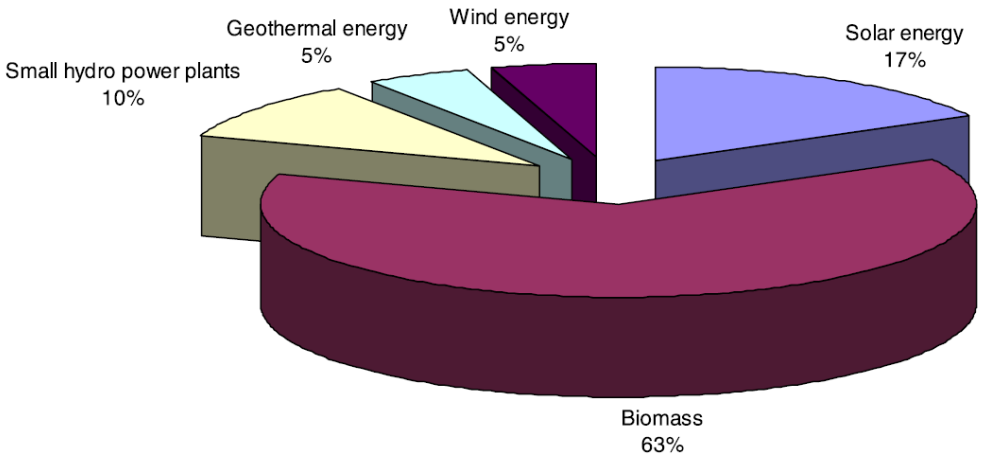

Figure 9. Potential of RES in Serbia by sources Source: Ivezic et al. 2013.

Serbia biomass potential is presented by mostly wood biomass as well as agricultural biomass (Golusin, *et al.* 2010). Central part of the country is rich in terms of wood biomass while in the northern part, province called Vojvodina, is well known for agricultural biomass potential (Ministry of Energy and Mining of Serbia 2016). Besides those two mentioned, some amount of potentials is covered by biodegradable municipal waste as well as waste cooking oils and animal waste which are in Serbia yet

not in use (Ministry of Energy and Mining of Serbia 2016). Over half of the Serbian land is arable while quarter is covered with forests (Golusin *et al.* 2010) which explains Serbian great potential for biomass utilization. Thanks to the good incentives agro-pellets are becoming more and more used especially in the northern part of the country (Vasić 2018). Regarding the biofuels, Serbia have capacity for utilization of both first and second generation of biofuels since the raw materials needed for their production are well grown cultures in agricultural crops since Serbia is rich with highly fertile land. So far, potentials for producing first generation biofuels exist. Nevertheless, as stated in Energy Strategy of the country, 2020 goal requires 10% biofuels share. Since first generation befoul production does not meet greenhouse gasses emission requirements and yet equipment for second generation production do not exist, Serbia will need to import some amount (Ministry of Energy and Mining of Serbia 2016).

Biomass presents valuable energy source since it can be used in numerous ways (Jovanovic et al. 2014). Biofuels, for example, also can be product of both animal and plants sources and present great alternative of fossils in transportation sector while in the same time can be produced from waste which is further on helping one more environmental issue to be solved (Jovanović *et al.* 2014). Current Directive2009/28/EC on force is obliging Serbia to follow many rules regarding biofuels production proposed by EU legislations (Jovanović et al. 2014). Unfortunately, Serbia is still on the bottom page regarding this topic and biomass utilization is limited on pellets and briquettes production (Jovanović et al. 2014).

Hydro energy production in Serbia is well developed, yet, not till the level it can be consumed. Currently around 10.5 TWh/ per year is produced from this renewable source with 16 hydro power plants capacities, although total possible energy and potential is estimated to 1.800 GWh per year (Ministry of Energy and Mining of Serbia 2016). Important to note that the estimated potential of the small hydro power plants dates from Cadastre of 1987 and therefore new research shall be done for providing possible location for new HPP building (Ministry of Energy and Mining of Serbia 2016).

The wind called “Košava” that is common in northern parts of Serbia as well as on mountainous terrains (Tešić *et al.* 2011), makes country suitable area for investments in the field of energy production from the wind. Nevertheless, currently its totally depended on non-native companies, technologies and investments (Tešić *et al*. 2011).Using general criteriums for wind utilization by modern technology, Serbia is again proved to have high potentials for utilizing this renewable energy source (Jovanović *et al.* 2014) as it can be noticed on the map provided below. Almost 500 km2 of its land, including high

mountains and flat areas, is suitable for production of electricity by wind (Jovanović *et al.* 2015). On the map with average wind power in Serbia is shown, on 100m elevation.

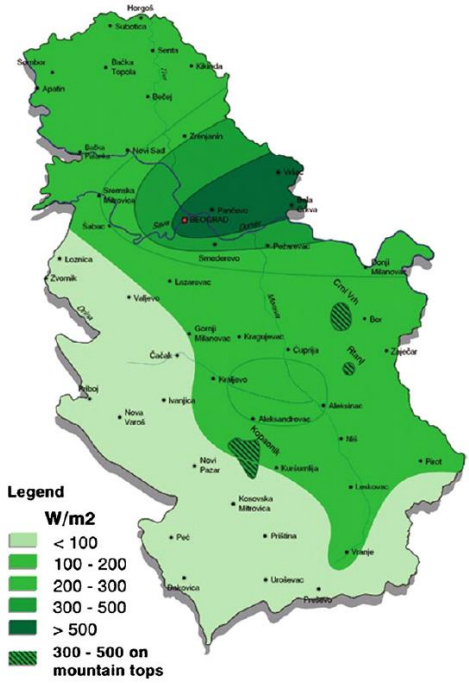

Figure 10. Map of average wind power at the height of 100 m in Serbia. Source: Tešić et al. 2011.

Regarding the solar energy utilization in Serbia, there are possibilities to use solar power for either electricity or heat generation (Ministry of Energy and Mining of Serbia 2016). Serbia is highly suitable country for solar energy production due to the solar radiation of 1500 and 2200 hours per year which is higher than in most of the European countries (Ministry of Energy and Mining of Serbia 2016). Yet, technology is not still affordable, and Serbia will rely on the foreign costly investments and incentives in the future. Currently there are very few samples of solar usage in and there is still long way to go (Tešić *et al*. 2011). Figure 11. is showing the map of Serbia with daily average amount of KWh per squer meter of territory, which would give total solar production capacities of 0,24 million toe/ year for Serbia (Table 3.).

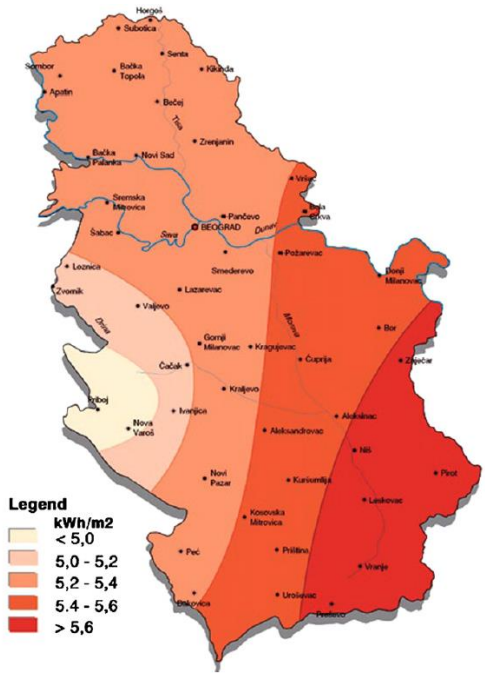

Figure 11. Map of daily average of global solar energy on horizontal plane in Serbia. Source: Tešić et al. 2011.

Finally, geothermal potential of Serbia is high both in terms of petro thermal and hydro geothermal energy sources (Ministry of Energy and Mining of Serbia 2016). With total potential that country has, it could be generated 216 MWt (Ministry of Energy and Mining of Serbia 2016). Yet, this type of resources is strongly under development although they are well explored (Tešić *et al.* 2011). Many of those resources are used in recreational and touristic purposes. In Serbia exist 159 thermal springs with warmest one of amazingly 96 degrees Celsius in Vranjska Banja (Milivojević and Martinović 2005). Geothermal can have significant share in energy power generation of the country, 400 x 106 tonnes of thermal-equivalent oil (Milivojević and Martinović 2005).

Less than decade ago, in 2009, almost half of the Serbian energy needs were depended on imports (Tešić *et al.* 2011). Having in mind that Serbian low amount of oil and gas present only 1 percent of total energy reserves and the rest stands for different types of coal, from which more than two thirds of reserves are located at Kosovo and Metohija, Serbia needs to utilize renewables (Tešić et al. 2011). Ninety-five percent out of these 99 is presented by cheap, environmentally harmful, lignite deposits or soft brown coal (Ministry of Energy and Mining of Serbia 2016). Main recommendation and need for Serbia to achieve faster energy transition towards renewables is creating set of incentives by policy makers to develop energy efficiency and higher utilization of renewables among the consumers,

weather its higher consumption of biomass for heating or encouragement of other renewable technologies (Vasić 2018).

2.4.3 Renewable Energy Policy in Serbia

There are numerous institutional bodies related to government that are in charge, or somehow connected with energy production measures from RES in Serbia (Golusin *et al.* 2010). Ministry of Mining and Energy is relevant in terms of bringing policies and directives form the EU level into the legislative system of Serbia. This Ministry is the core institution dedicated to Renewable Energy Sources utilization development and bringing in force main framework such as feed in tariff mechanism. Ministry for Energy and Mining oversees writing reports for European Commission, National Action Plan Action plans and giving yearly reports on energy consumption (Golusin *et al.* 2010). Ministry of the Environment and Spatial Planning is in charge of Climate Change actions, sustainable plans for the country and construction plans for plants in Serbia (Tešić *et al.* 2011). Together with the Ministry of Energy and Mining its working on the realisations of target under the Kyoto Protocol (Golusin *et al*. 2010). Ministry of Agriculture, Forestry and Water Management is mostly related to biomass utilization legislations (Golusin *et al.* 2010). Then, Ministry of Science and Technological Development is presented with 53 researchers and scientists who are in charge of investigating field of RES technology (Golusin *et al*. 2010). Also worth mentioning are Serbian Energy Agency (EARS), Regional Centres for Energy Efficiency and Serbian Energy Efficiency Agency (SEEA) and Secretariat for Energy and Mineral Materials of the Province of Vojvodina (Tešić *et al.* 2011) who are mainly focused on developing energy efficiency goals and increase of the RES utilization (Golusin *et al.* 2010). Besides those, number of non-governmental and business sector institution related to RES is on rice in recent years with same targets.

There are diverse policy acts in Serbia focused towards development of renewable energy sector and climate change mitigation. The previous *Energy Sector Development Strategy of the Republic of Serbia by 2015* named renewable energy resources utilization one of the top 5 strategies of Serbian Government (Golusin *et al*. 2010). Currently is on force *Energy Sector Development Strategy of the Republic of Serbia by 2025 with projections by 2030*. Strategy itself was a mandatory plan for overcoming energy and extensive society crisis that Serbia was going through from the beginning of 2000s (Ministry of Mining and Energy of Serbia 2016). There are three main principles of the strategy by 2030: development of the energy market, energy security and moving towards more sustainable standards in the country (Ministry of Energy and Mining of Serbia 2016). Besides that, important proposals in strategy are renewal of energy market and technology modernization (Ministry of Mining and Energy of Serbia 2016). Outcome

of Strategy by 2025 together with Energy Law is striving to achieve lower pollution and higher energy efficiency with sustainable development of both economy and society of the country (Ministry of Mining and Energy of Serbia 2016). In the following century population of the world increased almost 4 times and energy demand over 30 times (Ministry of Mining and Energy of Serbia 2016). Idea of most development strategies is to provide society within the energy in a long term, from renewable sources, cleaner better, but still with a target of declining costs and intensity of energy consumption which need to be bring out with the special policy mechanism and legal frameworks (Ministry of Energy and Mining 2016).

In 2006 Serbia became a member of Energy Community (EC) ratifying the Treaty on Energy community between European Community and other countries in the region (Ministry of Energy and Mining of Serbia 2016). Initially, Serbia has adopted *Directive 2001/77/EC* related on electricity production from renewable energy sources and *Directive 2003/30/EC* related to utilization of renewables in transportation sector (biofuels and other) (Ministry of Energy and Mining of Serbia 2016). Finally, in 2009, *Directive 2009/28/EC* of the European Parliament and the council of EU, repealed earlier two Directives (Ervine 2015). Main aim of new one was like previous, furtherance of the utilization of renewable sources for energy production. As stated in Directive: "*It sets mandatory national targets for the overall share of energy from renewable sources in gross final consumption of energy and for the share of energy from renewable sources in transport "*(Ervine 2015). Not only European Member States are part of this directive but also countries who are on the way to become EU members such as Serbia and other countries from the region. Two main targets of this Directive are b of Republic 2020 goal of Serbia to achieve 27 percent of gross final energy production (GFEP) from renewables and adopting and creating National Renewable Energy Action Plan (NREAP) of the Republic of Serbia (Ministry of Energy and Mining of Serbia 2016). Action Plan was finally created in June 2013 (Ministry of Energy and Mining of Serbia 2016). As stated in the Progress Report on the Implementation of the NREAP of the Republic of Serbia, the enforcement of the plan is supposed to be monitored and reported using data from Energy Balance every second year by the Ministry of Energy and Mining and delivered to the Government and EnC Secretariat. Besides the 27% RES share in gross production from Directive, other target is 10% of energy from renewables in final production in transportation sector by 2020, as all the other Member states. (Ervine 2015). Part of the directive is focused on necessary decrease of air pollutants emission from existing plants (Ministry of Energy and Mining of Serbia 2016).

Important law for controlling manufacturing power plants which are relying on renewable energy sources is *Law on Planning and Construction* which was adopted in the end of 2014 (Ministry of Energy and Mining of Serbia 2016). The Law is outlining special commitment for getting construction permits and strengthening support for renewable usage. In December 2014 *Energy Law* was presented as a structure for opening energy market to different investors in Serbia which was previously mostly based on Serbian Electric Power Industry's monopoly (Golusin *et al*. 2010). By initiating privileged producers, Energy law supported further development and investment in the area of energy production from renewable energy sources in Serbia (Golusin *et al*. 2010). Although *Feed-in tariffs* mechanism was implemented in 2009, only after adopting current Energy Law more than 5 years later, significant changes were seen in increase of number of the investments for wind energy production which started creating good climate and trust for many companies to invest money in Serbia (Ministry of Energy and Mining of Serbia 2016). Supportive system for RE electricity producers are supported by two decrees defending status of privileged producers and incentives (Jovanović *et al.* 2014) for companies who produce energy from RES. To become a temporary status of a privileged producer through this policy mechanism companies and investors needed to give deposit in the worth of 2 percent of total value (Ministry of Energy and Mining of Serbia 2016). To conclude, as stated in the *Progress Report on the Implementation of the National Renewable Energy Action Plan of the Republic of Serbia*, many wind farms are still not constructed because of bad experience of project coordinators with International Financial Institutions and lack of trust in political security of the country. However, *Feed-in tariff* presents legal framework for renewable utilization in Serbia which gives warranty over long term agreements of usually 12 years (PKS 2018). This period can also be from 10 to 25 years and increases with the amount of electricity produced and differ from project size and technology type (Couture et al. 2010). With feed-in tariff supportive scheme supplier is committed to buy electricity from renewables with incentive price (PKS 2018). Since the implementation of scheme, development followed by establishment of this policy mechanism was noticeable. The general trend of increasing number of investments can be visible in the Figure 12. bellow which shows number of build power plants from 2010 till 2016 divided by the renewable energy type. Those achievements are show in Figure 12. where is easily noticed effects of implementing this supportive scheme. Some of the installed capacities were 61 SHPP, 104 solar power plants, 2 smaller wind power plants while 7 plants with higher capacity and finally 7 biogas power plants (Ministry of Energy and Mining of Serbia 2016).

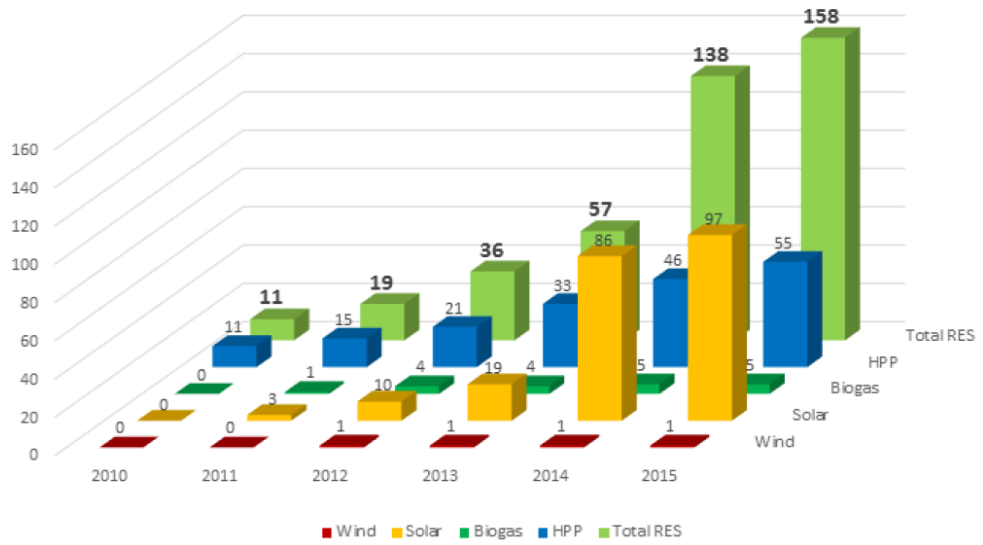

Figure 12.Number of power plant on RES in Serbia after introduction on "feed-in" tariffs. Source: Ministry of Mining and Energy of Serbia 2016.

In 2016, Serbia has undertaken new measures and developed new regulations in the field of RES to fulfil International Financial Institutions legal safety requirements. Unfortunately, as stated in the progress report made by Ministry of Energy and Mining, the goal for biomass utilization in transport sector will have slow development and assumable will not meet the short deadline planned for 2020. However, many measures and policies are about to be implemented in the field of "Promotion of Biofuel Production and Consumption" as a part of the Energy Law (Ministry of Energy and Mining of Serbia 2016). What is yet holding agricultural rich Serbian land to start utilization and production of biofuels is the fact that in the Directive 2009/28/EC is stated that biofuels and other liquid biofuels need to meet certain sustainability criteria which are still in the process of adoption in Serbia.

3 Methodology

3.1 Introduction

This section of the thesis depicts general procedure followed during the research, including collecting and analyzing data as well as explanation of research limitations. The main goal of this thesis is to acquire the current stage of development in the field of renewable energy utilization and policies of both Denmark and Republic of Serbia for the sake of making comparison and construct policy recommendations for further development of Serbia. To achieve this goal, three main stages were followed. Firstly, *introductory part* which included data collecting through literature review, correspondence and networking with relevant stakeholders. Secondly, research was additionally complemented with *interviewing* people from the sphere of Government, NGOs and Business sector in Serbia. Finally, data were analyzed to give valuable recommendations. In the final step, collected complete collected data were analyzed.

3.2 Data collection

3.2.1 Literature Review

Before conducting the interviews, literature review was undertaken. Purpose of this section was to see what is already written in the field of Danish and Serbian renewable energy potentials and policies as well as examination of the official documents written by Government and other relevant energy institutions, in both English and Serbian language. Literature review was a base for further interview conduction and construction of thesis focus. To notice obstacles of higher usage of renewable energy in the Republic of Serbia, comprehensive research was needed for both countries that are comparing. During the literature review, focus was on two types of resource.

Review of existing literature started with written *academic articles* approached through Google Scholar and CEU Library. Besides that, open access platforms like Elsevier, Springier, Wiley, MDPI and others were used for free approach to academic material. The amount of written academic articles in the examined field for Denmark was significant. On the other hand, number of academic documents for Renewable energy utilization and policies from Serbia wasn't that substantial. Besides lower number of academic documents comparing to Denmark, Serbian published papers were quite aged. Due to the sensitivity of the topic and its dependence on the fast technology change, outdated literature was not completely reliable and additional documents were needed.

However, second part of literature review was focused towards *grey literature*. Different official documentations were examined. Literature was published from official sites of Ministries in charge of renewable energy, Governments, diverse international energy agencies and other relevant websites. Considering both academic and grey literature was crucial for obtaining broader understanding of proposed topic.

3.2.2 Interviews

While doing literature review, no articles were found which are doing comparative analysis of renewable sector of these two countries. Although many official governmental documents exist, as mentioned above, academic literature regarding Serbian RES development are very few and quite aged. Due to this gap in scientific articles about barriers of utilization Serbian renewable potentials, additional collection of data via interviewing stakeholders in Serbia were conducted. Danish stakeholders were not interviewed for two reasons. Firstly, plenty of literature was available. Secondly, focus on this thesis is concentrate towards Serbian development since Denmark is used as a great example of RES usage with developed policies and significant number of supportive schemes. Organization of interviews was challenging and time-consuming process. Plenty time and exertion was needed for choosing people from relevant institutions and getting in touch with them. As it will be mentioned in limitation sector, numerous contacted stakeholders were not eager to participate and, in many cases, did not even reply to the emails.

Before choosing relevant people, existing and important institution from this field were reviewed. Due to importance of diversity of viewpoints and critical thinking, for interviews were chosen people from several spheres. Overall, seven people were interviewed. Two anonymous persons from government, two from NGOs, one from public company, one from international organization and expert in the field of renewable energy utilization in Serbia. Three of them were interviewed in person, 3 through skype while one of them was interviewed via email. Information gathered from persons working for government were beneficial for getting firsthand information for the future policies and regulative. Interviews with NGO had additional questions regarding the impact of non-governmental organizations in the decision-making process. Besides that, they have more experience with current social awareness of citizens in Serbia in regards of RES. Havin some suggestions and viewpoints from international organization, public company and expert helped for getting additional view over contemporary situation.

Table 4. Table of interviewed stakeholders from Serbia.

Sector	***Interviewee***
Government	Anonymous Ministry of Energy and Mining
Government	Anonymous Ministry of Energy and Mining
NGO	Vladimir Lale Janković "Centrala"
NGO	Nikola Vujović "Mreza dobre energije"
NGO	Nikola Blagojević "Pokret Gorana Vojvodine"
Expert	Milena Milosavljević Master Engineer in Renewable Energy
International Organization	Janez Kopač Director of "Energy Community"

Interviews, as a qualitative method are considered to be one of the best ways for more precise understanding of specific topic (Gill *et al.* 2008). The purpose of this qualitative method is to investigate views of different people or experts regarding the certain topic (Gill *et al.* 2008). Interviews conducted were *semi-structured*. This kind of interviews have several crucial questions prepared in advance, which are further determination of follow up questions and flow of the talk (Gill *et al*. 2008). Interview protocol was same for each interviewee. It began with introduction and explanation of the aims of the research (Gill *et al.* 2008). For everyone, there were some broad, general questions while each organization had some of the more precise questions regarding the background of the institution and main roles they have in renewable energy sector. Follow up questions were used in each interview depending on the flow of talk. Interviews were from 20 min to 40 min long. Finally, each interview was concluded with expression a gratitude to interviewee, as a significant confirmation of appreciation for their time and effort (Gill *et al.* 2008).

3.3 Data analysis

Data analysis process started with examination of literature review and it's finalized with analysis of transcribed interviews. Analyzing literature was conducted through screening and reading every relevant scientific article or grey literature. Each significant literature document was categorized in regards of the main themes using content analysis method. Division was focused towards good things about Serbian renewable energy sector and policies and, on the other hand, obstacles for further

Serbian development in this sector. After completing analyses of downloaded literature, interviews were transcribed and examined.

Content analysis, as an example of inductive approach of analyzing, is also used for examination of data gather through interviews (Burnard *et al*. 2008). This method is based on creation of classes in which related themes would be grouped together (Burnard *et al.* 2008). In this case same themes/groups were used as for literature review analysis. This kind of inductive approach suggests extraction of specific information and their division. Main themes gathered from analyzing interviews were again divided into driving forces and obstacles of Serbian development. Finally, both analyzed data from literature and interviews were merged into one unity which is further used for Discussion and Recommendation Chapter.

3.4 Study Limitations

During the time of thesis research, there were few limitations that hindered more detailed and reliable result of the thesis. Time limitation was the main issue for accomplishing more comprehensive study. This short time frame was resulting with second limitation, response rate of the stakeholders and their willingness to be interviewed. To get more valuable and accurate data, number of interviews should be noticeably higher. Due to the short period of time for total thesis research, and not high response rate of the stakeholder, only 7 interviews were done in Serbia. Good thing was that interviewed stakeholders were not from the same sphere. Initial idea was to have balanced number of interviews from each sphere and to have at least three people interviewed per sector. However, due to the mentioned research limitations, planned number of interviewees was not achieved. Therefore, it's important to emphasize that this thesis will give overlook on possible changes in Serbian renewable energy sector. However, due to insignificant number of interviews, results shouldn't be totally reliable and seen as an official proposal.

4 Results

4.1 Results from the interviews conducted in Serbia

To obtain greater insight in current situation of Serbian energy market and development of renewable energy policies and usage, interviews with people from different energy sectors were done in need for more profound understanding. However, as stated in methodology part, number of interviews was not significant so consequently this study is just providing an overlook on possible suggestions. As noted in methodology part, interviews were done through Interview protocol and questions organization was similar for every interviewee. They all had two key points. Firstly, questions related to current stage of Serbian development and which drivers and policies are helping increase in utilization of renewable energy sources. Secondly, questions related to barriers of more prompt expansion of RES were asked. For that reason, this section is divided in two crucial parts: drivers and barriers of renewable energy sector in Serbia. As mentioned before, conducted interviews were semi structured with already organized key points of the topics. All responses therefore, were congregate and further split in main themes followed by the content analysis of transcribed interviews. Most important answers were emphasized and taken into consideration for results, discussion and recommendation part of the thesis. In this Chapter, interview responses were discussed in order of derived themes about current policy, possible development and obstacles that Serbia is facing.

How is current policy mechanism functioning in Serbia?

While speaking about current supportive scheme on force, Feed-in Tariff policy mechanism, respondents had two different opinions. All the respondents, except two from government, didn't have positive opinion about FiT system as the only supportive scheme on force in Serbia. According to interviewees working in government, Serbia have achieved the satisfactory level of functioning of this policy mechanism. They stated that thanks to this system, utilization of renewable energy and construction process of new utilities are growing each year. One of those respondents explained that after the implementation of this policy, changes in new built capacities was noticeable, mainly in terms of small hydropower plants, solar, wind and biogas power plants from which many of them are still in the constructing process. Further, respondent stated that general atmosphere between investors and government is satisfactory. To conclude, respondent noted that different kind of supportive schemes are well functioning in develop energy market with high built capacities while the best for Serbian

situation is to keep this scheme for the near future until the amount of built PP for solar, wind small hydro and biomass utilization will be high enough.

However, other respondents have believed that this system should be changed for more advanced ones which would help opening the energy market. Therefore, they didn't agree that FiT is currently good policy framework for the country. Some of them were suggesting Feed-in Premium, some of them Tender systems. However, they were not satisfied with FiT for several reasons. One of the responded from NGO "Centrala" stated that FiT are "harmful" for development of Serbia. He stated that main problem is that building solar and wind power plants is based on imported technology. According to him, this basically means that we pay through our bills for profit of foreigner investors. shared an example of the negative effect of FiT. He stated that those incentives that are given to investors for 12 years should be invested in other more approachable utilization of renewables which will bring more benefit to Serbia in terms of availability of electricity and more job opportunities for young people. He concluded that this money provided through feed-in tariff system should be focused towards renewable energy resources which have capacity to be totally or practically supported by domestic production and therefore, he doesn't find current legal framework profitable for Serbia in general. Another interviewee from NGO also agreed that he doesn't find current supportive scheme adequate for good development of Serbian energy sector. The reasons he pointed out are like previous respondent. He explained that the costs of having this scheme that supports wind and solar PP building are high. He also stated that Serbia can have better utilization of hydro or heat pumps while getting more secure energy for lower prices.

What are the supportive schemes/policies whose implementation would help faster development RES sector in Serbia?

Respondents from non-government sector argued that biggest benefit of bringing new supportive schemes would be liberalization of energy market in Serbia. As most of them agreed this is suggested trough two possible market depended mechanisms such as auctioning and giving premiums to producers of renewable energy which are changeable according to the market price. While discussing this topic with all the interviewees, apart from governmental and expert form RE field, were in favor of either one of those supportive schemes. For example, respondent from international organization suggested introducing tendering system through the changes of the Energy Law of Serbia. He stated that this would be crucial step for liberation of energy market and would make renewable energy more affordable through time. As stated by interviewees from NGOs, both Feed in Premium and Auctioning

would work much better than current existing system, since it would bring lower costs. As they explained, in auctioning system, the permission to build will get the investor who offers the lowest price of electricity.

According to interviewee from government, those kinds of market depended suggestions are already proposed by Energy Community and EU. However, interviewees from governmental sector are still arguing that these measures would work well in countries with highly developed energy markets. Therefore, they are concern how implementation of those policies would work in Serbian, which has still poorly developed energy market. One of the respondents from government explained that introduction of premium tariff and auctioning systems would, as believed, decrease costs of energy due to the increase of competitions. However, he is questioning would this system work well in Serbia since he outlined that Serbian market basically doesn't exist. Therefore, they will put high effort in deeply evaluation and planning of those system in the future, since, as the part of Energy Community they will be obliged to introduced them sooner or later. Serbin expert in the RE field was claiming that auctions might lead to total cut down of domestic investors since foreign investors can offer lower prices because of more developed industry and competitiveness. This interviewee gave an example of Croatia as a bad outcome of implementation of auctions due to the relatively undeveloped energy market as Serbia has. According to this interviewee, one more issue lies in belief that premium system would not work well due to the current monopoly hold by public company "Elektroprivreda Srbije".

Important concerns regarding the general policy framework, outlined by one NGO interviewee is the fact that all supportive schemes are related to electricity production. He stated that government should provide more incentives from energy productions for heating or biofuels in transport. As he outlined, necessary measures consider spreading those supportive schemes in other spheres besides electricity. He especially indicated importance of developing policies which would allow local groups or individuals to invest for sake of producing their own electricity and accessing the grid. Other interviewee from the NGO also stated that one of his main suggestions for faster development of RES on local level would be new policy which would recognize smaller energy producers on microlevel and allow individual households or smaller groups to produce their own energy through satisfactory legal framework.

What are main barriers for faster development of Serbian RES sector?

All the interviewed stakeholders were questioned about barriers and obstacles for Serbian renewable energy sector development. Besides the importance of implementation of new policies and supportive

schemes that are covered in previous questions, there is one more outcome of the interviews regarding the barriers for RE growth in Serbia. This important concern, that was interestingly pointed out from all the respondents, is question of social aspect of Serbia. Throughout the interviews most of the participant stated that investment in education of people is mandatory for further development. Besides that, they outlined low awareness of Serbian citizens in regards of environmental protection and RE importance as a big barrier for further RE sector evolution. General opinion of all interviewees was that many investments both foreign and governmental should be focused towards the education of people in regards of environmental protection. As they all agreed, raising awareness of people about this issue would finally develop atmosphere in society that will be supportive towards future changes.

Respondent from NGO "Pokret gorana Vojvodine" believes that it is crucial to raise awareness of citizens about alternative possibilities for energy utilization. As he claimed during the interview, it all starts from the initial education about environmental issues and importance of utilization of renewable sources for future generation. According to his believes, people are not eager to bother about those things if they have cheap electricity. Currently usage of lignite is cheap and therefore people are satisfied without any will to think about alternative options. He believes that even people who are aware of solar panel utilization for their own needs and saw it from implementation in other countries would surely give up on this in Serbia due to the long administrative process and lack of legislative framework for supporting individuals who are eager to invest in their own households.

Interviewee from NGO "Mreza dobre energije" had similar point with previous respondent in regards of lack of information within the Serbian population. He believes that with increase of projects in this sphere as well as official promotion through media would be giving of credence to citizens about importance of this topic.

While discussing this topic with Expert in renewable energy sector in Serbia, she also outlined that current awareness of people is on the low level. However, she shared an example of different projects and foreign investment into campaign and workshops nowadays. She concluded that this process takes a lot of time and therefore we cannot expect drastic changes in short period.

Other interviewee from NGO "Centala" pointed out that awareness of people in Serbia about RE is tragic. As he claims, only small percentage of people even know what are the renewable energy sources and what it can bring to society. He believes that raising awareness can help for sake of informing people, but if they can't make profit or get cheaper energy from it, no one will be ready to invest.

Therefore, he stated that aggressive campaign together with legal framework for micro production that can pay out and make profit should be key targets of the government and NGOs.

5 Discussion and Recommendations

5.1 Introduction

In regards of data collected through literature review and interviews, this Chapter of the thesis will try to revise several key points. Firstly, mostly based on literature review with additional information gained from interviews, comparative analysis will be done for both potential and policies in Denmark and Serbia. After completing comparison, focus will be on the key recommendations proposed for Serbian faster development of RES sector. Recommendations will be outcome of examined literature and interviews.

5.2 Comparative analysis of renewable energy potentials in Denmark and Serbia

Danes are one of the most environmental protection minded nations due to their social engagement and awareness of renewable energy importance. Already in 2014 close to 30 percent of total energy production was from renewables while almost 60 percent of electricity was produced from RES (Ogden 2016). On the other hand, Serbia had only 18% of RE share in 2017 (Ministry of Energy and Mining of Serbia 2017). When talking about renewable energy potentials, both countries have significant amount of diverse renewable sources. Thanks to those renewable energy potentials, Denmark presents one of the world leaders in energy efficiency and security with 121% energy self-sufficient in 2010 (Sovacool 2013). Although rich with the sources, Serbia is far away from those developed achievements. Possibly crucial differences are based on the economy development of those two countries. It can be seen in the Table 5. below in drastic difference in both GDP and GDP PPP. In terms of the population, Serbia has 2 million more citizens. Additionally, electricity consumption and total primary energy supply (TPES) both countries obtain similar values. However, there are significant differences in terms of energy production, net imports and CO2 emission. Remarkably higher CO2 emission in Serbia is closely related to its high reliance on lignite fossil fuel for electricity generation. On the other hand, Danish strapping utilization of renewable energy comparing to Serbia is the reason for much lower CO2 emission. However, as a developing country, Serbia yet doesn't have strict commitments regarding CO2 emission decrease. Nevertheless, giving in mind that the main resource used for electricity generation is low quality lignite, Serbia will need to get ready for many changes once EU Emission Trading Scheme come on force. (Ministry of Energy and Mining of Serbia 2016). Higher energy production of Denmark can be related on their lower net import which are also seen in the Table 5.

Table 5. Overview of indicators of Denmark and Serbia 2015 Data: IEA 2016.

Denmark		Serbia	
Population (millions)	5.68	**Population** (millions)	7.10
GDP (billion 2010 USD)	341.01	**GDP** (billion 2010 USD)	40.18
GDP PPP (billion 2010 USD)	253.13	**GDP PPP** (billion 2010 USD)	87.72
Energy production (Mtoe)	15.95	**Energy production** (Mtoe)	10.76
Net imports (Mtoe)	2.27	**Net imports** (Mtoe)	4.10
TPES (Mtoe)	16.10	**TPES** (Mtoe)	14.76
Electricity consumption* (TWh)	33.02	**Electricity consumption*** (TWh)	32.21
CO2 emissions** (Mt of CO2)	31.98	**CO2 emissions**** (Mt of CO2)	44.51

However, according to the World Bank Data (2018b) In Serbia in 2016 GDP per capita was 5.348 USD while in the identical year in Denmark same value was for enormous ten times higher, 53.417 USD per capita. This points out drastic gap of those two countries in terms of possibility for investments into costly technologies for renewable energy production.

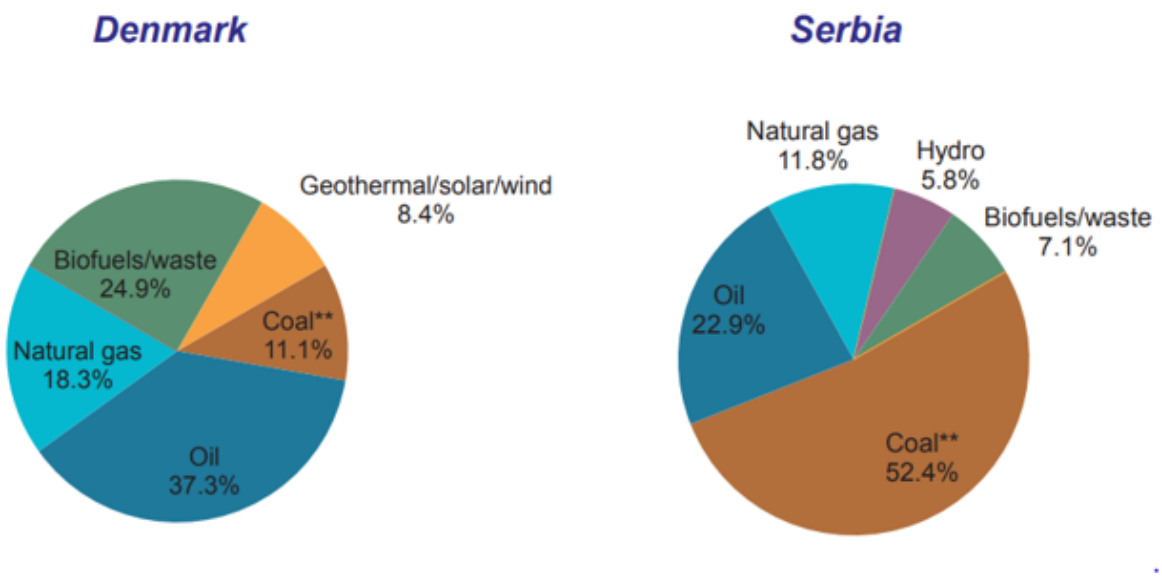

Figure 13. Share of total primary energy supply in 2015 in Denmark (16 096 ktoe) and Serbia (14 756 ktoe) Source: IEA 2016.

In the Figure above, share of total primary energy supply in both Denmark and Serbia is shown. The differences noticed in the fossil fuels on two pie charts is remarkable. Serbia still relies for more than a half of its energy supply on highly polluting lignite. However, according to this pie chart from International Energy Agency data (2016) utilized renewable potentials of Denmark stood for 24.9 and 8.4 percent from biofuel/waste and geothermal/solar/wind, respectively. On the other side, same source of data for Serbia showed that in 2015, 7.1 and 5.8 percent were presented by biofuels/waste and hydro energy, respectively. This displays significant difference in RES share of primary energy supply of those two countries. However, as mentioned before, Denmark presents almost ideal example of a country for its energy efficiency and RE utilization, while Serbia is on the beginning of its long way for notable achievement.

Danish crucial source of renewable energy production is wind. Their total RES potential is estimated by Danish Energy Agency (DEA) as a part of “Energy 21” plan (Liu and Lund 2014). Energy 21 plan is created back in 1996 and therefore estimation of the potentials is quite old. For that reason, it is believed that it is undervalued, especially talking about offshore wind turbines whose evolution in terms of technology is progressing every year (Liu and Lund 2014). However, at that time, estimated potential form onshore wind was 5 to 24 TWh per year while for offshore was 15 to 100 TWh per year (Liu and Lund 2014). Meaningful wind potential of Denmark is due to its geographical position with big area of flat land and offshore potentials. On the other hand, potential of wind utilization in Serbia is 0.103 million toe/ year

which is significant number considering lack of geographical richness of offshore potential like Denmark has. However, as argued before, wind technology for Serbia is still unapproachable in bigger amount due to its high price. All the current projects of windfarms in Serbia are based on the foreign investments through the Feed-in Tariff system that was described in the previous Chapter.

Biomass is main source of renewable energy in both countries. According to DEA (2017), biomass covers 2/3 of total renewable energy produced in Denmark including electricity, transport and heat production. Furthermore, in Serbia, 63% of RE potential is from biomass (Ivezic et al. 2013). This prospective is covered by wood and agricultural biomass (Golusin, Tesic, and Ostojic 2010). There are also some similarities between those two countries in terms of biofuels consumption. Althoug Denmark is distincitvly more developed than Serbia in terms of Climate Change goals and energy sector, yet total transportation sector is still depended on fossil fuels (Sovacool and Tambo 2016). As noted by Sovacool and Tambo, current infrastructure and cold weather will be main barrier for Danish achievement in facing out fossils from transportation sector. However, biofuels in Serbia are still on the beginner stage. According to the interviewee form government, they are currently preparing plans and polices in regards of biofuel utilization and expecting some first steps in production in upcoming years. Nevertheless, the potential for production of both first and second generation of biofuels exists due to the significant surface of Serbian arable land (Ministry of Energy and Mining, 2016).

Regarding hydropotential, Serbia is very rich and developed unlike Denmark. Capacity of the production of installed hydro PP is 10.5 TWh/year (Ministry of Energy and Mining, 2016) which is believed to be only 60 percent of total potential (Tešić en al. 2011). On the other hand, due to its flat surface, Denmark doesn’t have any significant hydro potentials.

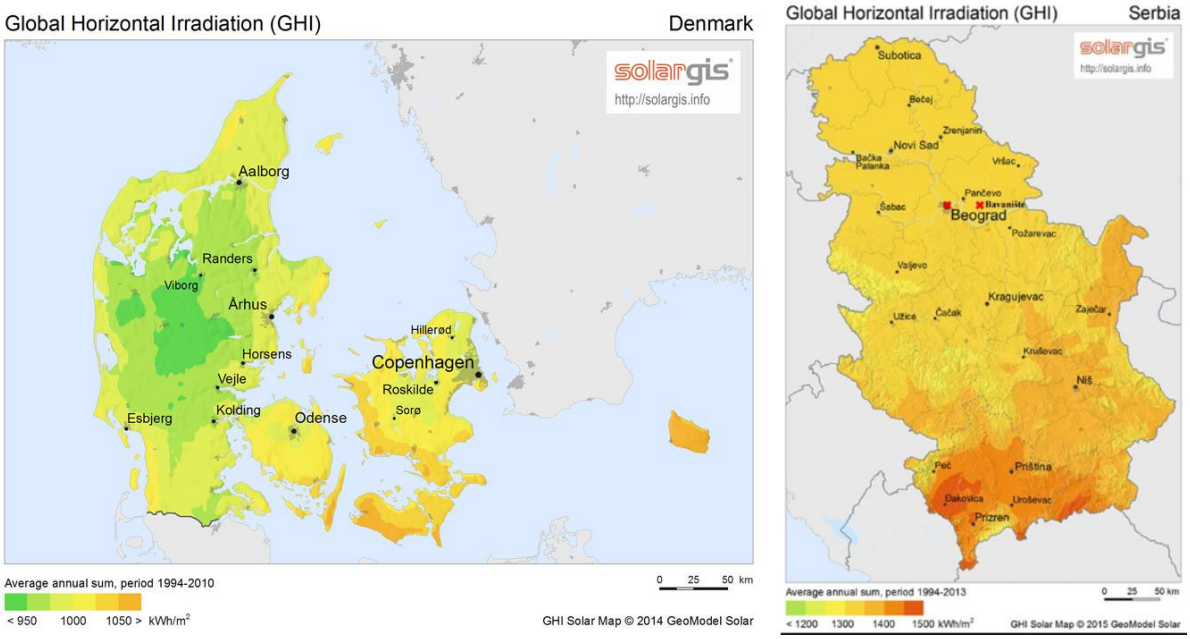

Figure 14.Maps of Global Horizontal Irradiation of Denmark and Serbia. Source: Tešić *et al.* 2011.

Solar potential in Serbia is significant. However, its potential is underused. Share of solar together with biogas and wind in RE production stands for less than 1 percent (Ministry of Energy and Mining of Serbia 2016). Yet, in Denmark solar stood for 2.2 percent in electricity production in 2015 (DEA 2017). In the Figure 14, maps of Global Horizontal Irradiation of Denmark and Serbia are shown. It is not hard to notice that Serbia has much higher potential due to the higher number of solar days and average annual sum of irradiation. Yet, as already stated regarding wind energy technology, for Serbia investments in solar cells or panels is still overpriced and potential is mostly relying on foreign investments and FiT systems.

5.3 Comparison of renewable energy related policies in Denmark and Serbia

During the conducted interviews, most of the examined people were outlining importance of the implementation of new supportive schemes into Serbian legislative framework. Moreover, in order to gain a more detailed insight, comparison of Danish and Serbian renewable energy policies and strategies will be shown in the table below and examined in the further text.

Danish beginning of developing policy framework for renewable energy utilization started much earlier than in Serbia. Since most of the energy production was dependent on the oil imports, Oil Crisis in 1970s brought many troubles to Danish energy sector. To overcome energy scarcity at that time, Denmark needed to implement energy saving measures and find alternative for coverage for energy demand.

After number of years and plenty of given effort from social movements, Danish government finally focused on renewable energy production as an alternative and phased out plan of nuclear power plant building. On the other hand, Serbia, at that time part of Yugoslavia, did not suffer with sanctions and huge consequences of the oil crises since it was mostly utilizing natural resources with some imports of Soviet Union, Libya and Iraq (Ministry of Energy and Mining of Serbia 2016). Besides that, Yugoslavia had plans of building nuclear PP in the today territory of Slovenia and therefore, there wasn't a need for big focus towards some other alternatives and development of RE industry.

Table 6. Comparison of crucial policies in the field of RES promotion in Denmark and Serbia Source: Liu and Lund, 2016.

Policies/solutions for renewable energy promotion	Denmark	Serbia
Feed-in Tariff (FiT)	✓	✓
Premium Tariff	✓	X
Investment subsidies	✓	X
Energy tax strategy	✓	X
Tender process	✓	X
Long-term government support for research and development	✓	X
Government energy planning and targets	✓	✓

As shown in the Table above, Danish renewable energy strategies and polices are significantly diverse from Serbian. High spread of supportive schemes as a policy mechanism is common for all developed European countries. Feed-in tariff system was initially favourable for smaller projects and more valuable incentives are given for national priorities (like wind power generation in Denmark) or in case of high-priced technologies (Fischer and Preonas 2010). Danish government implemented FiT system in 1993, 16 years before Serbian government did. In the case of Denmark, policy development and supportive schemes for RES started already in 1970s after the oil crises. Implementation of Feed-in Tarif system happened in 1993 together with high investments in technology research (Liu and Lund 2014) which helped fast maturation of wind turbines market and therefore growth of wind utilization. Many authors are arguing weather this system is good since it leads to over-subsidization (Liu and Lund 2014). However, this system has required utilities to buy produced electricity from wind power paying 85% of the total price (Liu and Lund 2016). Nowadays, this kind of FiT system is common for solid biomass, biogas and CHP power plants with specific circumstances (Liu and Lund 2016). On the other hand, in

Serbia this is currently the only available supportive scheme introduced by government back in 2009. As explained by one of the interviewee, the expert in the field of RE in Serbia, current FiT is third package of Feed-in Tariff system and it is expiring in the end of 2018. From the government perspective FiT was good option since they believed that financial incentives will be the best driving force for different companies to decide upon investing in Serbia (Ministry of Energy and Mining of Serbia 2016). Some of the main statutory provisions that support this policy mechanism in Serbia are among others, Energy Law, Regulation on Incentive Measures, Regulation on Privileged Producer Status and PPA (Ministry of Energy and Mining of Serbia 2016). In those three documents are giving warranty of buying total amount of energy produced from renewables which is in correspondence with priority entry of this type of energy to the grid-system as stated in Directive (Ministry of Energy and Mining of Serbia 2016).Finally, this supportive scheme brought many foreign investors and projects to Serbia. As stated in different reports of Ministry of Energy and Mining, many new wind, solar, biogas and small hydro power plants are built or under construction thanks to this system.

However, FiT system is not opening energy market for more competitive negotiations. Therefore, besides FiT system, there are many other supportive schemes in Denmark which are still under consideration in Serbia or yet not in the plan. As discussed in the previous chapter, policy such as Premium Tariff and Tender Process are planned to be implemented in Serbia, but still without any exact date or estimation. These two supportive schemes would help Serbia in liberalization of energy market. In Denmark, Premium system together with Tender process achieved this liberalization. Both of those mechanisms are mostly used for offshore and onshore wind production (Liu and Lund 2016). Although Denmark has highly developed energy market and technology companies, it is believed by some of the interviewees that those two supportive schemes would drastically help Serbian poor energy market to develop and increase competition which would provide lower prices for electricity. Those two systems were important steps that helped further opening of the market which eventually brought Denmark to current stage of wind energy utilization.

Besides already pointed out supportive schemes, worth mentioning are Investment Subsidies. Those measures are important for promotion of renewable energy usage. Subsidies had important role after the Oil Crises in Denmark. Together with other policies it leaded to faster energy transition of the country towards renewables. After the crisis, 30 percent subsidy was provided for producer plus feed in tariff which guaranteed purchase of that energy produced from wind (Odgene 2016). That was the reason that in the beginning of 21st century 80 percent of wind turbines was property of many

households (Odgen 2016). As stated by Odgen (2016), in the history of the country trust and cooperation between government and people was always on the high level. Government cares about people and their voice is of importance. In Serbia, on the other hand, those subsidies are still not existing although its believed by some of the interviewees that it would be great step towards more investments in RE of Serbia. Additional, relationship between people and government in Serbia can't be comparable with high connection and trust existing in Denmark.

Energy tax strategies are important part of legislative framework in Denmark. They have several types of this taxes. Most important ones are taxes on usage of any kind of fossil fuels and CO2 emission taxes (Liu and Lund 2016). It is debatable if this system would work in Serbia due to the still dominant amount of fossil usage as a crucial and cheap resource of electricity. Additionally, long-term government support for research and development started over 30 years ago in Denmark, in 1982 (Liu and Lund 2014). Even after oil crises and creation of small anti-nuclear communities, many researchers in the field of RE focused towards providing alternative, renewable energy-based plan to government to dismiss nuclear from the official plans. After government have accepted this proposal some years afterwards, significant investments were focused toward research of technologies for utilization of natural resources. This early focus of government towards creating educated and experienced experts in this field, made Denmark world leader in wind utilization and technology production. Contrary, Serbia is not even close to follow Danish development. Overall believe of the interviewed people from Serbia was that Serbia lacks for more investment in education and research. As explained by one of the interviewees, currently there are many investments from foreign organisation and government. Yet, this process takes long time to achieve noticeable results.

Finally, government energy planning and targets are present in both Denmark and Serbia. Since the oil crises in 70s till now, Denmark developed 4 significant Energy Plans (Liu and Lund 2014) which were described in detail in Chapter of Literature Review. Regarding the strategy and goals for future, Denmark is currently following "Energy Strategy 2050" (Liu and Lund 2014). Targets outlined in the strategy are quite ambitions, but due to the flow of Danish development, they are justified and achievable (Sovacool 2013). Some of the targets are: phasing out coal by 2050, relying on renewable energy totally in electricity and heating sector by 2035 and 50% of electricity produced form wind by 2020 (Greenpeace 2014). On the other hand, Serbia also has developed Energy Sector Development Strategy of the Republic of Serbia by 2025 with projections by 2030, yet without any high and ambitious targets. Focus is achieving EE (energy efficiency) and decreasing air pollution with the concentration toward

sustainability measures (Ministry of Energy and Mining of Serbia 2016). Besides that, important thing outlined in the Strategy plan of Republic of Serbia is, besides building new environmental friendly technologies, also renewal and modernization of the old once since mean age of current installed capacities is more than 25 years, shockingly main thermal plants are 45 years old with energy efficiency of 30 % (Ministry of Energy and Mining of Serbia 2016). However, although Serbia doesn't have highly ambitus measures as Denmark in Energy Strategy plan, there are significant goals which would, if achieved, bring the energy market closer to the developed stage of Danish example.
To conclude, policy measures and supportive schemes in Denmark and Serbia are hardly comparable. Huge problem of Serbian energy policies are unwell thought-out supportive systems. Finally, some of the measures could be introduced from Danish case study which will be discussed further in the Recommendation subsection.

5.4 Recommendations for better utilization of RES in Serbia

It's important to be mindful of the fact that for development of significant recommendations, number of interviews should be remarkable. Due to scarcity of interviewed people in this thesis, those recommendations are not completely reliable and present only writers overlook brought by existing data and seven completed interviews. Combination of information gathered during both literature review and interviews were divide into three groups for recommendations using content analysis method. Firstly, barrier for faster development of RES sector was noticed in social sector through a lack of awareness of people. Thanks to given example of social movements power after the Oil Crises in 1970s in Denmark, it is believed that informing citizens and raising awareness about importance of solving environmental issues would be important step forwards in Serbia. Secondly, thanks to the comparison of existing policies in Serbia and Denmark and interviews with people, proposition of specific supportive schemes will be given. Lastly, due to observed success of Danish local community investments in renewable energy, third proposal will suggest what can be done in Serbia on the local level.

5.4.1 Auctioning as a policy measure

Current Feed-in tariff system in Serbia has many advantages. Three main benefits of the system are assured connection to the grid, long term contracts, and increased payment with higher production (Couture *et al.* 2010). Other good side is freedom of any kind of institution to invest. This system is good for Serbia due to the economic situation of the country and fact that renewable energy technology costs are still great limitation to higher utilization of Serbian abundance of natural resources. Therefore, FiT is

providing stable market for foreign investors (Couture et al. 2010). On the other hand, disadvantage can appear if this system is rapidly growing and introducing new types of technologies which would finally lead to increase of electricity prices (Couture et al. 2010). Besides that, FiT is not providing competition among project developers (Couture et al. 2010). This is due to the fixed price system which is not depended on the market but giving warranty of payment for agreed period (Couture et al. 2010). Since this system is overaged in many European countries, in the past decade more developed and advanced supportive schemes are being introduced. Giving the above, some of those new policy systems should be introduced in Serbia for sake of further development of RE utilization. Currently, one of the two main mechanisms are introducing globally, Premium and Tender systems. Both systems are helping liberalization of energy markets.

Premium FiT systems are market depended and rewords "a premium above the average spot electricity market price"(Couture *et al.* 2010). This system can lead to the higher selling prices of renewable energy since electricity is sold on the spot market plus premium above the market price is given to producers (Couture et al. 2010). Although premium FiT is shown to be more expensive in some cases, it is better option in terms of competitiveness since its giving chance to both renewable and conventional energy to be put on the sale on the spot market (Couture *et al.* 2010). However, there are several cases where this system didn't show up well. One of the examples is Denmark. After phasing out of FiT system, there was noticeable decline in wind power utilization. With previous FiT system, the growth was drastically showed from 500MW to 3000 MW in the period from 1993 till 2004 (IRENA 2012). However, in the first 4 years after new mechanisms was introduced only 129MW of extra wind usage was noticed (IRENA 2012). Giving in mind that this system didn't work out in well-developed energy market such as Danish, there are conference about successful implementation of same scheme in Serbia. Most of the interviewees outlined the importance of bringing news policies which would help opening the energy market. However, several of them had a concern regarding this one. Respondent form Ministry of Energy and Mining stated that Serbia, as a part of Energy Community which so obliging implementation of EU policies, will need to turn to the Premiums sooner or later. However, he is conferenced weather this policy would work well. Other respondent also stated that with the current situation on the Serbian market, this scheme would not work well. As stated by this interviewee, expert in the RE sector in Serbia, this would work only after diversification of production and suppression of current monopoly of Serbian energy market.

Giving all the above, the suggested policy measure for Serbia would be Tender or Auctioning system which would provide lower energy prices and would strive for liberalization of energy market. From 2009, as a part of energy supportive scheme, tenders were introduced in Denmark (IRENA 2012) which additionally helped market liberalization and increased competitiveness among interested companies and showed up as a successful supportive scheme. The change of the monopoly in the market would massively help Serbias faster development. Therefore, positive change would be Tendering quota systems where state itself determine conditions and then calls for tender would be open (Odgaard 2000). One of the respondent that was interviewed through email was Director of Energy Community, important international organization that strives to create open energy market in EU. He stated that EnC proposed to Ministry of Energy and Mining in Serbia to introduce auctions through the changes of the Energy Law but Ministry ignores such proposals. As he claims, auctioning is much cheaper and in general doesn't allow political intervention in the decision who will be eligible receiver of the state aid. As he pointed out, new approach for the design of the support schemes for renewable energy in Serbia is needed. In the official proposal sent to the Ministry of Serbia in charge, he explains that the schemes require scrutiny to ensure they are proportionate and do not create undue distortions in the market, claiming that current feed-in tariff system is not proportionate and therefore needs to be changed. As he believes, public intervention in Serbian market is needed for sake of better promotion of renewable sources and to achieve policy objectives. Although there is general concern about those policy measures in undeveloped energy markets, there is some good example of these implementation. He gave an example of neighbouring country, Montenegro, which is also member of EnC and as well as Serbia obliged to follow modern energy policies as a part of the path toward European Union membership. He describes that in Montenegro, thanks to this system, they already plan a construction of PV power plant where the investors will have to pay to state to use its land for construction and will not receive any operational support. Ultimately, he gives grounds for good outcome of this system due to the incredibly fast technological development which will soon allow construction of renewables power plants without any subsidy. To summarise, although the success of auctioning in Denmark might be interconnected to some extent with well-built energy market, according to interview and given example of small country success, it is believed that this system would have good outcome if implemented.

5.4.2 Raising awareness of Serbian citizens about the importance of RE and environmental issues

After the oil crisis, changes in social and political system of Denmark lead to achievement of current successful status of highly developed country when it comes to renewable energy utilization. There is a lot that Serbia can learn from this case. Before beginning of 2000s, 80 percent of total amount of wind turbines were owned by more than 175 000 Danish households, individuals or local collectives which started already back in 70s. (Mey and Diesendorf 2017). These kind of wind partherships were created from the bottom-up consumers that agreed on sharing and utilizing existing natural power (Bolinger 2001).

Danish energy transition is one of the most examined examples. The core of its changes after the 70s were social movements and domestic collectives followed by educated engineers and their innovation (Mey and Diesendorf 2017). After the oil crises, country which was highly depended on imported oil and with significant energy consumption rate(Mey and Diesendorf 2017) needed to make drastical change in order to develop energy security. At that time, three key actions were undertaken according to Mey and Diesendorf. Firstly, consumption of energy needed to be reduced. Secondly, implementation of new legal framework was mandatory. Finally, development of energy strategy 1974 to 1979 with significant measures. Organisation for Information about Nuclear Power was created after the proposal of nuclear plant building plans in Denmark in 1974 with the goal to inform Danes about problems of nuclear power utilization (Mey and Diesendorf 2017). This was a good example of how the voice of the citizens of one country can make drastic changes. Besides highly educated people from the sphere, many tennagers, students and NGOs were part of the spreading voice (Kooij et al. 2018). Through the public debate this organisation came out with 50 collectives in the main beginningng and number didn't stop spreading as well as the ideas (Mey and Diesendorf 2017). Afterwards, they finally ended up with creating Renewable Energy Organisation (Mey and Diesendorf 2017). This organisation merged together best scientis and engineers in the field. This anti-nuclear organization was doing everything to spread the word. Almost one million newspapers were printed and distributed to Danish citizens while in the same time they were gathering signatures against nuclear power plant construction (Mey and Diesendorf 2017). Further establishment of Danish Wind Turbine Owners Association was created by professionals and experts from the field of wind renewable energy production in1978 with the aim of encouraging of buying at that time costly wind turbines (Mey and Diesendorf 2017). Finally, Government gave up on the nuclear plan and implement many new policies regardin the wind power utilization. The first plan from 1979 was

installation of 60 000 small wind turbines by the bginning of 21st century initially adopting tax free investments and ifeed in tarrifs (Mey and Diesendorf 2017).

Voice of the regular people and citizens in Denmark against nuclear energy was not just simple protest but rather argumented fight for erenewable enrgy utilization. People had exact alternative, a realistic path for green future. Therefore, one of the suggestions which would possibly bring Serbia faster development of the RE sector is indeed raising awareness of people and investments in their education. Social aspect of one country is believed to be as important as policy making. During the study on the social awareness of EU countries regarding the environmental protection and climate change, over 90 percent of interviewed Danes were feeling compassionate and responsible about these topics (Ogden, 2016). Simply, if they were not aware of the potential for renewable energy utilization back in 1970s, evolution path of policy makers might be different. Worth mentioning is also the importance of investment in research in Denmark. One of the main bodies for decision about priority of policies is Ministry for Science, Innovation and Higher Education together with Ministry of Climate, Energy and Building (Energy Research Knowledge Center, 2016). Education and research are important in every society and Danish investments in this field from the early stage of policy development helped them to become one of the leading countries in RES utilization and a world leader in wind technology production.

Regarding this, all of the interviewees agreed on the importance of this topic. All of them believe that in Serbia people are not well informed about the real impact of Climate Change and air pollution caused by combustion of low quality lignite. Overall thought of interviewees was that current situation about social awareness in Serbia is disappointing. They agreed that RES projects would be more social acceptable and implemented on the local level if people are more informed about importance of renewable energy. They also pointed out that educating professionals in this field would lead to the creation of better strategies and plans and possible development of the industry for RE utilization. However, one of the interviewees emphasized that the importance of costs is crucial. As he outlined, low living started, in comparison to Denmark, is not leaving the space for people to think about high investments. He believes that only in the case of investments that would pay-off after understandable number of years can be considerable in relatively poor society like Serbian. He claimed that only informing people with exact plan and counted costs of the measures on local level would bring achievements and bottom up

investments of the people. For that to be achieved, as he believes, we need to start from policy measures that would make “less painful” process of the individual investments in Serbia.

Finally, having in mind this enormous influence of education and awareness in Danish case study and overall opinion of interviewed experts from Serbia, this recommendation can be justified. Both government and non-government organization should concentrate towards educating society. It can be through different campaigns, workshops, TV and radio, or simply by implementation of relevant subjects and departments on university whose focus would be renewable energy capacities in Serbia. If the country introduces the plan in educational institutions, it can be sure that already next generation will be raised with high awareness of the proposed problems and topics. However, currently almost none of the Universities in Serbia have adequate programmes for creating experts in the field and therefore, lack of educated specialist is understandable. It is necessary to commit towards making changes in different levels to reach overall achievement. It is long process and changes should not be expected immediately. However, we should start from the tiny steps cause after all, with the power of united people, everything can be possible.

5.4.3 Heat pumps as the most feasible solution for current situation in Serbia

After completing interviews with experts from different sectors related to renewable energy and gaining information through literature review final recommendation for Serbia was made in favor of utilization of geothermal capacity in the form of heating pumps. Besides heating pumps, Denmark is well known for high usage of geothermal energy for district heating. However, with the current economic situation, for Serbia, only usage of geothermal pumps for heating would be recommended as the most feasible solution.

Several interviewees outlined that, with the current economical capacity of Serbia, would favor heat pumps as the highest potential of renewable energy sources. Generally, there are several advantages of this system. These potentials are already examined in Serbia, pumps and equipment is inexpensive without difficult development process (Stevanovic et al 2011). Also, they are in favor of climate change mitigation due to the low GHG emission and overall it presents inexhaustible resource (Stevanovic et al 2011). The process of utilization is not complex since geothermal pumps use heat from upper layers, up to 250 meters deep (DEA 2016). Claimed by one of the interviewees, investment is renewable energy sources in Serbia would be possible only if the profit is guaranteed over the understandable number of years which is the case of heat pump usage.

One of the interviewees from NGO “Centrala” was pointing out heat pumps as number one measure that Serbia should overtake regarding the affordable renewable energy usage. He claims that other sources of renewable energy don’t have high chances for significant development due to the higher costs of utilization. Respondent explained in detail that user would pay one quarter of price that he gives for heating from fossil fuels, which would pay off in the period from three to five years. He believes that if government invest in industry for producing heat pumps which would have either lower or same price as one imported from China, meaningful number of people would decide to choose this type of heating. He claims that this would be feasible since Serbia is naturally rich with copper who present one of the main materials for heat pumps production and therefore, this would bring many benefits to domestic market as it was back in the time of Yugoslavia.

Some of these projects are already existing in few municipalities in Serbia (Energetski portal, 2014). One of the great examples is hotel “Olimp” in Serbian mountain Zlatibor. In this hotel, heat is generated from thermal water with 10 degrees Celsius which was discovered nearby the building (Energetski Portal, 2014). Investment to this project for heating and cooling was 160 thousand of euros which will be payed of in the period of 3 to 4 years (Energetski Portal, 2014). Before installation of this heating pumps, hotel was using fossil which was far more expensive. It is believed that monthly savings with implementation of this system in hotel are 5 thousand euros (Energetski Portal, 2014). One of the fresh projects is the municipality of Bogatic in Central Serbia which will be the first example of geothermal heat usage for public facilities (Balkan Green Energy News, 2018). Yearly saving of this system will be from 100 to 150 thousand euros (Balkan Green Energy News, 2018). Those two examples prove that main investments and aspirations of the government and investors should be in this field of renewable energy. If in future more projects of this kind would exist, increase in energy efficiency and lower reliance on fossil utilization would be huge step towards making remarkable changes. Once people get the insight of savings they can make from heat pumps and government invest in the promotion of this RES, Serbia can be on the good way towards reaching higher utilization of its great potentials.

5.5 Suggestions for further research

Suggestions for the further research would be surely to involve higher number of stakeholders for the sake of interviewing and giving more reliable suggestions for implementation of Serbian policies. Moreover, to get greater insight in the certain field of RE, it is important to have interviewees from different spheres of renewable energy policies and resources. Throughout the research and interviews conduction, unluckily, none of the people from academia, public companies or business sector

responded to the emails. Therefore, the results of the interviews are not complete and reliably but only writers overlook about topic.

Additionally, one of the suggestions would be possible questioners or a survey of certain number of Serbian citizens in regards of willingness to invest in renewable energy on the local level while giving exact costs and projection of time framework for investments to pay off. Regarding that, interesting field of research can possibly be about needed legislative procedures of individuals or small groups willing to invest in heat pumps or small wind turbines for electricity or heat production. According to one of the interviews, these procedures are so long and administratively demanding that most of the people would give up on this idea. The research of those procedures and implementation of some good model from one of the Nordic developed country would be good recommendation for interested researchers. Governmental policy framework is not something we can directly affect. However, some steps on the local level would surely help development of Serbia on the smaller scale, which would affect general prosperity.

6 Conclusion

The aim of this thesis was to give comparative analysis on policies of Denmark and Serbia and finally propose some measures for Serbian development of renewable energy sector. The results of both literature review and interviews indicated that currently there are many barriers on the way to Serbian energy sector progress. However, although Denmark possess policies towards which every country should strive for, Serbia is still not able to follow that path. Therefore, this thesis was focused on revealing what are the things that should be brought from Danish example to Serbian society and policy systems in regards of renewable energy utilization. Both countries are rich concerning natural resources and have great potential for RES utilization. Yet, the main dissimilarity while doing the research was noticed in the part of economic and social development and lack of the education and awareness among Serbians regarding this topic. OPEC oil crisis was the trigger for Danes to develop strong sense of community and environmental awareness which resulted in total change of the energy policy plan. However, all bottom up movements and brought up ideas wouldn't be realised if the trust and care of government wasn't present. For the reason of noticeable gap in economic situation in those two countries (GDP in Denmark is ten times higher than in Serbia), technologically expensive and demanding projects of utilization of renewables are not considered as solution in Serbia. Yet, policy changes towards liberalization of energy market can still make big change on the Serbian transition path. Those changes in energy market can be brought by implementation of modern supportive schemes which would assumingly lead to higher development RES. Besides policy measures, investing in education and raising awareness of the citizens can bring prosperity to the society which further can influence development of the RE in the country. Finally, going through all sectors and potentials of Serbia as well as considering the cost, it was concluded that geothermal heat pumps have high potential for remarkable and cheap utilization. Sometimes people feel powerless in front of the obstacles which are not in charge of the individua, but more likely of someone who is deciding for us. However, even if we are not satisfied with the system that we cannot affect, there is always something we can do: to learn and to talk. United people with strong will can change a lot in the society which was explained through the achievements of anti-nuclear Danish movements. However, the most important thing is that Serbia has plenty of renewable resources and potentials which will, hopefully, one day be significantly more utilized.

"If so, then a new source of power, available at any point of the globe, in amounts practically unlimited, will be opened up." ***Nikola Tesla***

References

Arıoğlu Akan, M. Ö., Selam, A. A., Oktay Fırat, S. Ü., Er Kara, M., and Özel, S. 2015. A comparative analysis of renewable energy use and policies: global and Turkish perspectives*. Sustainability* 7 (12): 16379-16407.

Bolinger, M. 2001. *Community wind power ownership schemes in Europe and their relevance to the United States*. United States.

Burnard, P., Gill, P., Stewart, K., Treasure, E. and Chadwick, B. 2008. Analysing and presenting qualitative data. *British Dental Journal* 204 (8): 429–32.

Chamber of Commerce and Industry of Serbia (PKS). 2018. Unapređenje energetske efikasnosti kroz model javno-privatnog partnerstva [Improving Energy Efficiency through Public-Private Partnership Model]. Belgrade: Chamber of Commerce and Industry of Serbia.

Chalabi, F. J. 1997. OPEC: An obituary. *Foreign Policy,* 126-140.

Cherp, A., Vinichenko, V., Jewell, J., Brutschin, E., and Sovacool, B. 2018. Integrating techno-economic, socio-technical and political perspectives on national energy transitions: A meta-theoretical framework. *Energy Research and Social Science* 37: 175-190.

Couture, T. D., Cory, K., Kreycik, C. and Williams, E. 2010. *A policymaker's guide to feed-in tariff policy design*. Washington D.C.: National Renewable Energy Laboratory (NREL) and the United States Department of Energy.

Cropper, M. and Griffiths, C. 1994. The interaction of population growth and environmental quality*. The American Economic Review* 84 (2): 250–54.

Cuellar-Bermudez, S.P., Garcia-Perez, J.S., Rittmann, B.E. and Parra-Saldivar, R. 2015. Photosynthetic bioenergy utilizing CO2: an approach on flue gases utilization for third generation biofuels. *Journal of Cleaner Production* 98 (July): 53–65.

Danish Energy Agency (DEA). 2017. *Denmark's energy and climate outlook 2017*. Copenhagen: Danish Energy Agency.

Danish Ministry of Energy, Utilities and Climate. 2014. Denmark's national energy efficiency action plan (NEEAP). Copenhagen: Danish Ministry of Energy, Utilities and Climate.

_____. 2017. *Denmark's seventh national communication and third biennial report: under the United Nations Framework Convention on Climate Change (UNFCCC).* Copenhagen: Danish Ministry of Energy, Utilities and Climate.

Ehrlich, P.R. and Holdren, J.P. 1971. Impact of population growth. *Science* 171 (3977): 1212–17.

Ervine, C. 2015. Core Statutes on Company Law. London: Macmillan Education UK.

Fischer, C. and Preonas, L. 2010. Combining policies for renewable energy: is the whole less than the sum of its parts? Resource for the Future Discussion Paper No. 10-19. Available at: http://dx.doi.org/10.2139/ssrn.1569634

Friesenbichler, K. S. 2016. Policy interaction and the integration of volatile renewable energy. *Environmental Economics and Policy Studies* 18 (2): 193–211.

Gill, P., Stewart, K., Treasure, E. and Chadwick, B. 2008. Methods of data collection in qualitative research: interviews and focus groups. *British Dental Journal* 204 (6): 291–95.

Golusin, M., Tesic, Z. and Ostojic, A. 2010. The analysis of the renewable energy production sector in Serbia. *Renewable and Sustainable Energy Reviews* 14 (5): 1477–83.

Greenpeace. 2014. Denmark's commitment to 100% renewable energy. Greenpeace briefings. Accessed June 30. URL: https://www.greenpeace.org/archive-international/Global/international/ briefings/climate/2014/BRIEFING-Denmarks-commitment-to-100pct-renewable-energy.pdf

Hrayshat, E.S. 2007. Analysis of renewable energy situation in Jordan. *Renewable and Sustainable Energy Reviews* 11(8):1873-87.

International Energy Agency (IEA). 2010. *Renewables Information 2010*. Paris: International Energy Agency.

_____. 2016. Denmark – Energy system overflow. Accessed July 5. URL: https://www.iea.org/media/countries/Denmark.pdf

_____. 2017. *Energy policies of IEA Countries: Denmark 2017 Review*. Paris: International Energy Agency.

International Renewable Energy Agency (IRENA). 2012. *30 years of policies for wind energy: lessons from 12 wind energy markets*. Abu Dhabi: International Renewable Energy Agency.

_____. 2018. *Global Energy Transformation: A roadmap to 2050*. Abu Dhabi: International Renewable Energy Agency.

International Renewable Energy Agency (IRENA), International Energy Agency (IEA) and The Renewable Energy Policy Network for the 21st Century (REN21). 2018. *Renewable energy policies in a time of transition.* IRENA, OECD/IEA and REN 21.

Ivezić, D., Djajić, N. and Živković, M. 2013. The potential of and barriers to renewable energy sources in Serbia. *Energy Sources, Part B: Economics, Planning, and Policy* 8 (2): 162–70.

Jørgensen, M.S., Jørgensen, U. and Jensen, J.S. 2017. Navigations and governance in the Danish energy transition reflecting changing arenas of development, controversies and policy mixes. *Energy Research and Social Science* 33 (November): 173–85.

Jovanović, L., Ermakov, V. and Čajka, Z. 2014. Renewable energy resources in Serbia and Russia. *Zaštita materijala* 55 (2): 133-141.

Karakosta, C., Flouri, M., Dimopoulou, S. and Psarras, J. 2012. Analysis of renewable energy progress in the Western Balkan countries: Bosnia–Herzegovina and Serbia. *Renewable and Sustainable Energy Reviews* 16 (7): 5166–75.

Kooij, H., Oteman, M., Veenman, S., Sperling, K., Magnusson, D., Palm, J. and Hvelplund, F. 2018. Between grassroots and treetops: community power and institutional dependence in the

renewable energy sector in Denmark, Sweden and the Netherlands. *Energy Research and Social Science* 37 (March): 52–64.

Liu, W. and Lund, H. 2018. Comparative study of the potential of renewable energy sources and solutions between Denmark and China. Paper presented at Joint Actions on Climate Change, Aalborg, Denmark.

Lund, H. 2007. Renewable energy strategies for sustainable development. *Energy* 32(6): 912-919.

Malthus, T.R. 1960. An Essay on the principle of population. In *On population,* ed. G. Himmelfarb. New York: Modern Library.

Mey, F. and Diesendorf, M. 2017. Who owns an energy transition? Strategic action fields and community wind energy in Denmark. *Energy Research and Social Science* 35 (January): 108-117.

Milivojević, M. and Martinović, M. 1999. Geothermal energy possibilities, exploration and future prospects in Serbia. *Bulletin d'Hydrogiologie* 17.

Ministry of Mining and Energy of Serbia. 2014. *Progress report on implementation of the national renewable energy action plan of the Republic of Serbia.* Belgrade: Republic of Serbia, Ministry of Mining and Energy.

_____. 2015. Energy balance for 2016. [Energetski bilans za 2016]. Accessed July 3. URL: http://www.mre.gov.rs/doc/efikasnost-izvori/EN%20BILANS%20ZA%202016%20FINALNA%20VERZIJA%2018%2012%202015.doc

_____. 2016. *Energy sector development strategy of the Republic of Serbia for the period by 2025 with projections by 2030*. Belgrade: Republic of Serbia, Ministry of Mining and Energy.

_____. 2016. Energy balance for 2017. [Energetski bilans za 2017]. Accessed July 3. URL: http://www.mre.gov.rs/doc/efikasnost-izvori/EN%20BILANS%20ZA%202017%2012.12.2016.pdf

Odgaard, O. 2000. The green electricity market in Denmark: quotas, certificates and international trade. Paper presented at Workshop on Best Practices in Policies and Measures, 11 – 13 April 2000, Copenhagen.

Ogden, E. 2017. Structures, norms, and renewable energy policy: a comparative analysis of the driving forces behind energy policymaking in the United States and Denmark. Senior Theses, Trinity College, Hartford, Connecticut.

Pavlović, B. and Ivezić, D. 2017. Availability as a dimension of energy security in the Republic of Serbia. *Thermal Science* 21: 323–33.

Republic of Serbia. 2015. Intended nationally determined contribution of the Republic of Serbia. Acessed July 1. URL: http://www4.unfccc.int/submissions/INDC/Published%20Documents/Serbia/1/Republic_of_Serbia.pdf

Sands, P. 2013. The United Nations Framework Convention on Climate Change. *Review of European Community and International Environmental Law* 1 (3): 270–77.

Shafiee, S. and Topal, E. 2009. When will fossil fuel reserves be diminished? *Energy policy* 37(1): 181-189.

Schaffer, L. and Bernauer, T. 2014. Explaining government choices for promoting renewable energy. *Energy Policy* 68: 15-27.

Singh, B. R. and Singh, O. 2012. Global trends of fossil fuel reserves and climate change in the 21st century. In *Fossil Fuel and the Environment,* ed. K. Shahriar K. London: InTechOpen.

Smil, V. 2000. Energy in the twentieth century: resources, conversions, costs, uses, and consequences. *Annual Review of Energy and the Environment* 25(1): 21-51.

Smil, V. 2014. The long slow rise of solar and wind. *Scientific American* 310 (1): 52-57.

Smil, V. 2015. *Energy at the crossroads: global perspectives and uncertainties.* London: MIT Press.

Sovacool, B. K. 2013. Energy policymaking in Denmark: implications for global energy security and sustainability. *Energy Policy* 61: 829-839.

Sovacool, B. K., and Tambo, T. 2016. Comparing consumer perceptions of energy security, policy, and low-carbon technology: insights from Denmark. *Energy Research and Social Science* 11 (January): 79–91.

Tešić, M., Kiss, F. and Zavargo, Z. 2011. Renewable energy policy in the Republic of Serbia. *Renewable and Sustainable Energy Reviews* 15 (1): 752–58.

Vasić, G. 2018. Application of multi criteria analysis in the design of energy policy: space and water heating in households – city of Novi Sad, Serbia. *Energy Policy* 113 (February): 410–19.

Vasumathi, K. K., Premalatha, M. and Subramanian, P. 2012. Parameters influencing the design of photobioreactor for the growth of microalgae. *Renewable and Sustainable Energy Reviews* 16 (7): 5443-5450.

Zafir, C.Z. and Keivanfar, M. 2017. comparing renewable energy policies in the European Union and Turkey. *International Business Research* 10 (6): 112.

Young, R.M. 1969. Malthus and the Evolutionists: the common context of biological and social theory. Past and Present 43: 109–45.

_____. 2018a. World Bank database: country profiles. Accessed June 19. URL: https://data.worldbank.org/country/Denmark

World Bank. 2018b. World Bank database: country profiles. Accessed June 15. URL: https://data.worldbank.org/country/serbia