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ANALYSIS

Future of Lithuanian energy system: Electricity import or local generation?

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ABSTRACT

Lithuania's electricity import share compared to consumption is one of the highest among the European countries. The newly constructed inter-system power links connecting Lithuania to Swedish and Polish power systems will widen the low-cost electricity import possibilities. The electricity markets of the entire region (Baltic, Nordic, Poland and Germany) will make significant influence on the development of Lithuanian power sector through the electricity prices established in these markets. The long-term development options of the Lithuanian energy sector were analysed. The alternative of high imports is the most attractive longterm option to supply electricity looking from the economical point of view but creates security of electricity supply concerns. In this relation different measures to increase the country's electricity supply security and their costs to electricity consumers have been analysed through the special design of scenarios analysed. The alternative of "Installed capacities" is recommended which means that the requirement to maintain the necessary installed capacities in the country is set. Such scenario will allow Lithuania's energy consumers to benefit from the low electricity prices in the neighbouring markets and have possibility to generate power locally, in case the electricity import is not possible or too costly.

1. Introduction

The decommissioning of the Ignalina Nuclear Power Plant at the end of 2009 resulted in the considerable dependency of Lithuania on primary energy and electricity import. The share of all indigenous resources is only about 20% in the country's primary energy balance. The local power plants generate only about 40% from the total electricity consumed in the country because these power plants have failed to compete in the electricity market [1]. Such situation has caused concern and many discussions regarding country's energy security on academic and political levels [2–6]. The methodology in order to evaluate the energy supply security was discussed in the paper [2]; later on, the methodology was applied in order to assess the impact of Ignalina Nuclear Power Plant (NPP) shutdown on Lithuanian energy security [3]. It was concluded and that the shutdown of Ignalina NPP has changed the energy security level of Lithuania inconsiderably; however, the security level of Lithuanian energy system is in a pre-critical situation. Also, the developed system of energy security indicators, covering technical, economic and socio-political aspects, was applied for the assessment of the Lithuanian energy security level in different scenarios [4]. Currently, Lithuania's reliable energy supply is at risk in case unexpected natural gas and electricity supply disturbances occur or price of imported energy resources rises sharply. On the other hand, the infrastructure projects in natural gas and electricity sectors, which were intended to improve the energy security situation in the country, are completed or in the final phase [5].

In addition, discussions regarding relevance, opportunities and challenges of constructing a new regional nuclear power plant in Lithuania are continuing [7–10]. The local electricity generation is considered as priority by a part of energy policy makers [6]. The intention of this paper is to broaden this discussion by analysing different alternatives for future electricity supply. General strategic

Abbreviations: CCGT, Combined cycle gas turbine; CHP, Combined heat and power; IPS/UPS, The integrated power system (IPS)/Unified power system of Russia (UPS); MESSAGE, Model for energy supply strategy alternatives and their general environmental impact; NPP, Nuclear power plant; PP, Power plant; RES, Renewable energy sources.

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goals, objectives and a vision of Lithuanian energy sector were defined in National Energy Independence Strategy of 2012 [6]. The main objective of this strategy is to ensure Lithuania's energy independence in 2020. But energy independence in this case was treated only as building of an additional infrastructure, and in order to reach the objective, five substantial energy projects were foreseen: construction of the regional Visaginas nuclear power plant, connection of Lithuanian–Polish and Lithuanian–Swedish electrical power grids, construction of a liquid natural gas terminal in Klaipeda as well as full implementation of the EU Third Energy Package. However, after the analysis [11], has been concluded that a possible implementation of Visaginas NPP project is economically unjustified, and as it is demonstrated in this paper, it means higher costs for the entire energy system and, especially, for local electricity consumers. So, one of the goals of the present research was to evaluate the additional costs for electricity consumers when different measures are applied to increase the electricity supply security and to provide results and recommendations for policy makers. A dynamically changing situation in global and local energy environment is enforcing to react, and the national strategic guidelines of energy sector are reviewed and updated at the moment (for more information refer to Ref. [10]).

At present, natural gas is one of the most important fuels in the primary energy balance and Lithuania still depends on Russia as the main natural gas supplier. For years, natural gas prices from a monopolistic supplier were too high, and Lithuanian power plants burning natural gas were unable to compete in the electricity market. Natural gas also dominated in the fuel balance of the district heating systems with a share of more than 50% [1]. Lithuanian electricity and gas networks have yet to connect to the West European energy systems. However, liquefied natural gas terminal – one of the most important Lithuania's energy security projects – has begun operation at the end of 2014, and hopefully, it will significantly diminish the dependence on Russian natural gas as well as will help to transform the monopolistic structure of natural gas supply to the open gas market for consumers in Lithuania and the entire region.

In addition to high share of imported electricity, Lithuanian power system has an existing excess of power generating capacities. The total installed power generation capacity in Lithuanian energy system was 4372 MW in 2014, while the peak capacity demand was around 1700 MW. The imports have amounted to 60–75% of total electricity consumption in the period 2010–2013 [1]. Electricity import/consumption ratio in Lithuania is one of the highest in Europe. So, variations of electricity price in the Lithuanian market were shaped by various changes in the import structure or technical limitations to import the electricity. The newly constructed intersystem power links connecting Lithuania to Swedish and Polish power transmission systems will increase electricity exchange opportunities and trade possibilities in the competitive market environment. In addition, after the connection of Lithuanian and Sweden power systems in 2016, the electricity prices in Baltic market will be shaped by Scandinavian electricity market because of the magnitude and size of Nordic power system. Due to the mentioned factors, the Lithuanian energy sector is closely related and highly influenced by energy systems of neighbouring countries. Therefore, the prices of energy resources, demand-supply situation or policy decisions at neighbouring countries will make vital influence on the processes in Lithuanian energy sector. So, the political risks and the price increase risks of fuels or electricity are the main concern in this analysis from the energy security point of view.

In connection with crucial factors influencing the situation in power sector, the main goal of this paper is to analyse the Lithuanian power system development in the long-term perspective (until 2065). It was examined which of the following options – electricity import or own electricity generation – is optimal for power sector and should be the priority in order to satisfy country's electricity needs taking into account various factors mentioned above. The optimal option is calculated through the optimization process, and the optimization criterion in this case is the minimization of the present value of the cumulated energy system costs in the period analysed. For this task in Section 2, power systems of neighbouring countries, the forecasted developments in these markets as well as factors influencing electricity prices in the region and the development of Lithuanian power sector were overviewed and analysed. Section 3 provides the wholesale electricity price forecasts in the Scandinavian, Polish, German and Baltic power markets, which are especially relevant when analysing the development of Lithuanian energy system. Methodology used for the analysis of the long-term development of Lithuanian energy system is briefly presented in Section 4. Section 5 describes the main modelling results regarding electricity supply options and possible electricity generation costs; conclusions are presented at the end of the paper.

Table 1
Total installed capacities of power plants.

Technology	Capacity, MW	Fuel
Condensing PP	800	Natural gas, HFO
CHP PP	2145	Natural gas
	44	Biomass
	18	Biogas
	35	Waste
Hydro PP	128	
Hydro PSPP	900	
Wind PP	282	
PV	20	
Total	**4372**	

2. Situation overview

High level of energy imports and consolidation of electricity systems make the country dependant on its neighbours. The analysis of neighbouring markets is essential seeking to understand and evaluate their possible influence on Lithuanian power sector.

The total installed power generation capacity in Lithuanian energy system is summarized in Table 1.

Power system of Lithuania has very good interconnections with Latvia, Estonia, Belarus and Russian Federation (Kaliningrad region) (see Fig. 1). Transmission grid capacities from Latvia to Lithuania are up to 1300 MW, from Belarus to Lithuania – 1350 MW and from Kaliningrad region to Lithuania – 680 MW. The first interconnection from Baltic region to Scandinavia (a 350 MW submarine cable between Estonia and Finland – EstLink) was constructed in December 2006. Since 2014, the second cable (650 MW – Estlink2) between Estonia and Finland has been in operation. The construction of 700 MW Lithuania–Sweden power link was completed at the end of 2015. This will enable Lithuania to purchase electricity directly from Northern European countries. In addition, the 500 MW power link with the neighbouring country Poland has started operation in 2016 and finally connected Lithuania with the power systems of Central and Western Europe. The capacity of the power link will increase to 1000 MW in 2020. The forecasted peak demand in country will be 2000 MW in 2020, 2600 MW in 2030 and 3260 MW in 2050. So, the overall transmission lines capacity is more than three times higher compared with the current peak electricity demand in the country (1700 MW).

As it was mentioned before, Lithuania is importing up to 2/3 of its electricity needs from other countries (Table 2). Until 2014, the highest share of electricity was imported from the Russian Federation. As a result of new cable between Estonia and Finland, the import of the Finish electricity to Lithuania is increasing and is limited only by capacities of Estonian–Latvian transmission lines. As for the import from the third countries – Kaliningrad, Belarus and mainland Russia – it is