Sustainable Development of Lithuanian Electricity Energy Sector

Laura Aidukienė [1]

Gintarė Skaistė[1]

Abstract

Lithuania is very dependent on electricity produced from fossil fuels which is imported from the single source. Also, around half of the electricity consumed is imported from neighboring countries, mostly from Russia. After the shutting down of Ignalina nuclear power plant in 2009, thermal plants became the major producers of electricity in the country. Consequently, Lithuanian power sector must focus on augmenting energy sector independence by building new local electricity generation capacities based on nuclear and renewable energy and by constructing interconnections with European Union countries in order to benefit from unified market. Lithuanian government is willing progressively increase to 20 per cent the use of renewable energy sources in the production of electricity until 2020. Due to the Lithuanian climatic conditions geothermal energy and solar power are not used for power production and further development of hydropower plants is limited by environmental restrictions. Therefore, priority is given to wind energy development and installation of new biomass power plants. In this paper the possible future electricity scenarios for Lithuania are analyzed to identify the most adequate, independent, low cost and environmentally friendly energy source.

Keywords: electricity; electricity energy; sustainable development; Lithuania

1. Introduction

Electricity production is presently very much in focus in the environmental debate, due to urgent needs to mitigate climate change and to reduce the dependency on diminishing fossil fuel resources. Also, according to H.Moora and V.Lahtvee (2009), aggressive Russian commercial activity in the natural gas and oil markets has forced Lithuanian politicians to reconsider previous energy strategy, to make the security of energy supply the highest priority and take action to develop regional co-operation in the energy field. During 2012 in Lithuanian power plants 4,76 TWh of electricity were produced. During the same year 6,6 TWh (63 per cent of total consumption) of electricity energy were imported.

The electricity production in Lithuania includes a wide range of different types of plants – hydro, fossil fuelled condensing and combined heat and power, as well as pumped storage and wind. In the years to come, Lithuanian electricity sector is expected to go through major changes (Moora, Lahtvee, 2009).

Whereas, with growing economies of Lithuania and the Baltic States, a considerable lack of electricity supply will arise in the Baltic countries by 2020, amounting to a deficit of 1.3 GW of installed capacity (National energy strategy, 2010).

[1] PhD student, Banking and investment department, Faculty of economics and finance management, Mykolas Romeris University, Ateities st. 20, V-431; LT–08303 Vilnius, Lithuania.

In this paper the possible future electricity scenarios for Lithuania are analyzed to identify the most adequate, independent, low cost and environmentally friendly energy source. Because even comparing the higher costs of renewables with the environmental benefits, however, is not straightforward. Issues arise because the market value of electricity generation is very dependent on its timing, location, and other characteristics (Borenstein, 2012).

2. Sustainability of Energy Sector

A lot of opinions related to the estimation of sustainable development in scientific literature can be found. Grybaitė, V. (2011) citing Brundtland (1987) says that sustainable development is not a fixed state of harmony but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional changes are made consistent with future as well as present needs. It was emphasized that the economic growth is not enough. Sustainable development involves more than growth, it's indicators reflect environmental, social and economic aspects of development. Štreimikienė, Baležentis and Krisčiukaitienė (2012) in reach argue that sustainable development goals for *transition economies* are tightly related with *climate change* mitigation because these countries have high-energy intensities of economies, low energy efficiency in energy production and consumption sectors therefore the sustainable development goals for these countries include GHG mitigation challenges as well (Rammel and Van der Bergh, 2003). The targets of sustainable development in *energy sector* are related with reduction of energy intensity, increase of energy efficiency, increase use of renewable energy sources etc. All these issues have direct impact on GHG emission reduction.

Štreimikienė, Baležentis and Krisčiukaitienė (2012) remark that Lithuania has developed several important climate change mitigation policy documents however there are no attempts in Lithuania to develop local climate change mitigation policies or to decentralize climate change mitigation policy. Therefore seeking to achieve harmonization and decentralization of climate change mitigation and energy policies in Lithuania the framework for local climate change mitigation strategy need to be developed taking into account requirements, targets and measures set in national climate change mitigation and energy policy documents.

Directive, 2001/77/EC on the promotion of electricity produced from renewable energy sources (RES) in the internal electricity market sets the goal of raising the share of renewable forms of energy in the European Community's.

EU countries need to find secure sources of energy for future generations whilst taking account both of ecological objectives and economic growth. Alongside the important strategy of using energy resources sparingly and converting them efficiently, the Lithuanian Government is also promoting the use of renewable energy sources. A core component of its national energy strategy is to increase the share of RES in energy supply significantly.

According to National energy strategy (2010), Lithuania, like many other countries in Europe, is facing challenges in the energy sector on three main dimensions: energy independence, competitiveness and sustainability of the energy sector. This situation was determined by historic and political circumstances as well as scarce internal energy resources.

Most of fuel resources used in Lithuania are imported. After the shutdown of Ignalina Nuclear Power Plant (NPP) in 2009, the country is not able to satisfy its internal electricity demand. Now Lithuania turned from net electricity exporter into net electricity importer. Consequently, Lithuania is facing major shortcomings in electricity production.

Around half of the electricity consumed is imported from neighboring countries, mostly from Russia. The country is also very dependent on electricity produced from fossil fuels which is imported from the single source.

3. Nexus between Electricity Generation and Economic Growth

Uninterrupted and sufficient electric power supply is one of the most crucial determinants of stimulating economic growth for any economy. But the electricity sector in Lithuanian has been historically characterized by various processes. We present main indicators of electricity demand and supply.

Electricity production entry is the annual electricity generated expressed in kilowatt-hours. The discrepancy between the amount of electricity generated and/or imported and the amount consumed and/or exported is accounted for as loss in transmission and distribution.

As we see in 1 figure are shown the results of electricity production for 2000 –2012 period. The production of electricity production by this period decreased 21 per cent. The main reasons are the shutting down of Ignalina Power plant RBMK type reactors, which, could not be economically upgraded to a required level of safety and they were an acknowledged high risk.

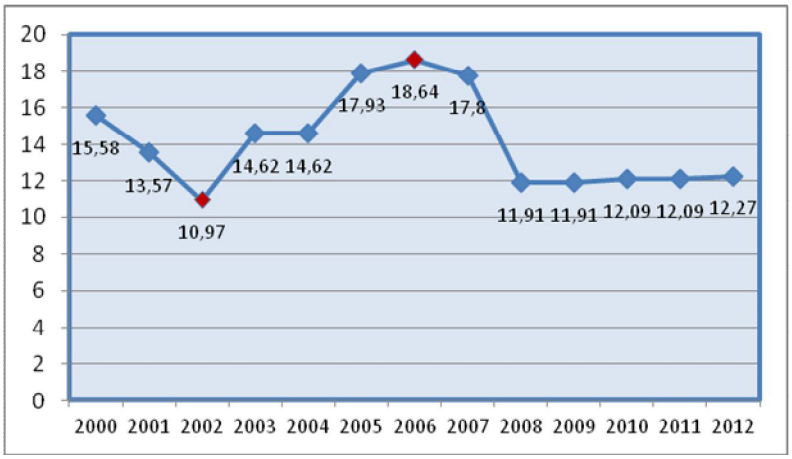

Figure 1: Electricity production (billion kWh) Source: Index Mundi

Already electricity production in 2007 was lower than in 2006 due to the first block of the Ignalina NPP close. As to the data of Central Statistical Board of Lithuania, rate of energy production in 2011 fell to 81.3 per cent. This decline occurred after the close of the second block Visaginas nuclear power station in 2010.

Electricity consumption consists of total electricity generated annually plus imports and minus exports, expressed in kilowatt-hours. The discrepancy between the amount of electricity generated and/or imported and the amount consumed and/or exported is accounted for as loss in transmission and distribution.

As we see in figure 2, consumption of electricity was the highest in 2005 period 10.17 per cent and then decreased by 10 per cent. In 2006 was fixed grow 3 per cent and 2007 electricity production increased 11 per cent.

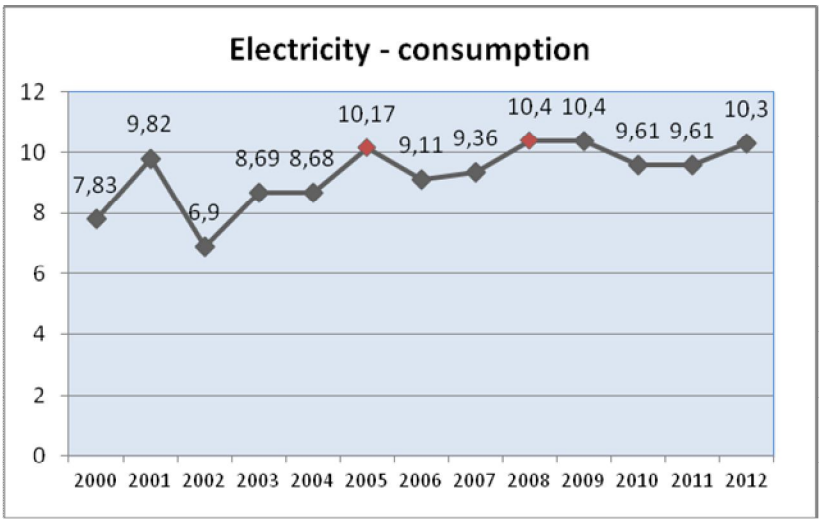

Figure 2: Electricity consumption (billion kwh) Source: Index Mundi

It can be said, that demand of electricity depends on factors that affect the economy such as trade, money based on their assessment of future economic growth. In addition to growth factors, the demand for electricity depends on the price of electricity.

Generally, demand projections have to take two main aspects into account: income drivers and price drivers. The income drivers are macroeconomic and demographic factors such as GDP growth, growth in household disposable income, population growth, growth in the number of households or the living space per capita, etc. Price drivers, on the other hand, are related to the price level for electricity and other energy sources that could substitute electricity (Observatoire Méditerranéen de l'Energie (2007).

The Lithuanian energy sector constructed through 1990 was oriented towards large, but inefficient energy consumption, as well as towards considerable exports of electricity. The energy policy in the former Soviet Union was based on principles of central planning and was directed to creation of strongly integrated energy systems. According to very high dependence on import of primary energy sources from Russia, the Lithuanian Government since early 1990s was concerned with political and economic consequences of this dependence. Therefore stimulation of increased use of renewable energy sources was one of the main strategic objectives in the country's energy policy (Miškinis, Konstantinavičiūtė, Tarvydas, 2009).

4. Former and New Connections

It is important to mention, that most of fuel resources used in Lithuania are imported. According to the National energy strategy (2010), after the shutdown of Ignalina NPP, the country is not able to satisfy its internal electricity demand. Lithuanian electricity network is not connected to the European electricity system and therefore electricity can be imported only from a very limited number of countries.

After the shutdown of Ignalina NPP, local electricity generation capacities are being increased and electricity sector is being restructured in order to ensure competitive and continuous electricity supply. Currently internal electricity network is being strengthened, construction of electricity links with Sweden and Poland has been started, a new electricity generation capacity in Elektrėnai was build, and electricity power exchange has been established. However, despite success in the development of the sector, full energy independence has not been achieved and consumers still can't buy electricity at competitive prices.

After shutdown of Ignalina NPP, Lithuania turned from net electricity exporter into net electricity importer. Consequently, Lithuania is facing major shortcomings in electricity production. According to National energy strategy (2010), around half of the electricity consumed is imported from neighboring countries, mostly from Russia. The country is also very dependent on electricity produced from fossil fuels which is imported from the single source.

In terms of infrastructure, Lithuania has a relatively old electricity grid with no interconnections with Continental Europe and Scandinavia. The interconnections are essential for Lithuania in order to increase the energy independence and to benefit from a single EU energy market.

In the country's electricity market, pursuant to the 3rd EU energy package, ownership of electricity generation was unbundled from transmission. In 2010 Lithuania started to gradually liberalize its electricity market. Market operator Baltpool was established, organizing the activities of the electricity market according to the principles of NordPool electricity market. This is the first major step towards creating an effective Lithuanian electricity market as a part of a single electricity market in the Baltic Sea Region and Continental Europe.

Strategic initiative in the electricity sector is creating electricity interconnections with neighboring countries to exploit common market benefits. Thus, construction of interconnection Lithuania-Sweden will create favorable conditions for export of electricity, in particular that generated by the new nuclear power plant, from Lithuania not only to Baltic Countries, but also to the Nordic countries (Deksnys et al, 2007). Therefore power systems of the Lithuania should be ready to compete with producers of neighboring countries and to comply with requirements of reliability and quality of electricity supply.

5. Sources of Energy

After shutting down Ignalina NPP, Lithuania is not a notable energy producer or consumer, ranking in the bottom five among the European Union countries. Nearly all of Lithuania's energy imports originate in Russia, including crude oil and liquid fuels, natural gas, and coal. Prior to 2009, Lithuania generated approximately 77 percent of total net generated electric power from nuclear sources. However, at the end of 2009, Lithuania closed its last nuclear reactor and electricity ceased to be the country's major export commodity.

Following the closure of the nuclear reactors in 2009, Lithuania became dependent on electricity imports to satisfy its demand. Although most of its 2012 electricity imports came from Russia, Lithuania also imports electricity from Estonia, Latvia, and Belarus.

5.1. Renewable sources of energy

In these days, the energy sector in Lithuania faces sustainability challenges. According to National energy strategy (2010), energy intensity per unit of GDP is 2.5 times higher than the EU average. This reveals vast untapped potential for energy efficiency. Lithuania's dependence on fossil fuels has caused CO2 emissions to increase, especially after the closure of the Ignalina NPP. This creates additional difficulties for sustainable development of the energy sector. Lithuania is already taking a number of measures to decrease the level of CO2 emissions.

Three measures are expected to have the largest impact (23 per cent): construction of the Visaginas NPP; increasing energy production from renewable energy sources; increasing efficiency of energy consumption. Timely and comprehensive implementation of these measures are expected to enable Lithuania to tap the full potential of curbing GHG emissions and limiting their maximum increase to 15 per cent by 2020 compared to 2005 as required by the EU Energy and Climate Package.

According to National energy strategy (2010), Lithuania will progressively increase the use of renewable energy sources in the production of electricity and heating as well as in the transport sector.

The state will aim to reach the target of no less than 20 per cent of renewable energy in the electricity sector. However, according to Moora and Lahtvee (2009), the total power of renewable sources will constitute only 6 per cent of total electricity production, since hydro, wind and biomass energy share will remain small as all government resources will be used to cover the construction costs of the new NPP, thus no state funds will be allocated to support renewable development. On the other hand, based on the modeling of the Lithuanian power system development (Rodins et al, 2013) it was discovered that taking into consideration expected reduction of electricity demand the share of green electricity in the gross electricity consumption will reach 13.6 per cent in 2020. So, we can conclude, that the real impact of government policies on electricity energy sector structure is still discussible issue.

Still, one of the main priorities appointed in National energy strategy (2010), is electricity generation from renewable energy sources. Major focus is put on the use of biomass in the Combined heat and power (CHP) plants and on the use of wind power. The state will create conditions to reach 500 MW of installed wind capacity by 2020. Priority is also put on full realization of hydro energy.

A more accurate picture of the Lithuanian energy can be made by analyzing the production and consumption of various forms of energy, reduced to a unified natural indicator ktoe (thousand tons of oil equivalent).

In 2012, Lithuania was made in the amount of energy 1866,1 ktoe, of which 60 per cent gave heat, 23 per cent of electricity, 13 per cent of the energy of chemical processes, 2 per cent hydropower and 2 per cent wind energy (3 figure). 736,3 ktoe of electricity energy were imported.

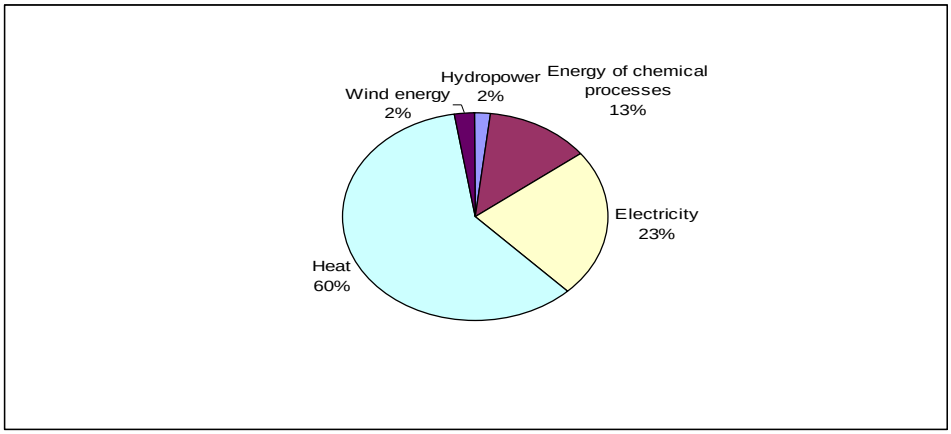

Figure 3: Forms of energy in Lithuania, 2012, per cent

Volumes of production of solar, geothermal and other alternative energy does not reach one per cent. Based on the recent analysis, fuel demand in the transport sector due to significant reduction of economic activities in all sectors of the economy and mobility of population in coming few years will growth more slowly, and in 2020 total consumption of motor fuel will be less by about 15 per cent compare with the previous forecast. Consequently bio-fuel will replace less petroleum products – about 330 thousand toe in 2020 (keeping in mind the same country's target that a share of renewable energy sources in the balance of fuel for transportation needs will increase to about 15 per cent). Certain reduction of bio-fuel consumption for district heat production and possibly for needs of final consumers is also expected. Thus, total amount of renewable energy sources would amount to about 1600 toe in 2020 (Figure 4).

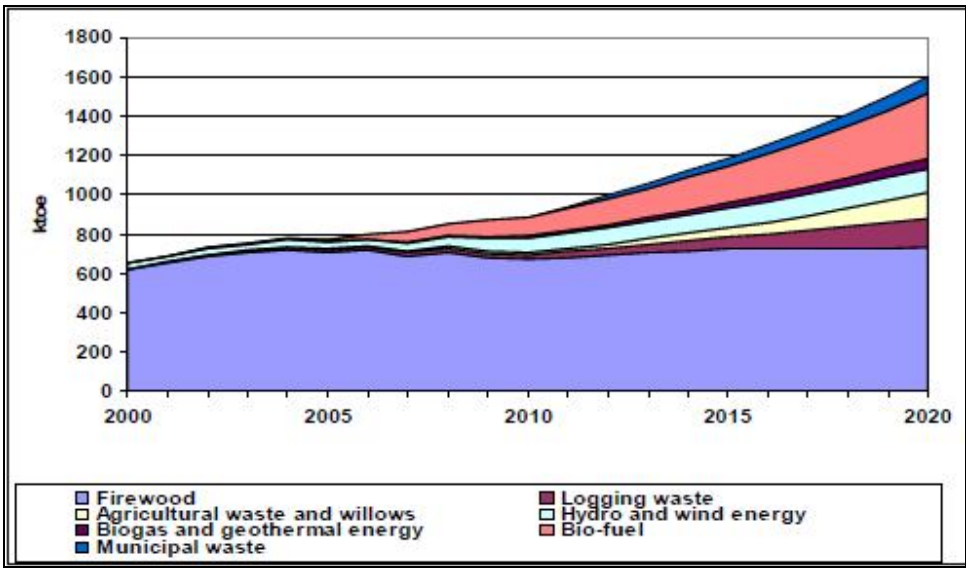

Figure 4: Development on utilization of renewable energy sources in Lithuania (rational scenario). National energy strategy (2011)

Performed analysis confirmed that Lithuania in a case of rational scenario also can reach the mandatory target of utilization of renewable energy sources established by the EU Commission (National energy strategy, 2010).

5.2. Nuclear power

The strategic safety of energy supply, highly unstable prices of fossil fuel and limited resources along with the climate change have become predominant factors making a great impact on the choice of future electricity production technologies. In this context, nuclear energy seems to be a reasonable option since it does not pollute the atmosphere, uranium mining industry is concentrated in the politically stable regions, fluctuations in the cost price of produced electricity are insignificant, and resources of natural uranium surpass those of fossil fuel (Grinevičius, Klevinskas, Koraliovas, 2009).

The decision about construction of a powerful power plant should be based on the analysis of its competitiveness in the internal electricity market as well as in electricity markets of Estonia, Latvia and other neighboring countries (Deksnys et al, 2007). Construction of a new nuclear power plant should be justified taking into consideration such factors, as: investment cost, discount rate, technical and economic indicators of alternative technologies, fuel prices, size of nuclear unit, regimes of power system operation, environmental requirements, country's international obligations, pace of electricity demand growth, decisions related to the problem of storage and final disposal of spent fuel and radioactive waste, policy and ways of modernization of district heating sector, necessity to increase usage of renewable energy sources, etc.

Nevertheless, construction of the new NPP has one important priority - nuclear fuel will significantly reduce utilization of natural gas for electricity production and will increase energy security in Lithuania and other Baltic States (Deksnys et al, 2007).

According to R.Deksnys et al (2007), construction of a new nuclear power plant in Lithuania as early as possible can be economically justified also in the case of high (20 EUR/t and more) taxes on CO2 emissions. Thus, commissioning of the new NPP in Lithuania could be justified by the necessity to reduce the dependence on import of expensive fossil fuels and to reduce harmful impact of emissions.

Building new local electricity generation capacities based on nuclear and renewable energy will help to provide competitive electricity prices for consumers, ensure Lithuania's security of electricity supply, and substantially increase the sustainability of the electricity sector (National energy strategy, 2010).

According to National energy strategy (2010), the main strategic project in electricity generation until 2020 is the construction of the Visaginas nuclear power plant (NPP). Although the investment is large, it is equal to around 10 years of payments for imported gas to produce the same quantity of electricity. In this regard, the Visaginas NPP is the most viable option to close the electricity supply gap. It would additionally bring a number of benefits: have a favorable impact on the local economy by attracting unprecedented levels of investment to Lithuania, creating jobs and orders for local companies. The NPP would operate for more than 50 years.

However, according to World nuclear association (2013), a non-binding referendum held in conjunction with a national election in October 2012 has clouded the prospects for the Visaginas NPP project. The referendum question asked if voters wanted new nuclear power capacity built, and 63 per cent said no. The Social Democrats had forced the referendum in order to make Visaginas NPP an election issue. The former Homeland Union-Christian Democrat Party was replaced, since Labor and Social Democratic parties did better electorally and formed a coalition with another small party. The matter will be decided by the new government. However, a 2009 year survey carried out for Lithuania's State Nuclear Power Safety Inspectorate (VATESI) found that 73 per cent of the population felt that it was possible to operate nuclear power plants in a safe manner. This is slightly up on the 69 per cent recorded in the European Union's 2006 Eurobarometer special survey.

Without Visaginas NPP, both Lithuania and its two Baltic neighbors to the north will remain largely dependent on Russia for electricity. Also the economic prospects of the 2400 MWe Baltic plant now under construction in Kaliningrad, 200 km from Vilnius, would be greatly improved. Russia's RAO UES (57% owned by Rosatom) has signed an agreement with its Lithuanian subsidiary RAO Lietuva to export 1000 MWe of power from this to Lithuania from 2017. However, Lithuanian former government was therefore not keen to buy electricity from it. Poland also discontinued talks with InterRao regarding buying power from the Baltic plant.

However, in March 2013 Rosatom said that Russia had officially notified the European Commission (EC) that it wanted its Baltic exclave of Kaliningrad to join the ENTSO system. The European Union (EU) authorized the EC to hold talks with Russia and Belarus on disconnection of the transmission systems of Lithuania, Latvia and Estonia from the IPS/UPS system controlled by Russia. According to the World nuclear association (2013), Rosatom renewed the proposal for a transmission link between Kaliningrad and Poland, and asked the EC to build this into the Baltic Energy Market Interconnection Plan (BEMIT) to obtain EU financial support. It appears that there was no positive response, and Lithuania continues to take measures to isolate Kaliningrad.

Lithuanian government has some concerns about their neighbors plans to build the nuclear power stations in the zones of Belarus and Kaliningrad near the borders of the EU. The building of the nuclear power stations whose safety is not guaranteed near the borders of the EU demands for the overall position of the EU Member States. Lithuania has a special experience in this sphere because the power nuclear stations will be built near the border of Lithuania. Also, the recent explosion in Fukushima opens the security question for a closer look, especially taking into consideration both the claims of insufficient scientific clearance for such construction and Belarus' tragic experience with the consequences of Chernobyl (Vasilevich, 2011).

6. Internal and External costs of Electricity Production

A large literature exists on the social cost of the air pollutants that power plants emit. For local pollutants, the cost varies across plants and depends very much on the population density, climate, and geography around the plant, as well as the presence of other pollutants (Fowlie, Muller, 2010).

On the other hand, renewable sources other than hydroelectricity (solar power, wind energy, etc.) are currently expensive to produce, though with advancements in technology their cost of production is coming down. Government of Lithuania provide subsidies to offset the high cost and make their production economically feasible. Issues arise (Borenstein, 2012), because the market value of electricity generation is very dependent on its timing, location, and other characteristics and because quantification of the nonmarket value from reduced emissions is difficult and controversial.

According to S.Borenstein (2012), the primary public policy argument for promoting electricity generation from solar, wind, and other renewable sources is the unpriced pollution externalities from burning fossil fuels. Similar opinion is given by World Nuclear Association (2012), saying, that environmental and health consequences are usually seen as external costs - those which are quantifiable but do not appear in the utility's accounts. Hence they are not passed on to the consumer, but are borne by society at large. They include particularly the effects of air pollution on human health, crop yields and buildings, as well as occupational disease and accidents. Though they are even harder to quantify and evaluate than the others, external costs include effects on ecosystems and the impact of global warming. These external costs of electricity generation technologies are highly important to analyze in order to create an effective policy to reduce the negative effects of energy supply and consumption (Štreimikienė, 2013). However, unless policies are adopted so that utility rates account for these societal and environmental costs, customers may ignore them when deregulation enables customers to choose their generating sources. Such policies might include pollution taxes or placing total limits on each emission for the geographic area affected by the emission (Katinas et al, 2008).

Production of electricity from any form of primary energy has some environmental effect, and some risk. A balanced assessment of electricity power source requires comparison of its environmental effects with principal alternatives.

Table 1: Electricity energy sources: Internal and external costs generates total price

Technology	Description	Lifecycle greenhouse gas emissions 50th percentile (g Co_2/kWh_e)*	Price EURct/kWh**	External costs EURct/kWh***	Total price EURct/kWh
Nuclear	Various generation II reactor types	16	0,05349	0,499	0,55249
Natural gas	Various combined cycle turbines without scrubbing	469	0,05349	3,197	3,25049
Coal	Various generator types without scrubbing	1001	0,05349	4,544	4,59749
Biomass	Various	18	0,11006	5,098	5,20806
Hydroelectric	Reservoir	4	0,06372	0,168	0,23172
Wind	Onshore		0,0753	0,166	0,1913
Solar thermal	Parabolic trough (integrated)	22	0,18536	0,463	0,64836
Solar PV	Polycristaline silicon (not integrated)	46	0,23459	0,964	1,19859

Sources: * Moomaw et al, 2011
**National control commission for prices and energy report online [www.regula.lt]
*** Štreimikienė (2013).

Looking at the 1st table, we can see, that the lowest total price is in general for renewable sources of energy: Wind (0,1913EURct/kWh), Hydroelectric (0,23172 EURct/kWh), Nuclear (0,55249), Solar thermal (0,64836), Solar PV (1,19859), Natural gas (4,59749), Coal (4,59749), Biomass (5,20906).

Most attention from the side of Lithuanian government, while increasing electricity production from renewable sources of energy, is given to wind energy, which has the lowest total costs. The investigations of wind resources distribution have shown that average annual wind speed in the coastal region of Lithuania is 6.4 m/s at 50m above ground level (Katinas et al, 2008). Such wind speed is sufficient for wind energy development and is similar to the wind conditions of other countries of Europe. For this reason the coastal region can be used for large wind energy development in Lithuania.

Biomass is a broad category that includes both burning the inputs directly and biomass gasification, in which the inputs are heated to produce a synthetic gas. The primary biomass fuels are wood scraps and pulping waste, but also agricultural residue, landfill gas, and municipal solid waste. The levelized cost of biomass tends to depend to a great extent on the idiosyncratic local cost of collecting and preparing the fuel (Borenstein, 2012).

7. Conclusions

The key factors influencing energy sector in Lithuania: prevalence of import of primary energy resources from Russia as well as absence of interconnections with Western European energy systems and the decommissioning of the Ignalina Nuclear power plant in 2009. So, there is a risk for the reliability of the energy supply of Lithuania and the Baltic States.

The energy interconnections are important in order to increase the energy independence and to benefit from a unified EU energy market. Creation of the market operator Baltpool was the first step towards creating an effective Lithuanian electricity market as a part of a single electricity market in the Baltic Sea Region and Continental Europe. Thus, ongoing construction of interconnection Lithuania-Sweden will also create favorable conditions for export of electricity, in particular that generated by the new possible nuclear power plant.

Based on the analysis of existing potential of renewable energy sources, during the period 2008-2020 their consumption for the countries needs would increase and owing to absence of appropriate legal regulation, national renewable energy action plan, delayed or reduced financial support and striking decline of the Lithuanian economy in 2009-2010 possibilities to use renewable energy sources at maximal extent are limited. In a case of rational scenario it is foreseen that total their amount will increase up to 1600 toe in 2020.

Without Visaginas NPP, Lithuania and its two Baltic neighbors to the north will remain largely dependent on Russia, on the other hand, electricity from renewable sources in Lithuania is promoted mainly subsidizing it. In this regard, the Visaginas NPP is the most viable option to close the electricity supply gap. The matter of construction of new NPP will be decided by the new government of Lithuania. It is still open question because of non-binding referendum (2012) in which majority of population said no to construction.

Due to the Lithuanian climatic conditions geothermal energy and solar power are not used for power production. Moreover, the further development of hydropower plants is limited by environmental restrictions; therefore priority is given to wind energy development and installation of new biomass power plants. According to specifications (small and modular) of some renewable technologies, they can be sited in or near buildings where energy is used. More important, distributed generation technologies can avoid costly expenditures on transmission and distribution.

References

Borenstein, S. (2012). The private and public economics of renewable electricity generation. Journal of economic perspectives, 26, 67-92.

Deksnys, R., Staniulis, R., Nargėlas, A., Navickas, A., Miškinis, V., Galinis, A., Konstantinavičiūtė, I., Norvaiša, E. (2007). Competetiveness of nuclear power plant in electricity markets of the Baltic sea region. Oil Shale. Vol. 24. No.2. , 347-362.

Fowlie, M., Muller, N. (2010). Designing Markets for Pollution when Damages Vary across Sources: Evidence from the NOx Budget Program. Working paper.

Grinevičius, M., Klevinskas, G., Koraliovas, L. (2009). Implementation of the Visaginas nuclear power plant project. International conference Opportunities and Challenges for water cooled reactors in the 21st century, 39-40.

Grybaitė, V. (2011) Towards measurement of sustainable development: systems of indicators. Journal of Security and Sustainability Issues, 1, 19–26.

Index Mundi. Data portal. [Online] Available: http://www.indexmundi.com (August, 2013).

Katinas, V., Markevičius, A., Erlickytė, R., Marciukaitis, M. (2008). Governmental policy and prospect in electricity production from renewables in Lithuania. Energy policy, 36, 3686-3691.

Miškinis, V., Konstantinavičiūtė, I., Tarvydas, D. (2009) Current trends and future role of renewable energy sources in Lithuania. 10th IAEE conference: Energy, policies and technologies for sustainable economies.

Moomaw, W., P. Burgherr, G. Heath, M. Lenzen, J. Nyboer, A. Verbruggen, (2011). Annex II: Methodology. In IPCC: Special Report on Renewable Energy Sources and Climate Change Mitigation, 973-1000.

Moora, H., Lahtvee, V. (2009). Electricity scenarios for the Baltic States and marginal energy technology in life cycle assessments – a case study of energy production from municipal waste incineration. Oil shale, 26(3), 331-346.

National energy (Energy independence) strategy 2020-2050, (2010). [Online] Available: http://www.enmin.lt/en/activity/veiklos_kryptys/strateginis_planavimas_ir_ES/NIS_project_2010_2050.pdf (August, 2013).

Observatoire Méditerranéen de l'Energie (2007). The Drivers of Electricity Demand and Supply. Fondazione Eni Enrico Mattei (FEEM) project Cost assessment of sustainable energy systems (CASES) working paper.

Rammel, C., Van den Bergh, J., (2003). An Evolutionary Perspective on Sustainable Development Policies: Adaptive Flexibility and Risk Minimising. Ecological Economics, 47(2-3), 121-133.

Rodins, M., Gaponenko, A., Dovladbekova, I. (2013). Lithuania's energy sector - trends and problems of development. Baltic Rim economies, 3, 52-53.

Štreimikienė, D. (2013). Elektros energijos gamybos šaltinių išorinių kaštų Lietuvoje vertinimas. Energetika, 59(1), 11–19.

Štreimikienė, D. Baležentis, T. Krisčiukaitienė, I., (2012). Promoting interactions between local climate change mitigation, sustainable energy development, and rural development policies in Lithuania. Energy Policy, 50, 699–710.

Vasilevich, H. (2011). Belarusian Nuclear Power Plant, Russian Interests and Lithuanian Protests. The Belorusian review, 23(2), 7-8.

World nuclear association, (2013). Nuclear power in Lithuania. [Online] Available: http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Lithuania (August, 2013)