Development of the Lithuanian Electric Power System and Transmission Grids

Abbreviations and Some Terms

BEMIP – the Baltic Energy Market Interconnection Plan

DS – distribution station

ENTSO-E – the European Network of Transmission System Operators for Electricity

ETL – electricity transmission line

EU – the European Union

HEP – hydro electric plant

HPSP – hydro pumped storage plant

IPS/UPS – the power system consisting of a synchronous transmission grid of the power systems of the Baltic States, Russia and CIS

kV – kilovolt (1 kilovolt = 1,000 volts)

MW – megawatt (1 megawatt = 1,000 kilowatts)

MWh – megawatt-hour (1 megawatt-hour = 1,000 kilowatt-hours)

NEIS – the Nacional Energy Independence Strategy

NPP – nuclear power plant

PS – power system

RES – renewable energy sources

SGCE – the Synchronous Grid of Continental Europe, an electricity grid including the power systems of the states of continental Europe

TG – transmission grid

TS – transformer substation

TSO – transmission system operator

TWh – terawatt-hour (1 terawatt-hour = 1,000,000,000 (billion) kilowatt-hours)

VNPP – Visaginas Nuclear Power Plant

Installed capacity – sum of the installed capacities of all the generators at a power plant

Reliable available capacity – capacity that can meet the system's needs at any moment of time

Primary active power reserve – a power reserve intended for compensating for sudden misbalances in the capacity generation and consumption throughout the synchronous area and for limiting the frequency deviations arising from the capacity misbalance. The primary power reserve must be activated within 30 seconds; after 15 minutes it is replaced by the secondary reserve

Secondary active power reserve – a power reserve intended for restoring the frequency and the primary power reserve loss as well the agreed capacity exchange between the PS and the control areas; the secondary power reserve must be activated within 15 minutes

Tertiary active power reserve – a power reserve intended for restoring the exhausted primary and secondary power reserves

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Introduction

The reliability of a power system's operation, the power and energy balances, and readiness to meet the needs of electricity users at any time all depend on numerous parameters of the transmission grid and the power plants operating in the system. They also depend on the proper coordination of actions by different parts of the system and the responsible and professional behaviour of all electricity market participants. While the high-voltage electricity grid may not seem very visible amid everyday activity, it is in fact vital for business, new investments and overall economic growth. With that in mind, Litgrid, the Lithuanian electricity transmission system operator, updates its development plan for the 110 kV and 330 kV transmission networks on an annual basis. The plan takes into account many factors, including electricity producers' expansion plans, grid deterioration over time, progress in cross-border power-link projects, and other matters.

Development of the high-voltage electricity transmission grid must reflect long-term plans and strategic guidelines such as the Lithuanian state's ambition to achieve energy independence, the energy decarbonization goals set by the European Commission, and the future European Grid Codes. Lithuania has written into law the aim of integrating the energy systems of the Baltic countries into the Europe's Continental Synchronous Area. A study on the feasibility of such integration found the project to be very complex, both organisationally and technically, and said several implementation scenarios are possible. A summary of the findings of the feasibility study is included in this publication.

The need to integrate as many renewable-energy producers as possible into the system poses additional challenges for its operational reliability. The European Commission in 2009 set a goal of reducing greenhouse emissions by nearly half by 2050, leaving it to EU member states to decide how many and what types of renewable energy-source power plants they need over time. Wind farms and biofuel-fired plants have the greatest potential in Lithuania, according to the newest Feasibility Study on the Connection of Power Plants Using Renewable Energy Sources to the 330–110 kV Electricity Transmission Grid by 2030. The authors of the study examined several scenarios for the development of generation sources, assessing the sufficiency of reserves in the power system and performance of the transmission grid under different operating regimes. While biofuel plants are seen as having the greatest potential, the study focuses on analysing the development of wind power, since wind-farm production is the most difficult to forecast and the most dependent on weather. A summary of this study is also included in this publication.

Lithuania's electricity transmission system operator is not only responsible for proper development of the transmission grid, but also must care for the power system as whole. That means planning long-term development and reconstruction in a way that maintains the reliability and quality of power supply and that meets the demands of efficiency, consumption, good management and environmental protection.

The main purpose of the development plan for Lithuania's 330–110 kV power transmission networks is to assess the current national power system and project potential changes in demand for electricity and capacity through 2023. The plan was prepared taking into account Lithuania's long-term strategic objectives in the area of electricity as well as its international obligations to reduce carbon dioxide emissions, ensure sustainable development of the grids and earmark the necessary investments for grid development and reconstruction.

Integration of the Baltic States into the EU Internal Electricity Market. Feasibility Study on the Construction of Potential Power Links

Synchronisation involves the interconnection of neighbouring power systems for operation at the same frequency and speed. Any technical failure in one of the systems in a synchronous area will affect the operation of the neighbouring power systems. Synchronisation of the Baltic States' power systems with the Synchronous Grid of Continental Europe (SGCE) is an imperative objective, as established in a law enacted by the Seimas (Parliament) of the Republic of Lithuania in 2012.

At present, operational control of Lithuania's power system – like those of Estonia, Latvia and Belarus – is managed as part of the IPS/UPS system run by Russia's power system operator. Most key parameters of the Baltic countries' power systems are thus centrally controlled. The goal of synchronisation with SGCE is to become part of the decentralised European power system and so make a transition to European standards for system control.

The Baltic States have made the political decision to link together into the continental European grid. Connecting the three countries to the SGCE for synchronous operation is a lengthy and complex process. It will require large-scale harmonization of complicated engineering and system issues, careful implementation of cross-border procedures and intergovernmental agreements.

Synchronisation will enable the Baltic States to re-orient the management of their electricity systems toward the West, become part of the European power system and insulate themselves from Russia's rapidly ageing electricity system.

Summary of the Findings of the Feasibility Study

BIn 2012-2013, the Baltic transmission system operators, together with the Swedish consulting firm Gothia Power AB, undertook a detailed feasibility study on the integration of the three countries into the EU internal electricity market by 2020, including power-link options.

The study concludes that, technically, synchronous operation within the SGCE is feasible, i.e., as regards the distribution of electricity flows in the grids, system control and ensuring stability. Nonetheless, connection to the SGCE requires strengthening of the present electricity transmission systems of the Baltic States and Poland, modernisation of system and generator control processes, assurance of the required power reserves, and construction of back-to-back converter stations at the Russian and Belarusian borders. Special attention must be given to the installed capacity parameters of the generator at the projected Visaginas Nuclear Power Plant, as this will be an important factor in determining the allowable limit values for unit size under most operating conditions, in particular for isolated operation. Moreover, the capacity of the generator at the projected VNPP will require considerable reserves.

No significant legal or regulatory obstacles to synchronisation with the SGCE were identified, though a number of issues require negotiated solutions and agreements. Total investment and annual costs of the transition to synchronous operation are high relative to the market benefits.

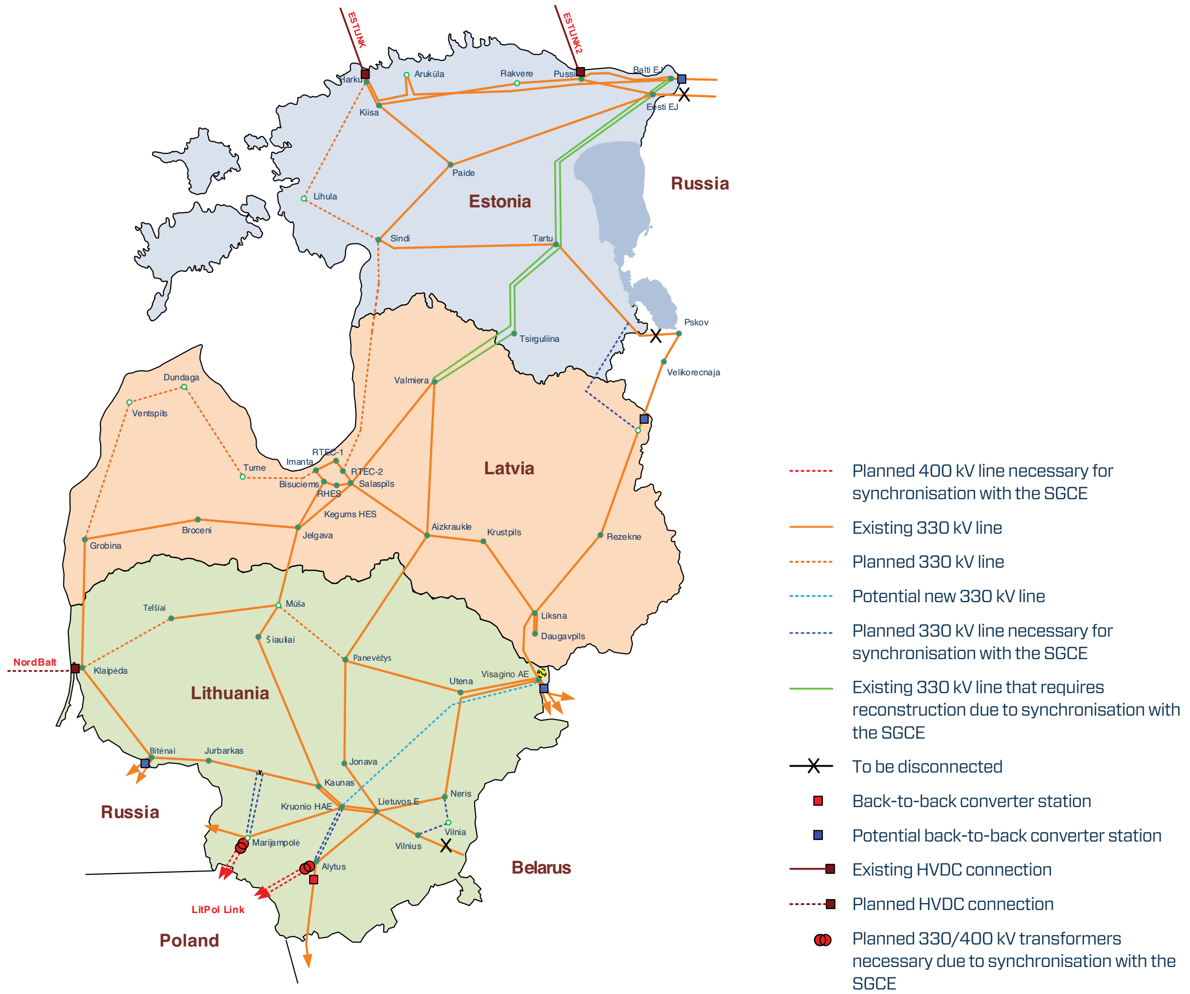
The following alternatives for installing possible power links were analysed:

- synchronous operation of the Baltic States with the IPS/UPS system;
- synchronous operation of the Baltic States and Kaliningrad Region with the SGCE;
- synchronous operation of the Baltic States with the SGCE and asynchronous operation with Kaliningrad Region.

Based on electricity flow distribution calculations and consideration of potential line overloads as well as network development and modernisation, the study finds that synchronisation of the Baltic States' power system with the SGCE is possible.

Regional stability analysis is used to identify any risk of short-term instability in the synchronous operation of the Baltic States' systems within the SGCE. Isolated operation of the Baltic States' systems is also analysed, including the time needed to eliminate failures of the main components of the grid, frequency changes due to the disconnection of generators and high-voltage cross-border links, and the operating stability of the largest generators in the Baltic States and Kaliningrad Region. The regional stability analysis showed that the required primary reserve can be secured through cross-border links to the synchronous operation with Poland.

Synchronisation of the Baltic States' power systems with the SGCE



No significant constraints related to temporary stability were identified for the Baltic States' synchronous operation with the SGCE. Temporary stability of the VNPP, as the largest unit, could be an exception, and this should be taken into account in the plant design phase.

To ensure sufficient stability measures for the generators and the distribution of the power systems, a large-scope stability analysis of the connection of the Baltic States' power system to Poland and the SGCE system was undertaken. Frequency oscillations causing capacity variations in the connecting transmission lines were examined and measures identified to suppress such oscillations. The study emphasises that system regulators must be installed at the Baltic States' main generators in order to guarantee reliable operation.

The socio-economic part of the feasibility study includes a discrepancy analysis, reviewing the differences between the current situation in the Baltic States and the SGCE requirements for operational planning and control. It also identifies changes that the Baltic States, as ENTSO-E members, must implement in keeping with the future network codes.

Broader socio-economic analysis in the study compares the different power link options in terms of investment costs and benefits for the electricity market. It should be noted that it is not important for the power market whether a connection is synchronous or asynchronous. The cost-benefit analysis includes not only investment outlays, but also, for example, the costs of operation, reserves, management and administration, as well as costs related to socio-economic risks.

Analysis of legal and regulatory issues focuses mainly on assessing the differences between the regulatory environment applicable to members of the Regional Group Continental Europe (RGCE) and the regulatory activity of the Baltic TSOs. For comprehensive assessment of possible operating scenarios of the Baltic countries' power systems, the legal consequences of continued synchronous operation within the IPS/UPS system are also analysed.

Feasibility Study on the Connection of Power Plants Using Renewable Energy Sources to the 330–110 kV Electricity Transmission Grid through 2030

Summary of the Findings of the Feasibility Study

Litgrid in 2014 commissioned experts at Kaunas University of Technology to conduct a feasibility study on the connection of power plants using renewable energy sources (RES) to the 330–110 kV transmission grid through 2030. To assess the potential for connecting RES power plants to the grid, a comprehensive analysis of the power system's operating characteristics was carried out. The study thus reviews the outlook for electricity demand, outlines scenarios for the development of electricity generation sources, examines the sufficiency of the Lithuanian power system's active reserves, and determines the condition of the transmission grid under different operating regimes.

Particular attention is given to the potential for developing wind farms. Findings show that the development of new wind farms is feasible, though certain technical and organisational issues have to be resolved in light of a potential future shortage of active power reserves. When strategic electricity projects are complete and cross-border power links with Poland and Sweden start operating, more active power reserves will be needed for these links or the projected new nuclear power plant. So the implementation of these strategic projects and the development of RES plants, especially wind firms, must be coordinated with the installation of reserve energy sources.

The European Commission in 2009 set an energy decarbonisation target of by 2050 reducing greenhouse gas emissions by 80% to 95% relative to their 1990 level. Each country must determine what share of RES is required in its structure of generating capacities in order to achieve this target, taking into account the country's energy needs and production facility specifics, geographic conditions, grid technical characteristics, and economic potential.

The feasibility study analyses three scenarios for RES development in Lithuania by 2030. The main scenario sees renewable plants producing 24% of all the electricity consumed in the country, while an intermediate scenario puts the share at 30%, and an ambitious scenario foresees 35%.

Among renewable sources, wind farms and biofuel plants are seen to have the greatest development potential. The study forecasts they will account for 84% to 93% of RES power.

The main scenario for the expansion of renewable power in Lithuania gives the greatest weight to biofuel-fired power plants. Wind farms are seen generating 500 MW under this scenario, up to 670 MW in the intermediate scenario, and up to 840 MW in the ambitious case. In the ambitious scenario, wind farm capacities are close to the Lithuanian power system's lowest load (lowest maximum demand) capacity. If even more ambitious goals were set for RES development, provision would have to be made for flexible energy accumulation, load management, and exchange of capacity and power with neighbouring energy systems.

It is foreseen that new biofuel power plants near large cities will be connected to the electricity transmission grid, while those in other areas will be connected to the distribution grid. Solar power plants in Lithuania will be connected only to the distribution grid.

The main factors limiting the maximum allowable capacity of wind farms are the capacity of electricity transmission networks and the sufficiency of active power regulation reserves under different operating scenarios for the Lithuanian power system.

The study shows that, according to the N-1 criterion, possibilities for connecting new wind farms to the 110 kV transmission grid in western Lithuania are already exhausted. The aggregate capacity of wind farms connected to the existing 330 kV transmission network may not exceed 240 MW.

For onshore wind farms, possible connection points and allowable capacities, along with locations where changes to the grid are required, are shown below in the map of RES power plant connections to the 330-110 kV grid by 2030.

Connection of offshore wind farms is possible only if the 330 kV and 110 kV electricity network is expanded. Lithuanian offshore wind farms can be installed in the Baltic Sea in the Republic of Lithuania's territorial waters and exclusive economic zone. Lithuania's Ministry of Energy has provided information on preliminary sites for wind farms based on current use of the sea area, geological-geomorphological composition of the sea bed, specifics of the ecosystem, and technical possibilities for installing wind farms. Four wind farms foreseen in the initial development phase, for which an environmental impact assessment has been completed, have a capacity potential of 850 MW.

It is planned that, depending on the installed capacity of the wind farms and the distance to the shore, electricity could be transmitted to the mainland either by a 110 kV cable to the 110 kV switchyard at the Klaipėda 330/110 kV transformer substation, or by 330 kV variable current to a 330 kV transformer substation built specifically for this purpose on the Klaipėda–Grobiņa line.

When the NordBalt link is put into operation, Lithuania will be able to import up to 700 MW from Sweden. At that point Lithuania's transmission grid will meet the N-1 reliability requirements, though the western part of the grid would be fully loaded by 2030. Thus power transmission from offshore wind farms essentially demands expansion of the transmission grid.

It is foreseen that having 500 MW of installed wind-power capacity will require a power reserve of approximately 170 MW for the forecasting margin of error, and each additional 100 MW will require approximately 24 MW for the regulation of secondary reserve deviations. Since this reserve needs to be ensured continually, it should be provided by mandatory generation sources such as combined-cycle power plants. For 500 MW of wind farms, some 280 MW of installed mandatory generation are needed, including about 200 MW for wind farm capacity forecasting errors.

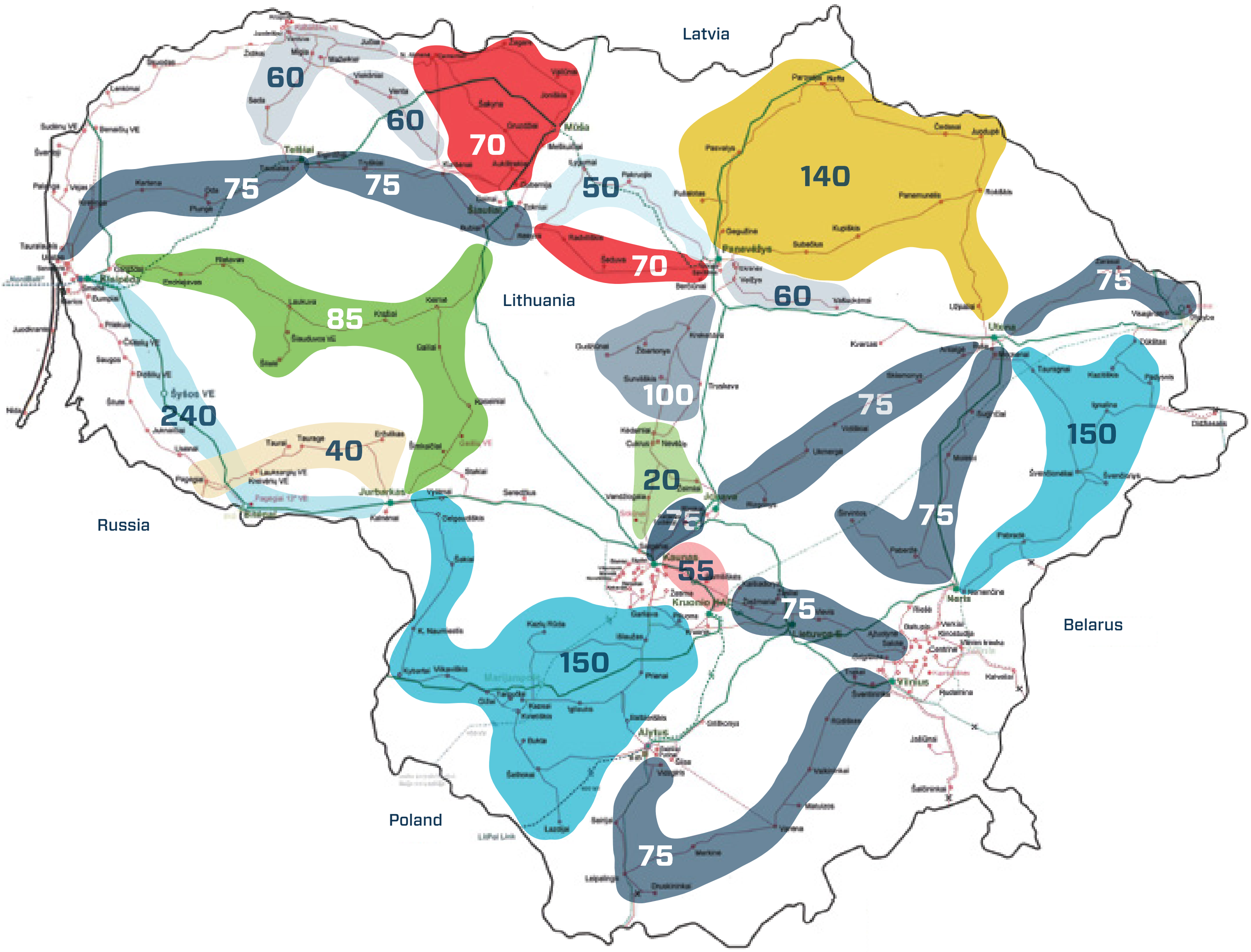
The Lithuanian power system's required emergency reserve would be 700 MW in regard to the NordBalt power link and 1350 MW for the Visaginas nuclear plant. Securing adequate reserves requires the provision of both regulation and emergency power reserves, including reserve sharing with neighbouring energy systems.

To ensure an adequate emergency reserve of active power, it would be expedient both to expand the Kruonis HEPP and to install reserve power plants with gas turbines that can be started quickly. It is recommended to install reserve power plants at the Panevėžys, Kaunas and Lithuanian power plants, using existing infrastructure. A unit of up to 35 MW could be installed at the Panevėžys plant, and larger-capacity units could be added at the Kaunas and Lithuanian power plants.

Seeking more effective use of reserve resources, TSOs from different countries in the future probably will unite in coordinated balancing areas, collaborating to expand and connect them while developing regional and European-integration models based on a balancing market. This feasibility study was carried out in accordance with requirements of the ENTSO-E Continental Europe Operation Handbook for 66% of the needed secondary reserve or 50% of the needed secondary and tertiary reserves to be maintained domestically, while the rest of the reserve requirement can be secured through cross-border links.

Each step toward the integration of the balancing areas will require strengthening cross-border relationships so that countries can exchange and share generation as well as balancing and regulation reserves. This is fully in line with the Baltic States' objectives for synchronous operation within the Synchronous Grid of Continental Europe and with Poland's goals for strengthening its grid.

Map of RES Power Plant Connections to the 330–110 kV Transmission Grid by 2030



LEGEND

330 kV line

110 kV line

Projects under implementation

Double-circuit line

330 kV TS

110 kV TS

Back-to-back converter

Back-to-back converter station

75 Maximum wind plant capacity that can be connected to transmission and distribution grids. Capacities of individual wind farms in specific areas are not summed. Technical specifications for the connection of wind farms to the transmission grid are issued based on the technical specifications already issued in adjacent areas and the remaining transmission grid capacity potential in the area concerned.

Plan for the Development of 330-110 kV Transmission Grids of the Lithuanian Power System in 2014-2023

Key Indicators of the Lithuanian Power System

		2013	2023
Electricity demand (including grid losses)			
Worst-case	TWh	10.57	12.4
Baseline	TWh		13.0
Best-case	TWh		14.2
Maximum capacity demand at peak load of the system			
Worst-case	MW	1,810	2,140
Baseline	MW		2,200
Best-case	MW		2,320
Installed / available capacity at power plants, total:	**MW**	**4,296/3,388 (3,958)***	**4,898/4,554**
Power plants			
Visaginas NPP	MW	0/0	1,350/1,303
Lietuvos (Lithuanian) PP	MW	1,955/1,275 (1,845)*	455/435
Vilnius PP	MW	360/320	180/160
Kaunas PP	MW	170/155	110/102
Petrašiūnai PP	MW	8/4	0/0
Panevėžys PP	MW	35/33	35/33
Klaipėda PP	MW	11/10	0/0
Other	MW	288/274	288/274
Kaunas HEPP	MW	101/99	101/99
Kruonis HPSP	MW	900/760	1,125/950
Small HEPPs	MW	27/27	41/41
PP using RES (excluding HEPPs):	MW	441/431	1,213/1,157
Including wind farms	MW	281/281	800/800
High voltage lines		**6,702.8**	**7,821**
400–330 kV overhead lines	km	1,671.6	2,212
110 kV overhead lines	km	4,966.7	5,112
300 kV direct current cable	km	-	2x213
110 kV cable lines	km	64.5	71
400–330 kV transformer substations	**vnt.**	**13**	**17**
330 kV switchyards	**vnt.**	**2**	**2**
110 kV transformer substations	**vnt.**	**219****	**229**
Compensatory equipment			
110 kV condenser batteries	number	112	112***
400 kV by-pass reactors	number	-	100***
330 kV by-pass reactors	number	180	180***
10 kV by-pass reactors	number	300	300
Average electricity price in the Lithuanian electricity market	**Cents/kWh**	**16.9**	

**Considering that the operation of the two units 300 MW each at the Lithuanian PP can be restored within 2 months from the moment when the demand arises*

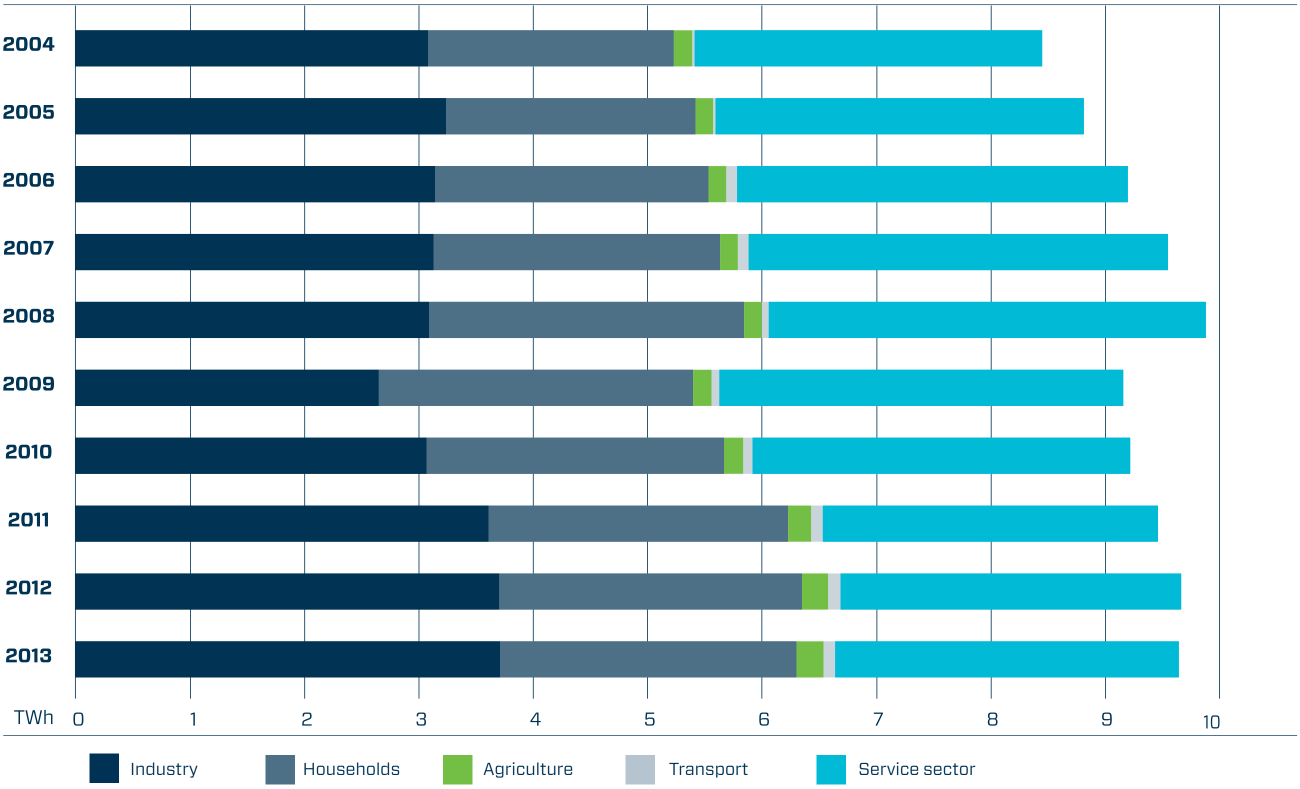
***Including one switchyard*

**** Excluding the compensatory equipment installed in the converters*

1 Overview of the Lithuanian Power System and the Electricity Market in 2013

In 2013, the final electricity demand in the country, excluding the grid losses, was 9.64 TWh (Figure 1.1) and the total electricity consumption (including the grid losses) was 10.57 TWh. Compared with 2012, the final electricity demand has remained almost the same, whereas the total electricity consumption has slightly decreased. Just as in 2012, industry accounts for the largest share in the electricity consumption (3.7 TWh). The household sector and the service sector consume similar amounts of electricity: 2.60 TWh and 3 TWh respectively. Lowest consumption has been recorded in the transport and agricultural sectors, 0.11 and 0.23 TWh respectively. Generally, there is a slight increase in the demand in the Lithuanian PS after the fall in 2009, and the current level is close to that of 2007.

Figure 1.1. *Electricity consumption in 2004–2013 by customer groups*



In 2013, the most significant growth in the installed capacity has been recorded in the power plants using renewable energy sources, in particular solar power plants: while the total capacity of the solar PPs connected to the national power system was just 8 MW in 2012, it totalled 68 MW at the end of 2013. The total capacity of the biofuel-fired power plants connected to the power system reached 71 MW at the end of 2013, upon connecting approx. 35 MW capacity during the year. Even though only 7 MW of capacity of the wind farms was connected during 2013, according to installed capacity wind farms are leaders among the power plants using RES. The last incentive quota allocation auction took place in 2013 for the energy producers using wind energy; the total quota of 500 MW was allocated at the auction.

It should be noted that all the power plants using RES that were connected to the system in 2013 were connected to the distribution network.

As of 31 December 2013, the installed capacity of all the power plants in the Lithuanian PS totalled 4,296 MW. Considering that part of the capacity is used for own needs of the power plants, put into prolonged storage, or limited by the quantity of water in the hydro electric power plants, the maximum available capacity (i. e. the capacity which the power plant can generate and transfer to the grid, also called disposable capacity) totalled approx. 3,958 MW (Table 1.1).

Table 1.1. *Power plant capacities as of 31-12-2013*

Power plants	Installed capacity, MW	Available capacity, MW
Thermal power plants	**2,827**	**2,071 (2,641)***
Lithuanian PP	1,955	1,275 (1,845)*
Vilnius PP	360	320
Kaunas PP	170	155
Petrašiūnai PP	8	4
Klaipėda PP	11	10
Panevėžys PP	35	33
Other	288	274
Hydro electric and hydro pumped storage power plants	**1,028**	**886**
Kaunas HEPP	101	99
Kruonis HPSP	900	760
Small HEPPs	27	27
Power plants using RES	**441**	**431**
Wind	281	281
Biofuel	92	82
Solar	68	68
Total	**4,296**	**3,388 (3,958)***

* Considering that the operation of the two units 300 MW each at the Lithuanian PP can be restored within 2 months from the moment when the demand arises

Electric power balance is a balance reflecting the electricity generation volumes at power plants, generation and consumption. The electric power balance in the Lithuanian power system (Table 1.2) includes export and import, losses in the transmission and distribution grids, and the final electricity consumption.

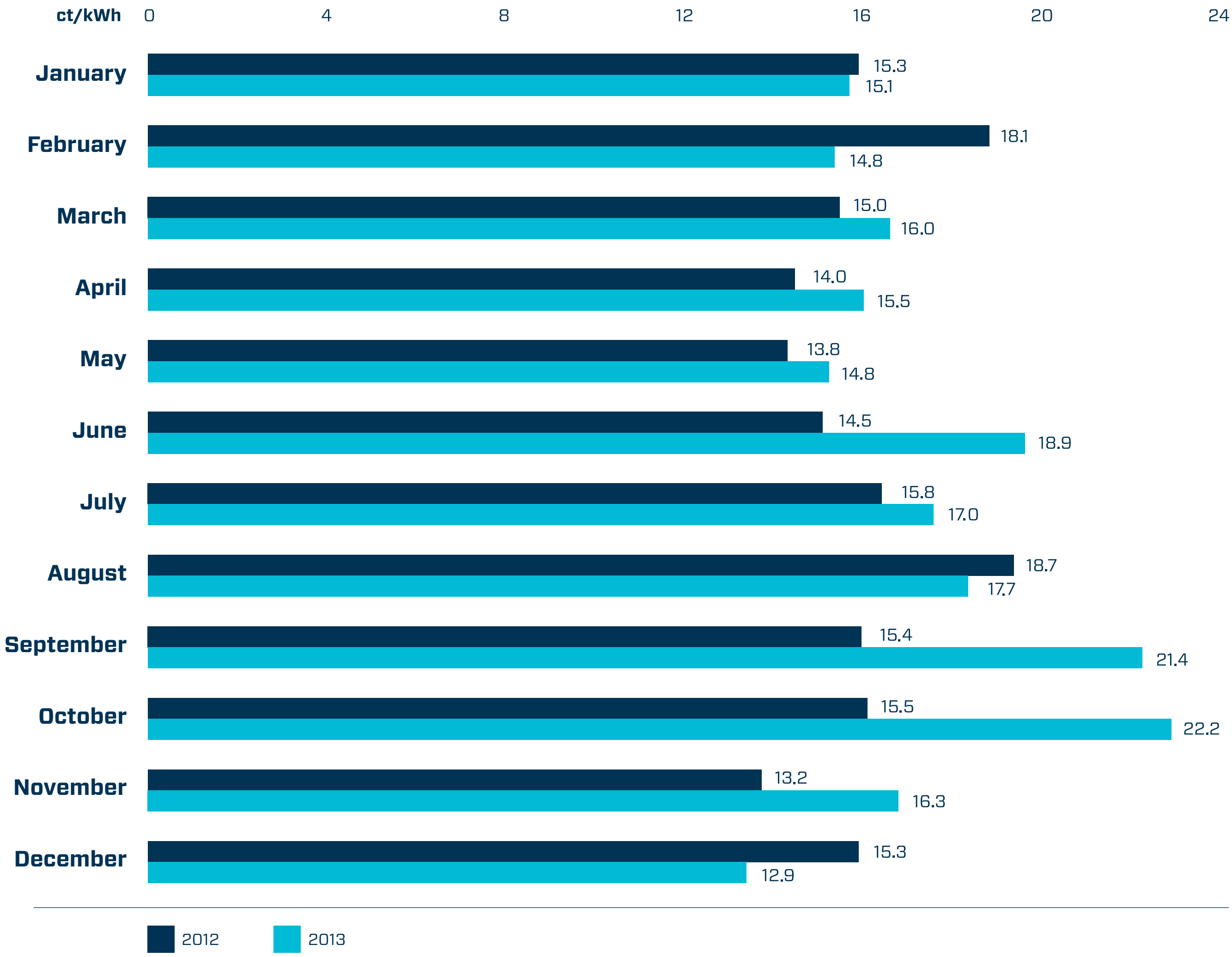
Table 1.2. *Electric power balance in 2012 and 2013*

	2012	2013
Electricity generation (net). TWh	**4.71**	**4.40**
Thermal power plants	**3.04**	**2.36**
Lithuanian	1.42	1.10
Vilnius	0.43	0.43
Kaunas	0.32	0.26
Panevėžys	0.10	0.07
Other	0.76	0.50
Hydro electric power plants	**0.94**	**1.06**
Kaunas HEPP	0.33	0.42
Kruonis HPSP	0.51	0.54
Small HEPPs	0.10	0.09
Wind farms	**0.54**	**0.60**
Connected to transmission grids	0.44	0.49
Connected to distribution grids	0.10	0.11
Power plants using RES	**0.20**	**0.38**
Biofuel	0.20	0.26
Solar	0.00	0.05
Wind	0.00	0.07
Trading balance (– imports / + exports)	**– 6.62**	**– 6.95**
Imports	– 8.56	– 7.61
Exports	1.94	0.66
Total electricity demand	**11.33**	**11.35**
Loading of Kruonis HPSP	**0.72**	**0.77**
Total electricity consumption	**10.61**	**10.58**
Process costs in transmission and distribution grids	**0.95**	**0.93**
Final electricity consumption	**9.66**	**9.65**

In 2013, approx. 21% of the electricity consumed in Lithuania (the general electricity requirement) was generated at the Lithuanian thermal power plants fired with the imported gas and fuel oil. Electricity imports accounted for 61% of the total electricity demand. Significant dependence of the Lithuanian PS on electricity imports has been determined by the supply of cheaper electricity in the neighbouring electric power systems. Considering that the final electricity demand has remained practically the same, a decrease in imports could have resulted also from an increase in the share of electricity generated from RES (up to 18%) (Table 1.2).

In 2013, the average electricity price in the Lithuanian bidding area of Nord Pool Spot, a Nordic and Baltic electricity exchange (Figure 1.2) was 16.9 cents per kWh (48.93 EUR/MWh). The exchange price for electricity in 2013 was 9.6% higher than the price in 2012, which was 15.4 cents per kWh (44.64 EUR/MWh). The highest monthly price of the year was recorded on the exchange in October 2013 (22.2 cents per kWh (64.18 EUR/ MWh)) and the lowest daily price of the year was recorded on 23 April (8.4 cents per kWh (24.35 EUR/MWh)). The highest daily price was on 1 October: 43.6 cents per kWh (126.32 EUR/MWh).

Figure 1.2. *Average electricity prices on the electricity exchange in Lithuania in 2012 and 2013, cents/kWh*



7,983 GWh (73% of the electricity consumption in Lithuania) were bought on the electricity exchange in 2013. 24 independent electricity suppliers were trading on the exchange as of the end of 2012 (2013: 22). The volume of electricity purchases on the exchange increased 7% in 2013 compared with 2012.

On 10 December 2013, Elbas intraday trading was launched. On Elspot exchange, electricity is traded upon closing of Elbas trading and until one hour prior to the start of supply. Exchange members can trade in electricity on Elbas upon closing of Elspot trading and until one hour prior to the start of supply. The intraday market enables the exchange members to more effectively manage the business risks faced by electricity wholesalers and balance the trading in electricity generated from renewable energy sources. Elbas traders can respond to the current consumption or generation changes and optimise the electricity trading by concluding exchange transactions even if only an hour remains until the actual generation and consumption.

2 Demand for Electricity and Maximum Capacity in 2014–2023

The electricity demand forecasts are made based on an assessment of trends in the gross domestic product (GDP) growth (Figure 2.1). The GDP growth rate is the main factor determining the demand for electricity: the larger the GDP, the higher the demand for electricity. The medium-term GDP growth projections are provided by the Ministry of Finance of the Republic of Lithuania, whereas the long-term projections are made on the basis of EU-28 GDP projections for the period until 2050 provided by the European Commission. Under the worst-case scenario, the GDP growth rate is 0.7% lower than the baseline scenario, and under the best-case scenario the GDP growth rate by 2023 is 1% higher compared to the baseline scenario. The GDP growth rate is an aggregate figure not divided by sectors.

The projections of the electricity and maximum capacity demand are provided in Figures 2.2 and 2.3.

Figure 2.1. *Lithuania's GDP projections at 2005 prices, EUR bn*

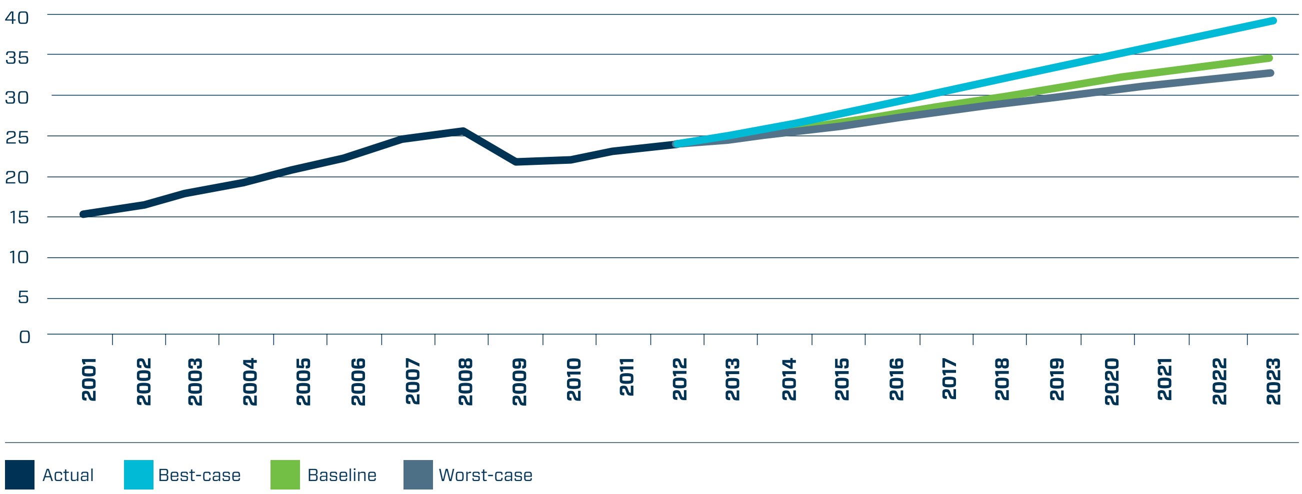


Figure 2.2. *Projections of electricity demand in Lithuania, TWh*

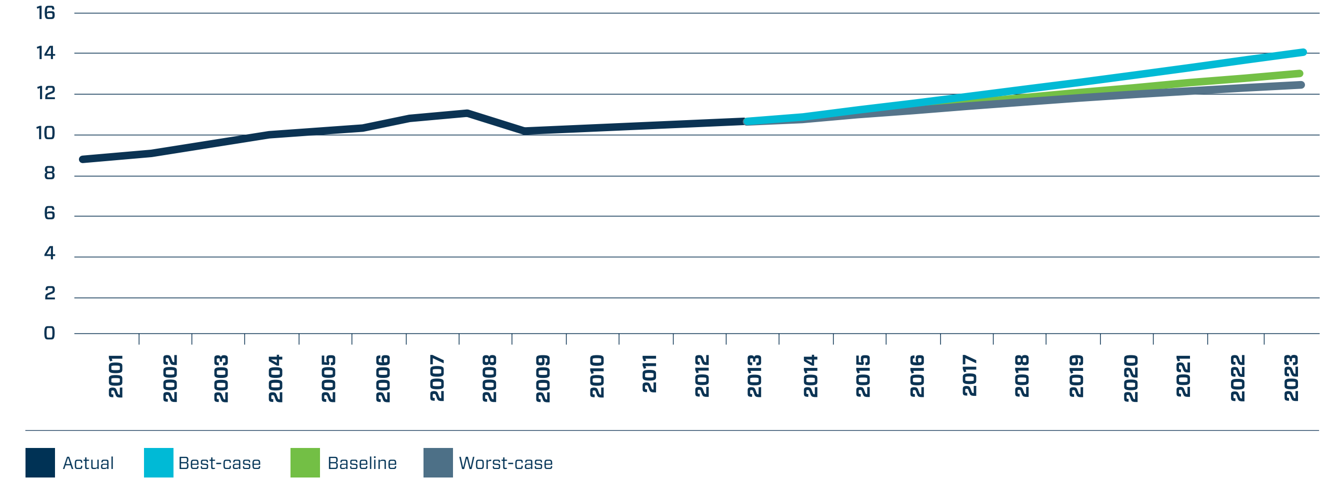
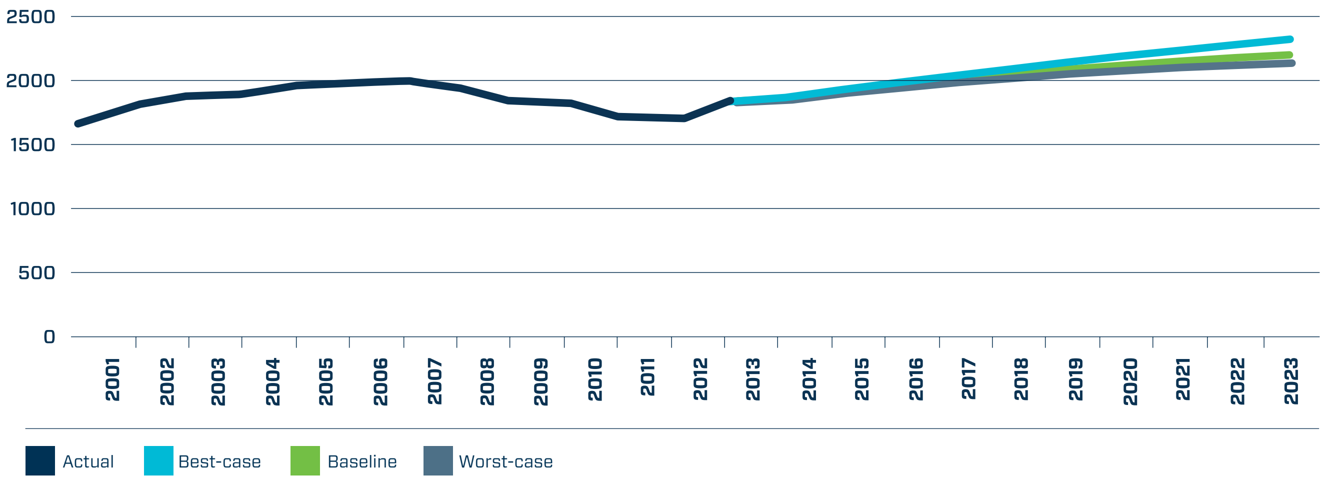


Figure 2.3. *. Projections of maximum capacity demand in Lithuania, MW*



It is estimated that in case of baseline scenario the demand for electricity in Lithuania will increase to 13 TWh by 2023 (average annual growth rate 2.1%), in case of a slower economic growth to 12.4 TWh (average annual growth rate 1.6%), and under the best-case scenario to 14.2 TWh. The maximum capacity demand in 2023 could be approx. 2,200 MW under the baseline scenario, 2,140 MW – the worst case scenario, and 2,320 MW – the best case scenario.

3 Power Plant Capacities in 2014–2023

The dynamics of the electricity generating capacities in the Lithuanian power system for the period 2014-2023 has been estimated based on the information on the power plant development plants obtained at the end of 2013, the information on the capacities of power plants using RES available at the beginning of 2014, and the capacity development trends presented in the National Strategy for the Development of Renewable Energy Sources (approved by Resolution of the Government of the Republic of Lithuania No 789 of 21 June 2010), the National Action Plan on Renewable Energy Sources (submitted to the European Commission on 19 July 2010), the National Strategy for Energy Independence, and the Law on Energy from Renewable Sources No XI-1375.

Four scenarios have been considered in modelling the development of the generating sources:

Minimal development of generating sources (Scenario A) – it is assumed that there will be no new power plants using fossil fuel and the development of power plants using RES will take place in the scope provided in the Law on Energy from Renewable Sources except for the total capacity of solar plants, which is assessed based on the current situation.

Minimal development + VNPP (Scenario B) – changes in the capacities of the generating sources are the same as in Scenario A plus it is assumed that operation of the Visaginas Nuclear Power Plant is started in 2023.

Probable development of the generating sources (Scenario C) – plans for the potential development of the power plants and the progress in preparatory works (design specifications issued, development plans under preparation) have been taken into account.

Probable development of the generating sources + VNPP (Scenario D) – changes in the capacities of the generating sources are the same as in Scenario C plus it is assumed that VNPP is put into operation in 2023.

Table 3.1. *Estimated power plant capacities as of 31-12-2023*

Power plants	Scenario A		Scenario B		Scenario C		Scenario D	
	Installed capacity, MW	Available capacity, MW	Installed capacity, MW	Available capacity, MW	Installed capacity, MW	Available capacity, MW	Installed capacity, MW	Available capacity, MW
Nuclear power plant	**0**	**0**	**1,350**	**1,303**	**0**	**0**	**1,350**	**1,303**
Thermal power plants	**1,248**	**1,164**	**1,248**	**1,164**	**1,068**	**1,004**	**1,068**	**1,004**
Lithuanian PP	455	435	455	435	455	435	455	435
Vilnius PP	360	320	360	320	180	160	180	160
Kaunas PP	110	102	110	102	110	102	110	102
Panevėžys PP	35	33	35	33	35	33	35	33
Other	288	274	288	274	288	274	288	274
Hydro electric and hydro pumped storage plants	**1,042**	**900**	**1,042**	**900**	**1,267**	**1,090**	**1,267**	**1,090**
Kaunas HEP	101	99	101	99	101	99	101	99
Kruonis HPSP	900	760	900	760	1,125	950	1,125	950
Small HEPs	41	41	41	41	41	41	41	41
Power plants using RES	**685**	**670**	**685**	**670**	**1,213**	**1,157**	**1,213**	**1,157**
Wind	500	500	500	500	800	800	800	800
Biofuel	105	90	105	90	333	277	333	277
Solar	80	80	80	80	80	80	80	80
Total	**2,975**	**2,734**	**4,325**	**4,037**	**3,548**	**3,251**	**4,898**	**4,554**

4 Availability of Generating Capacities in 2014–2023

A forecast of the generating capacities' sufficiency is being made in order to:

- assess whether the power system will have sufficient generating capacity to meet the country's demand;
- determine the volume of the power reserves required to ensure the operational reliability of the system;
- identify the need for increasing cross-border capacities and receiving deficient capacities from the neighbouring power systems in cases where the system's generating capacities are not sufficient, provided that excess capacities are available in other power systems;
- identify the need for the generating sources' development in cases where it is not possible to receive deficient capacities from the neighbouring power systems.

Sufficiency of generating capacities is assessed in the most complex operating modes of the power system:

- during peak loads in winter – the highest demand and the majority of the power plants is in operation;
- during minimal loads in summer – the lowest demand, considering the decrease in the generating capacities due to power plants' repairs.

An analysis of the generating capacities' sufficiency has been made for each scenario of the power plants' capacity development.

Scenario A
Minimum Development of Generating Sources

It has been adopted that, at the beginning of 2023, power plants using fossil fuel totalling 2,450 MW, hydro electric power plants and hydro pumped storage plants totalling approx. 1,040 MW, wind farms totalling approx. 500 MW, biofuel-firing power plants totalling approx. 105 MW, and solar power plants totalling approx. 80 MW will be connected to the grid.

Figures 4.1 and 4.2 show an assessment of sufficiency of the generating capacities at the maximum load in winter and at the minimum load in summer.

Figure 4.1. *Sufficiency of generating capacities at maximum load in 2014–2023, Scenario A*

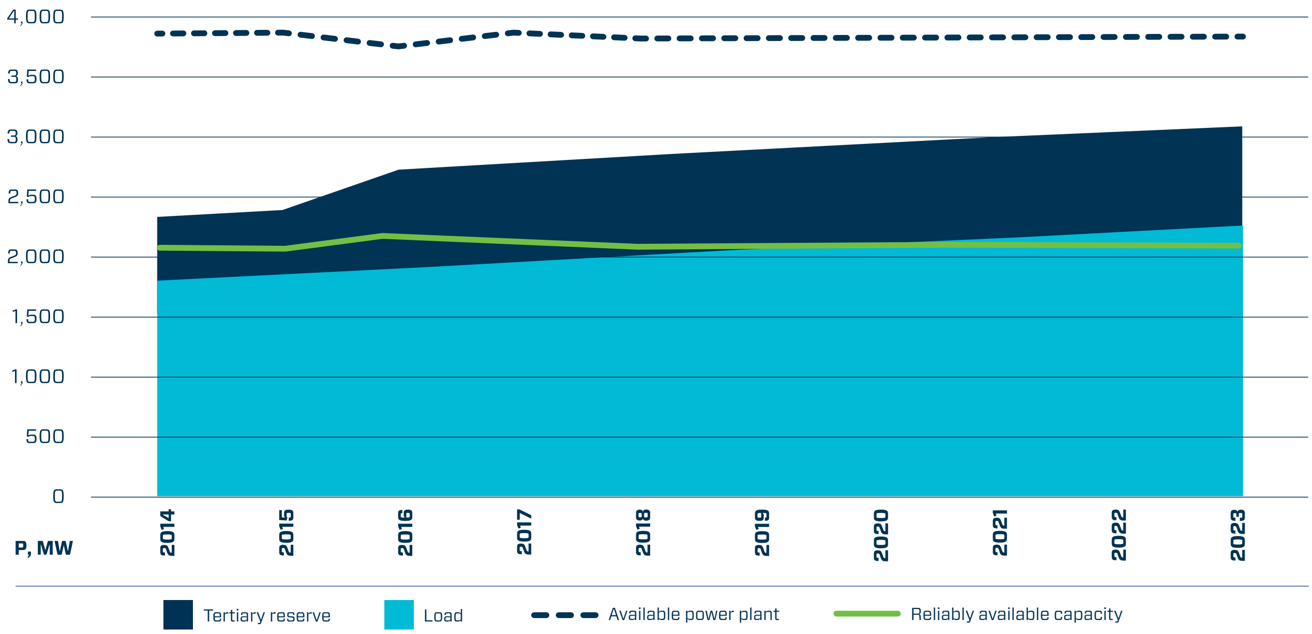
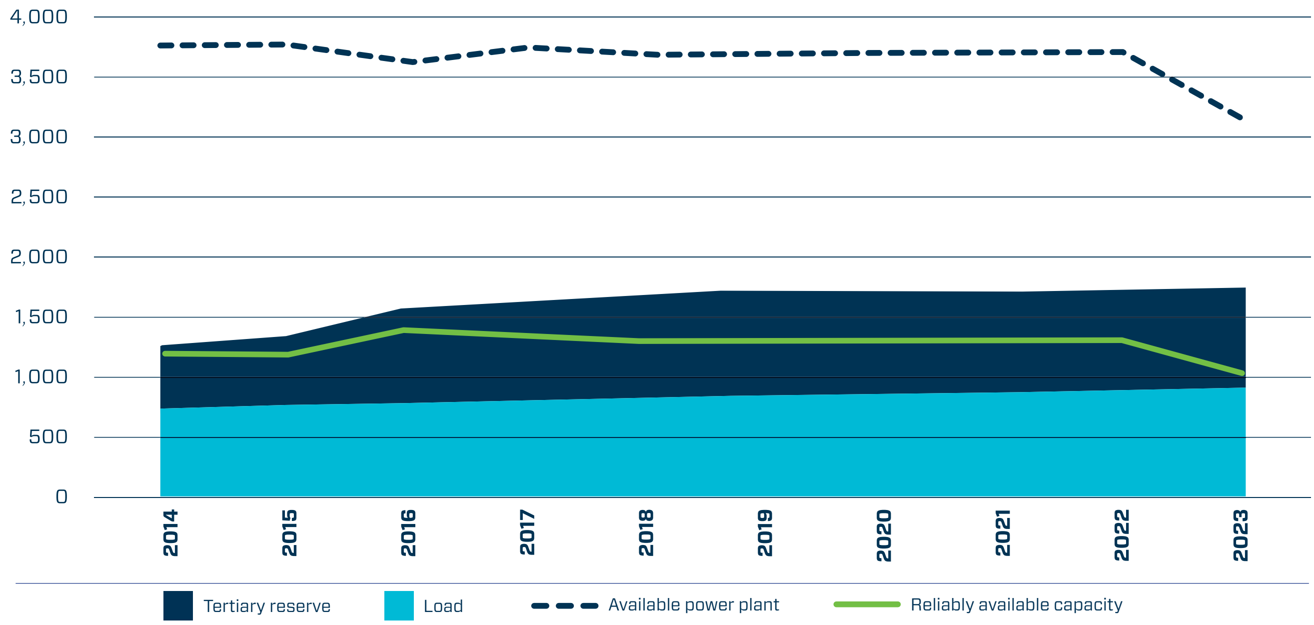


Figure 4.2. *Sufficiency of generating capacities at minimum load in 2014–2023, Scenario A*



In winter, when the thermal power plants are in operation, the system has sufficient capacities to cover the highest load by 2021. After 2021, a capacities' deficiency amounting to 68-166 MW is anticipated. As regards the tertiary reserve which is required to secure a stable and reliable operation of the system, a capacity deficiency will emerge as early as in 2014. The minimum system load in summer is approx. 60% lower than the peak load in winter, however, due to the specificity of operation of co-generation plants there is a decrease in the reliably available capacity while the demand for the tertiary reserve remains the same. The situation is improved due to reduced load – throughout the projected period, the system has enough capacities to meet the demand, however, the issue of securing the tertiary reserve remains.

Scenario B
Minimal Development + VNPP

It has been adopted, for the purposes of this scenario, that a new nuclear power plant with 1,350 MW installed capacity is put into operation in Visaginas in 2023. It is assumed that Lithuania receives a 500 MW* share in the total installed capacity of the VNPP.

Figure 4.3. *Sufficiency of generating capacities at maximum load in 2014–2023, Scenario B*

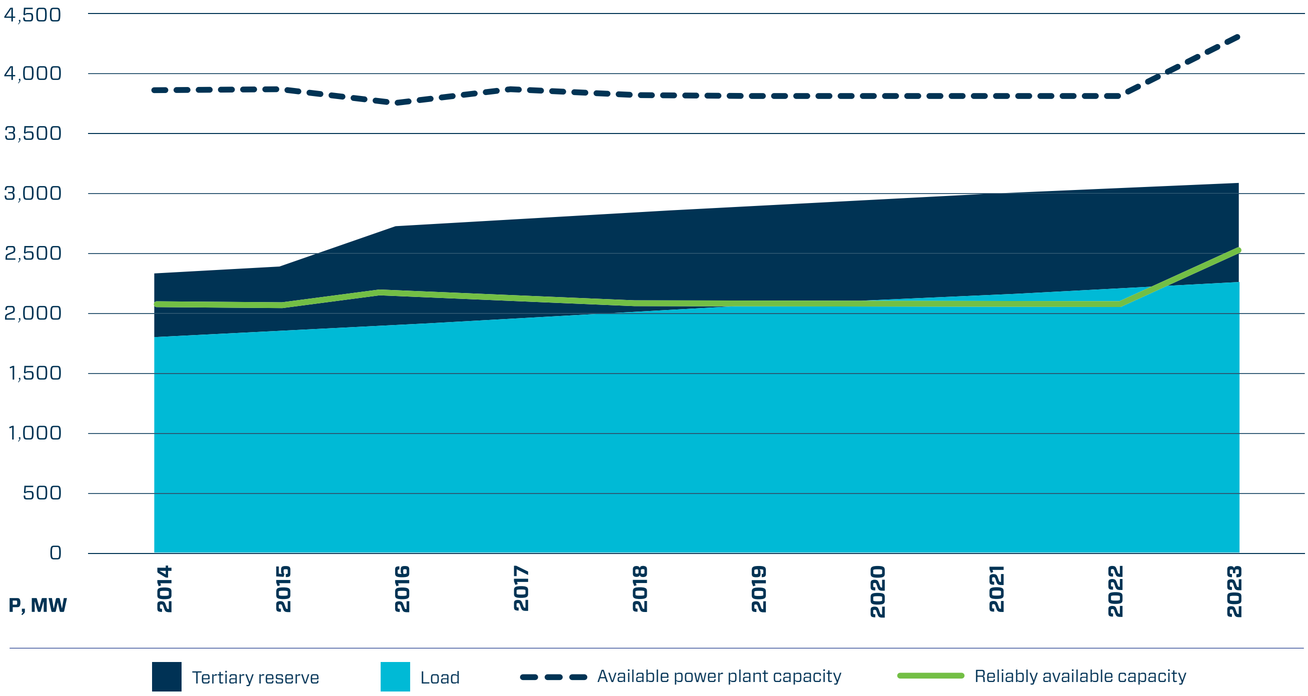
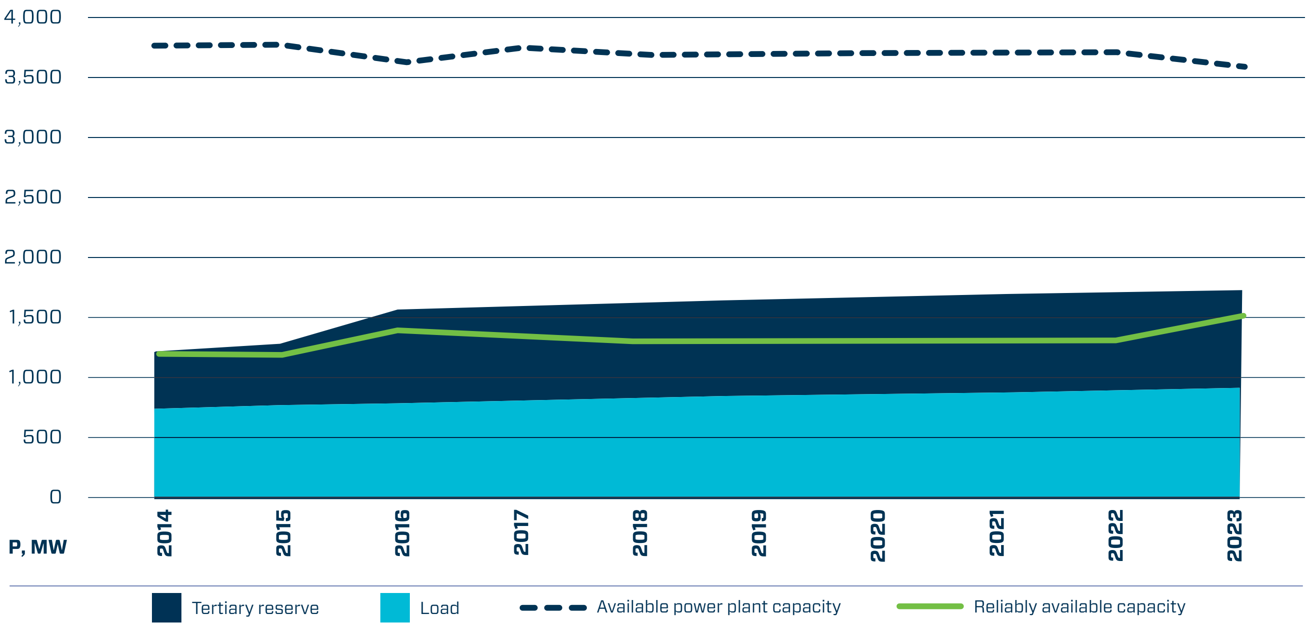


Figure 4.4. *Sufficiency of generating capacities at minimum load in 2014–2023, Scenario B*



* *http://www.vae.lt/faktai/#!/lietuvos_dalis*

Until 2023, the situation in both winter and summer remains the same as in Scenario A, and it is only in 2023, upon putting the new nuclear power plant into operation, the system receives additional capacities to meet the system's demand and part of the tertiary reserve. Assuming that the capacity of the new NPP will be allocated among the partners, they will have the responsibility for maintaining the required reserve capacities in proportion of this allocation. The available capacity will undergo no significant changes during the 2023 summer season because the capacity increase due to VNPP will be compensated by the decommissioning of the old units of the Lithuanian Power Plant.

Scenario C
Expected Development of Generating Sources

It has been adopted that, at the beginning of 2023, power plants using fossil fuel totalling 1,068 MW, hydro electric power plants and hydro pumped storage plants totalling approx. 1,267 MW, wind farms totalling approx. 800 MW, biofuel-firing power plants totalling approx. 333 MW, and solar power plants totalling approx. 80 MW will be connected to the grid.

Figure 4.5. *Sufficiency of generating capacities at maximum load in 2014–2023, Scenario C*

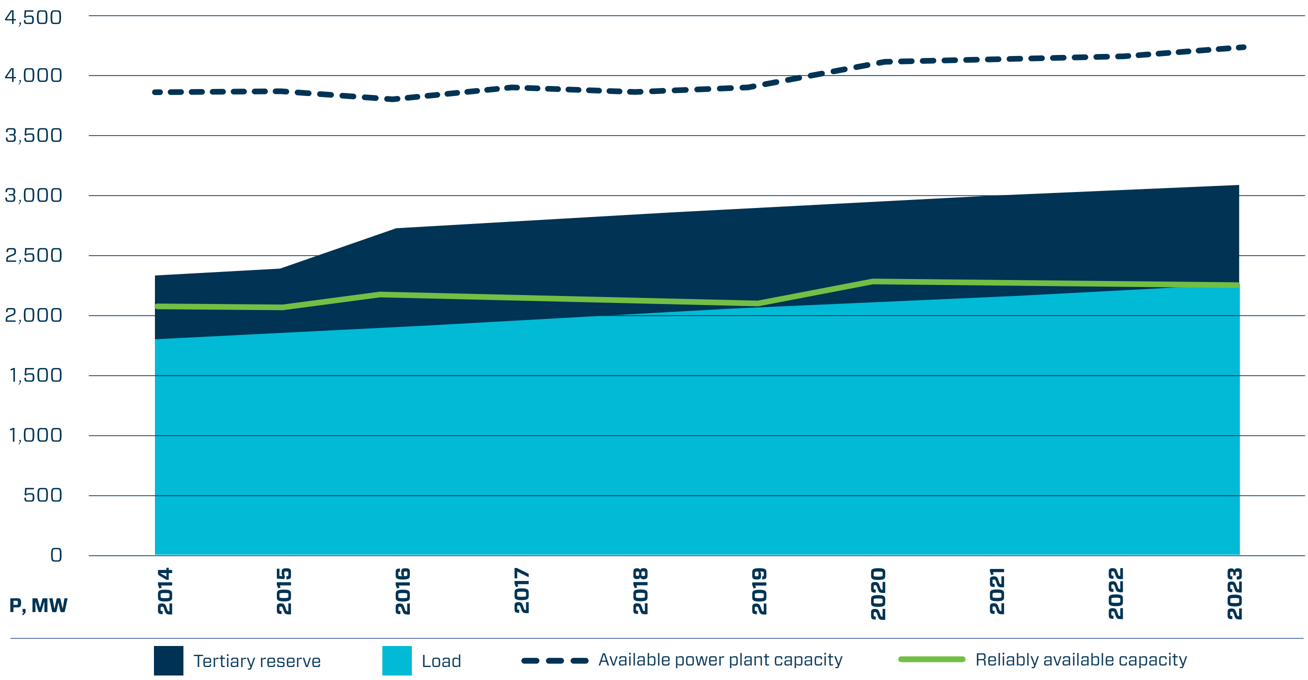
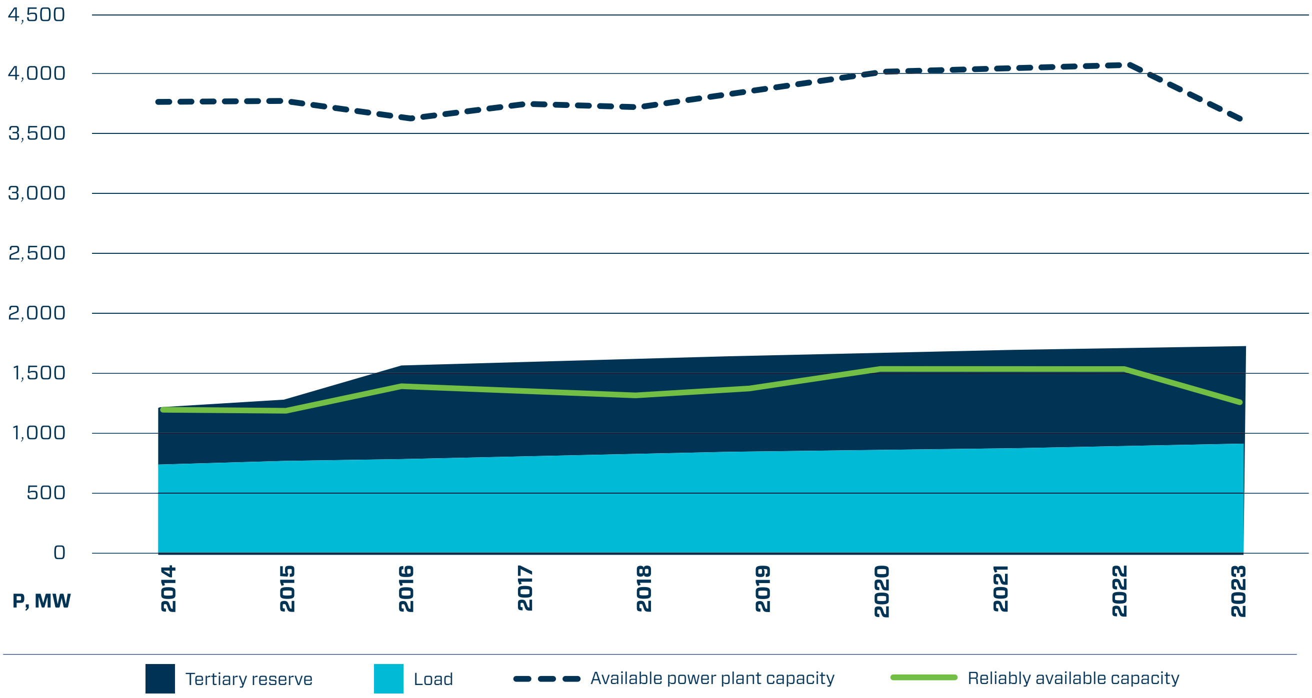


Figure. 4.6. *Sufficiency of generating capacities at minimum load in 2014–2023, Scenario C*



The available capacity of the power plants varies throughout the planning period due to decommissioning of old units and construction of new power plants. Under this scenario, throughout the period the system will have sufficient capacity to cover the peak load in winter, however, domestic generating capacity will not be sufficient to secure the tertiary reserve.

As the minimum system load in summer is approx. 60% lower than the maximum load in winter, the system has sufficient capacity throughout the planning period. To secure the tertiary reserve in this period, approx. 90–550 MW are deficient. The highest deficiency is estimated for 2018 (approx. 300 MW) and 2023 (approx. 550 MW).

Scenario D
Expected Development of Generating Sources with VNPP

Under this scenario, changes in the capacities by 2013 are the same as in Scenario C, with the added putting VNPP into operation in 2023. Just as in Scenario B, it is assumed that Lithuania receives a 500 MW share of the installed capacity of the new nuclear power plant.

Figure. 4.7. *Sufficiency of generating capacities at maximum load in 2014–2023, Scenario D*

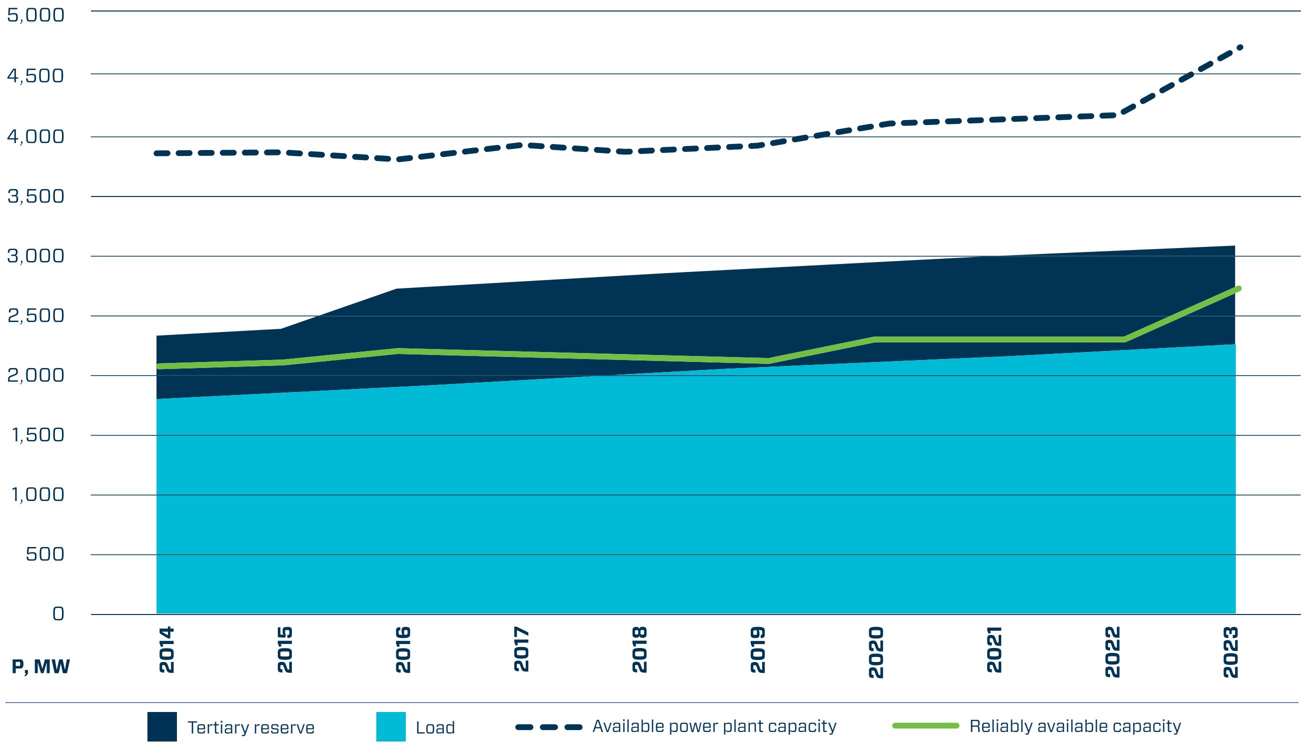
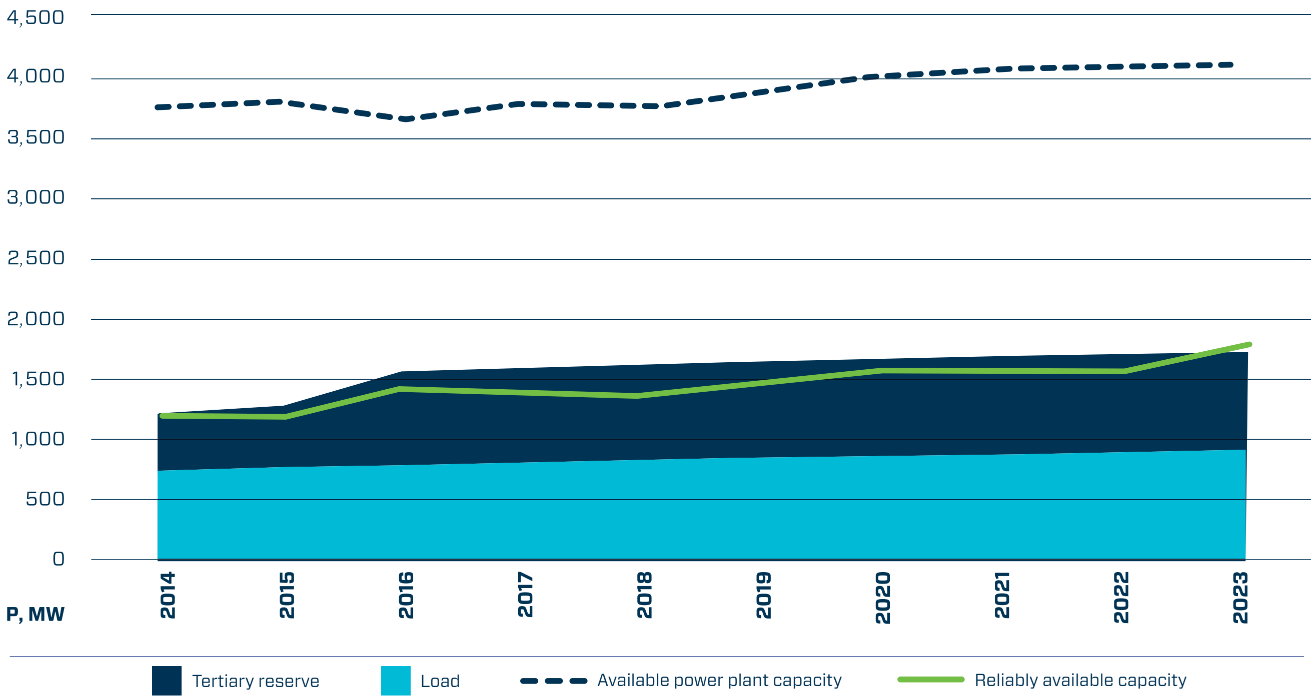


Figure. 4.8. *Sufficiency of generating capacities at minimum load in 2014–2023, Scenario D*



By 2023, the power system will have sufficient capacity to cover the peak load in both winter and summer, however, the available capacity will not be enough to secure the capacity required for the tertiary reserve. The deficiency for the purposes of the tertiary reserve is significantly reduced along with the decrease in the system load in summer. The generating capacity adopted in Scenario D (expected development of generating capacities including VNPP) is used in further transmission network calculations.

5 Electricity Market in 2014–2025

The evaluation of the electricity market situation is based on the findings of the analysis of the Lithuanian and the Baltic States electricity market completed by Litgrid in 2013. The analysis covers the period of 2013-2025. As no significant differences have been identified between 2022 and 2025, it is probable that they would not be marked in 2023 as well, therefore, market calculations are presented for 2025.

It is probable, based on the findings of the electricity market analysis, that in the baseline scenario the Lithuanian electricity market deficiency can reach 6.3 TWh in 2014 (Figure 5.1).

The electricity flows in the northern-southern direction will be determined by the generation of cheaper electricity in the Nordic countries. Part of the electricity demand in Lithuania will be met by imports from third countries. In 2025 the situation would change if VNPP is put into operation: Lithuania would become an electricity exporting country (net exports 2.1 TWh, Figure 5.2). Due to higher prices for electricity in Poland, annual electricity exports to this country could potentially reach 4.7 TWh. Upon narrowing of the electricity price difference between Sweden and Lithuania, a decrease in the electricity imports from the Nordic countries is expected in 2025.

Figure 5.1. *Electricity balance and trading flows in 2014*

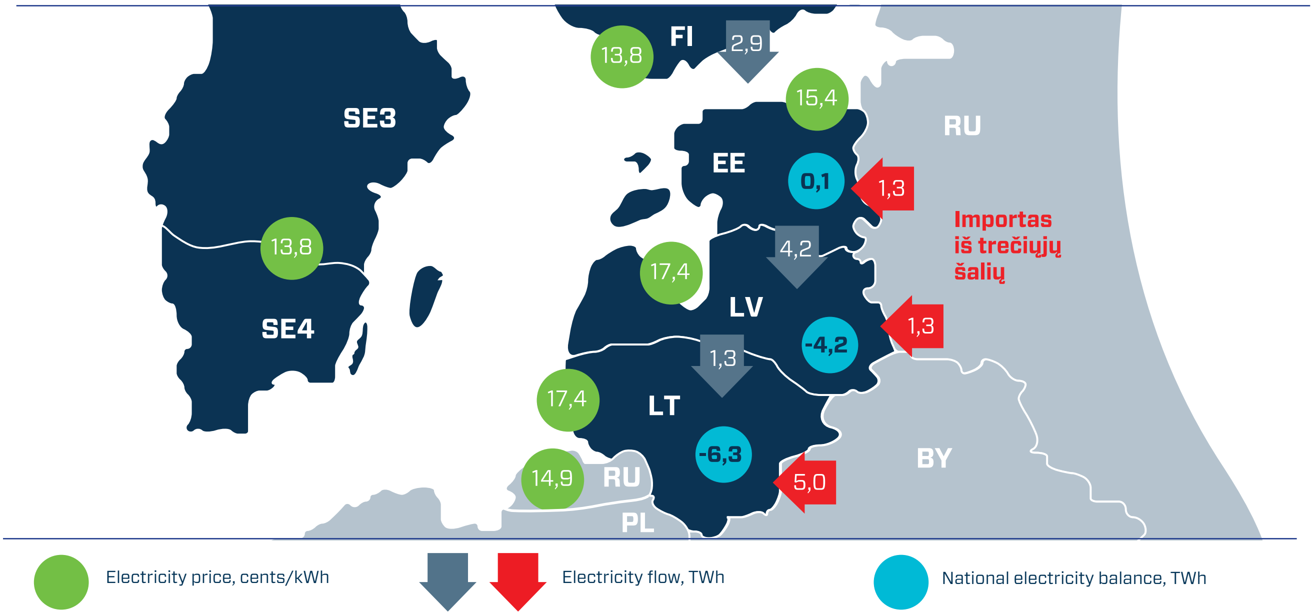
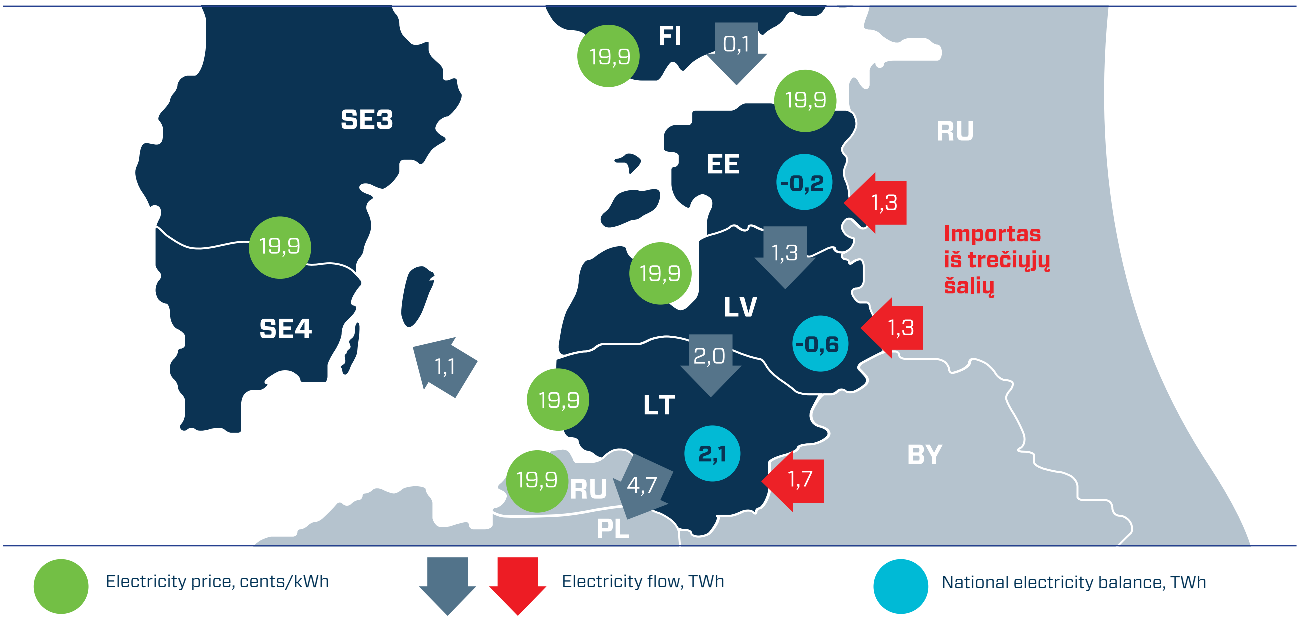


Figure 5.2. *Electricity balance and trading flows in 2025*



6 Transmission Grid Development in 2023

The planning of the transmission network development has been based on the guidelines and assumptions contained in the National Electrical Grids Strategy and the Litgrid Strategy for 2014-2023: construction of a new nuclear power plant, integration into the Nordic market for electricity, and synchronous operation in the Synchronous Grid of Continental Europe.

This plan encompasses to phases of the power system development by 2023:

The first PS development phase has been projected based on existing agreements on the cross-border power links and related contracts as well as on the ongoing internal projects of Litgrid.

The second phase covers the implementation of the new NPP project and the preparation of the PS for synchronous operation in SGCE.

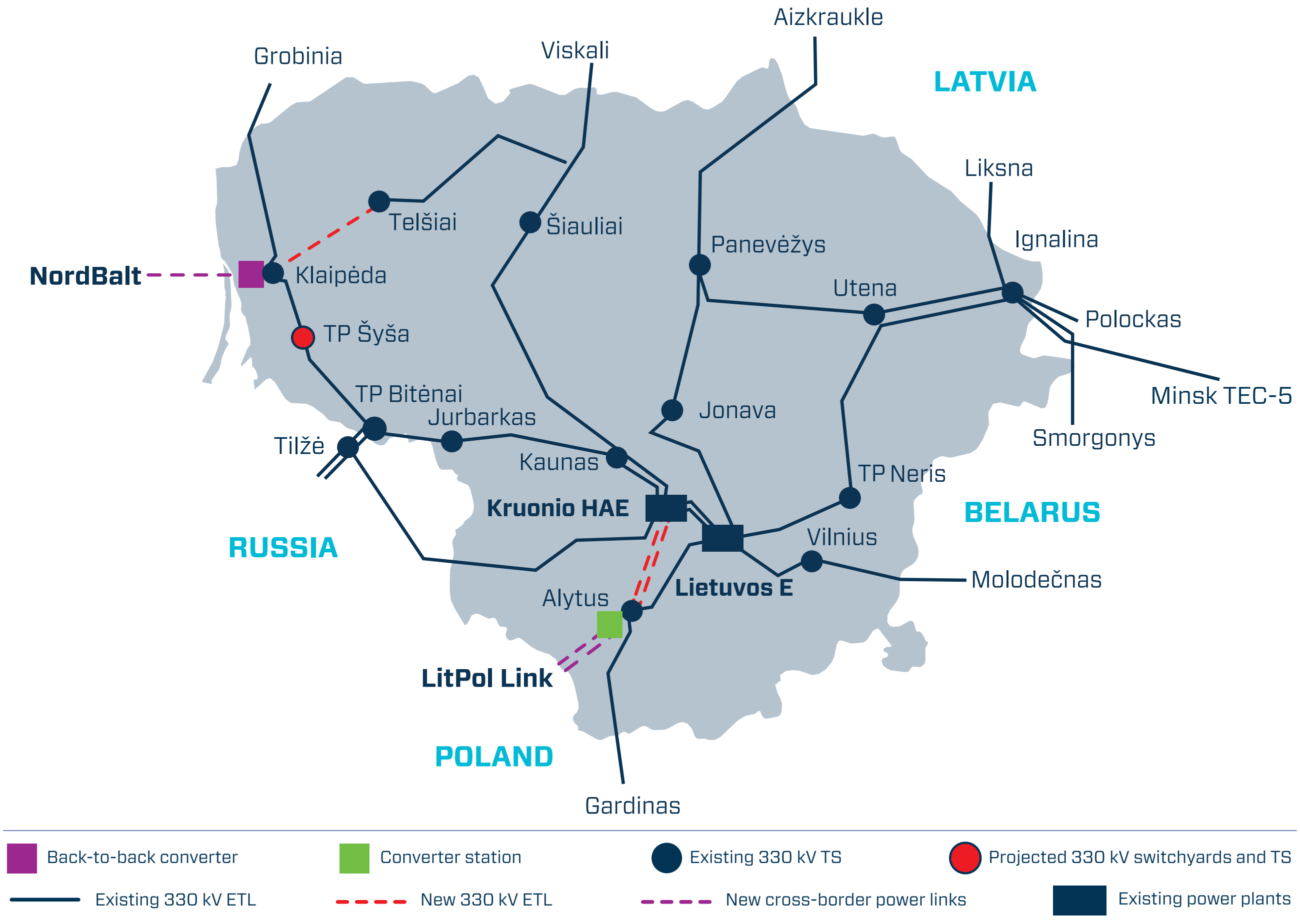
Phase 1 of TG development: 2014–2016

In this phase, the Baltic power systems operate synchronously with IPS/UPS and the agreements on the cross-border power links and the related contracts are implemented (Figure 6.1). The following is required for the implementation of this phase:

- completion of construction of NordBalt, a power link with Sweden: a 700 MW subwater cable from Klaipėda to Nybro and back-to-back converters at Klaipėda and Nybro transformer substations;
- completion of construction of LitPol Link, a power link with Poland: a 400 kV line Alytus–Ełk and a 500 MW back-to-back converter station;
- completion of construction of new 330 kV lines: Klaipėda–Telšiai and Kruonis HPSP–Alytus.

Along with these projects, internal PS development projects will be implemented to secure the reliability of the grid operation and to increase the flexibility of the system's control, along with the grid reconstruction projects (mainly TS and line reconstruction) and ICT systems' upgrading and implementation projects.

Figure 6.1. *Transmission system in 2016*



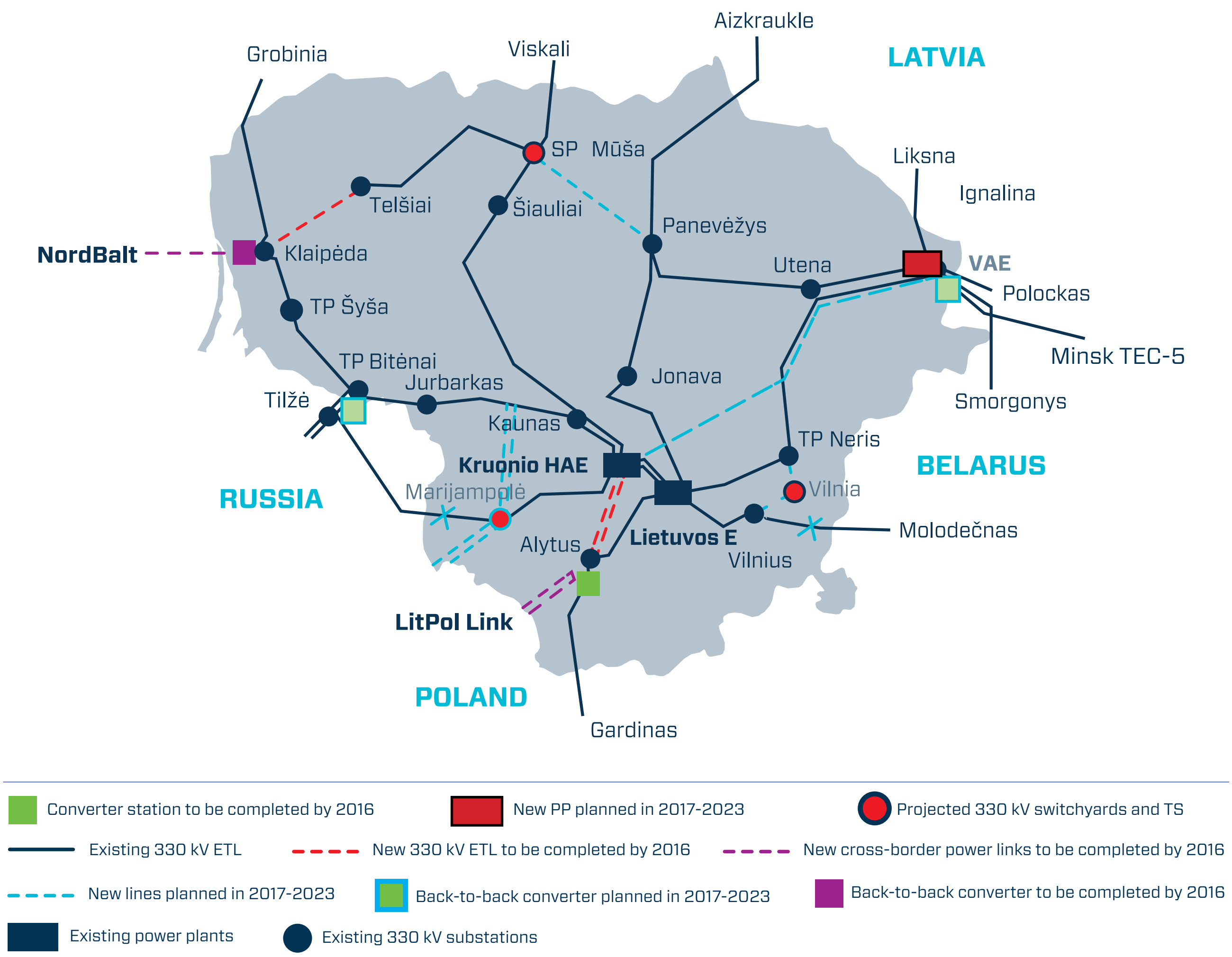
Phase 2 of TG development: 2017–2023

This phase will include the transmission network development required for the connection of the new power plant and the interconnection of the systems of the Baltic States (Lithuania, Latvia and Estonia) to the SGCE for synchronous operation (Figure 6.2). All the preparatory works necessary for the VNPP construction and the interconnection with SGCE have to be completed in this phase:

- construction of a second 400 kV cross-border line for synchronous operation with Poland. The point of connection of this second line has not been determined as yet and will be known upon adoption of the decision on the SGCE connection scenario;
- modernisation of the power plants' control and monitoring systems;
- construction of the required number of the back-to-back converter stations for the cross-border links with Belarus and Russia;
- the necessary grid adjustments due to the construction of VNPP (a 1350 MW unit);
- construction of a 330 kV Mūša DS;
- construction of new 330 kV lines VNPP–Kruonis HPSP, Panevėžys–Mūša, and Vilnius–Vilnia–Neris;
- construction of a 330/110/10 kV Vilnia TS;
- construction of additional 110 kV overhead lines at the Lithuanian-Byelorussian border.

Along with these projects, internal PS development projects aimed at securing the grid's operating reliability and increasing the flexibility of the system control will be implemented, mainly TS and line reconstruction and ICT systems' upgrading and implementation.

Figure 6.2. *Transmission network in 2023*



The capacity and installation of the back-to-back converters required for the connections with the Russian and Byelorussian power systems will depend on the need for electricity from and system services' trading from Russia as well as the outcome of negotiations with the Russian TSO over the desynchronisation of the Baltic PS and breaking of the BRELL ring. As regards the interconnection with SGCE, the exact number of lines with Poland and the interconnection schemes will be known on completion of the ENTSO-E led study required for obtaining the interconnection specifications. The Alytus back-to-back converter station will be reconnected from the Polish side to the Byelorussian side.

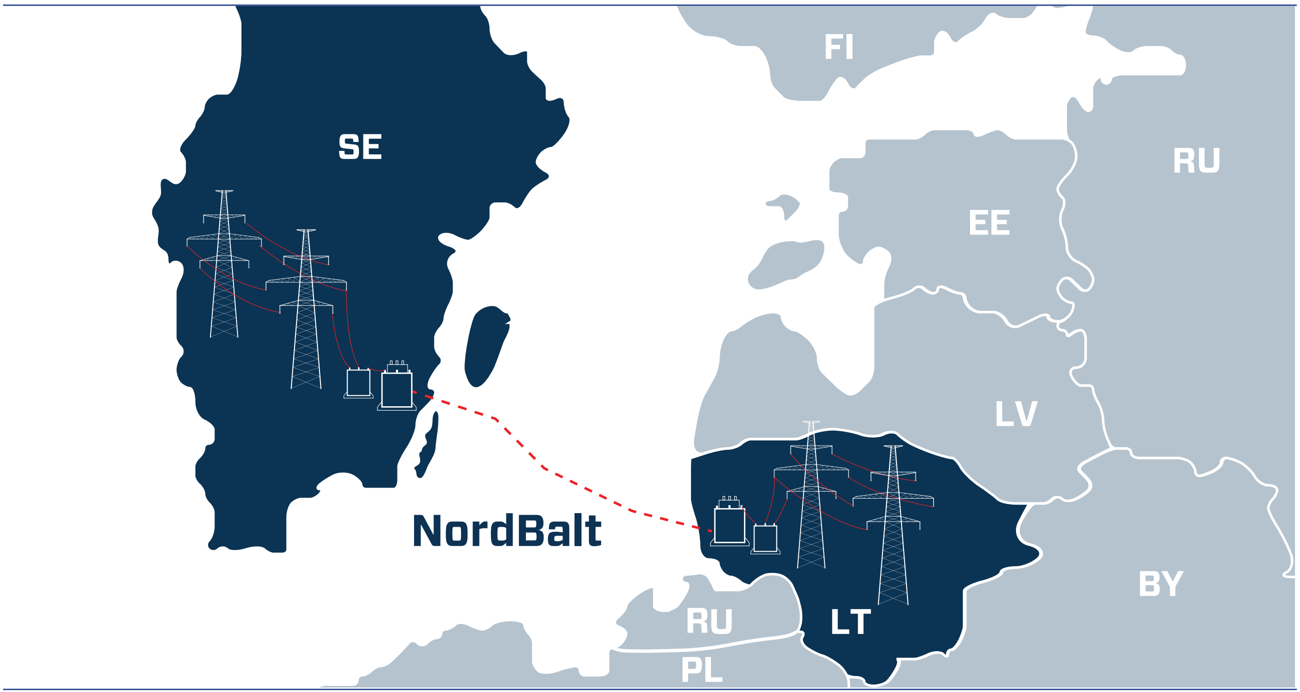
7 Projects on Modernisation and Development of Transmission Grids in 2014–2023

The planning of the transmission grid development has been based on the guidelines and assumptions set out in the National Energy Strategy and Litgrid's Strategy for 2014-2023 including the integration into the Nordic market for electricity, synchronous operation with the grid of Continental Europe, and construction of a new nuclear power plant. In case of amendments in these strategic documents, both timing and scope of implementation of the grid modernisation and development projects will have to be reviewed and adjusted.

7.1 Integration into the Nordic Electricity Market: NordBalt, a 700 MW Cross-Border Power Link Lithuania-Sweden

The NordBalt project is designed for the integration of the Baltic States' power systems into the Nordic power systems and markets and for the enhancing of the region's energy security and the reliability of electricity supply. The project has been provided for in the Baltic Energy Market Interconnection Plan (BEMIP). NordBalt power link consists of a 300 kV direct current cable from a 330/110/10 kV Klaipėda transformer substation to a 400 kV Nybro transformer substation (Sweden) and direct current back-to-back converters connected to these TS (Figure 7.1.1.).

Figure 7.1.1. *Cross-border link Lithuania-Sweden*



On 11 April 2014, a very important phase – laying the cable on the Baltic seabed was started in NordBalt cross-border power link project. The first metres of the subwater cable were inserted into the pipes by a designated vessel through the Curonian Lagoon. The cable is laid further in the Baltic Sea, towards Sweden. The works of laying of the cable are performed by ABB, a global technology company, which has also undertaken to lay a 13 km mainland cable in Klaipėda County. The cables will be connected to the new back-to-back converter which is under construction at Klaipėda TS. It is estimated that up to 250 km of the cable will be laid towards Sweden by September 2014, with the remaining cable-laying works to be completed in the summer of 2015.

Putting of NordBalt power link into operation In December 2015 will increase the opportunities for electricity imports to the Baltic States by more than one-third compared to 2014.

To use the capacity of the cross-border link in full, 330 kV lines Klaipėda-Telšiai and Panevėžys-Mūša have to be constructed.

A 90 km long 330 kV line Klaipėda-Telšiai will enhance the western part of the Lithuanian power system by increasing the transmission reliability for the customers in the Klaipėda, Telšiai and Plungė districts. Construction of more than two-thirds of the new overhead line has been completed by the autumn of 2013. The remaining construction works are carried out in 2014. The line is to be completed by 2015.

According to estimations, a reliable transfer of 700 MW from the Visaginas nuclear power plant to Sweden would be impossible without a 330 kV line Panevėžys-Mūša. There are almost no generating sources in the western part of Lithuania; the region has an electricity deficit and uses imported electricity from the neighbouring countries. A 330 kV line Panevėžys-Mūša (approx. 72 km) has to be constructed to increase the system's reliability and to transmit capacity from VNPP to the western part of the Lithuanian system.

On completion of construction of these lines, reliability of the Lithuanian power system will increase, and capacity losses in the 330 kV transmission network will decrease along with the amounts of electricity transmitted via the Latvian power system.

A 330/110/10 kV transformer substation in Klaipėda is being reconstructed for the purposes of a back-to-back converter required for the cross-border link. A new 330 kV overhead line Klaipėda-Telšiai will be connected to the 330 kV switchyard.

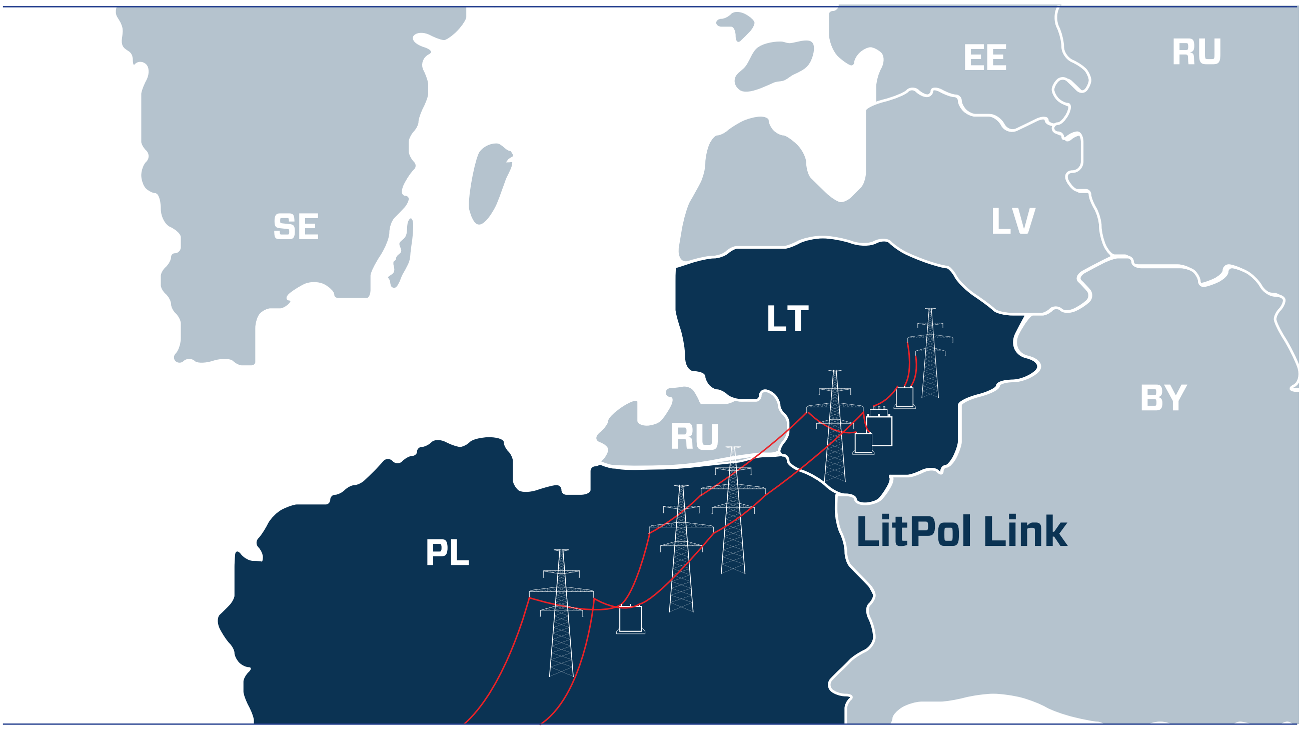
7.2 Integration into the EU Internal Electricity Market: LitPol Link, a 400 kV Cross-border Power Link Lithuania-Poland

Construction of a power link connecting Lithuania and Poland has been started in order to ensure the reliability of electricity supply, the system's operating stability, the diversification of energy sources on both national and Baltic Region's scale, and the integration of the Baltic electricity market into that of the EU.

LitPol Link, forming part of BEMIP, will interconnect the energy systems of the Baltic States in 2015, eliminating the energy islands in the EU.

The Lithuanian-Polish power link consists of the three main components: transformer substations at both ends of the link, i. e. at Alytus and Ełk (Poland), a back-to-back converter station at Alytus (prior to start of synchronisation with SGCE, the converter will be re-switched to a 330 kV Grodno line subject to the parties' agreement), and a high-voltage double-circuit 400 kV power transmission line from Alytus TS* to Ełk TS, total length of the line 163 km (Figure 7.2.1).

Figure 7.2.1. *Cross-border link Lithuania-Poland*



A double-circuit 330 kV overhead electricity transmission line Kruonis HPSP-Alytus has to be constructed in order to secure the maximum cross-border capacity exchange.

At present, the preparation of the transmission line route is nearing completion; the first towers for the line were erected in the summer of 2014; and construction of the back-to-back converter – the only one of a kind in the Baltic States has been started.

The LitPol Link project is indispensable for the integration of the Baltic States in the EU's common electricity system and market. Implementation of this project will mean the full completion of the Baltic power ring joining the power systems of Lithuania, Latvia, Estonia, Finland, Sweden, Norway, Denmark, Poland and Germany together into a single system. The ring will improve both security and reliability of the Baltic electrical grids.

** The construction of a second 500 MW back-to-back converter station at Alytus TS will depend on the start of synchronisation with SGCE*

7.3 Interconnection for Synchronous Operation in the Synchronous Grid of Continental Europe

The interconnection of the Lithuanian power system with the Synchronous Grid of Continental Europe has been provided for in Resolution of the Government of the Republic of Lithuania No 449 of 25 April 2012 'Concerning Approval of the Concept of the Project on the Interconnection of the Lithuanian Power System with the Synchronous Grid of Continental Europe for Synchronous Operation and the Strategic Lines of the Project's Implementation' and the Republic of Lithuania Law on the Integration of the Power System of the Republic of Lithuania into the European Electricity Systems enacted by the Seimas on 12 June 2012.

In 2013, Gothia Power, a Swedish consultancy, completed a feasibility study on the Baltic States' integration into the EU internal market for electricity. The study on the feasibility of construction of potential power links ('the feasibility study'), commissioned by the TSOs of the Baltic States, analyses several options for the interconnection with the SGCE for synchronous operation. The findings of the feasibility study have shown that the connection of the Lithuanian PS with SGCE for synchronous operation is possible provided that the transmission grid development is properly planned in order to ensure a stable and reliable operation of the system and the Lithuanian PS's integration with the Continental European Synchronous Area.

The feasibility study made by Gothia Power proposes a new 400/330 kV TS at Marijampolė as one of the alternative points for the connection of a second double-circuit 400 kV overhead transmission line between Poland and Lithuania (subject to a bilateral agreement of the countries). The existing 330 kV line Kruonis HPSP-Sovetsk and a new double-circuit 330 kV line from Marijampolė TS to the 330 kV line Kaunas–Jurbarkas would be connected to the new transformer substation. Upon switching to the synchronous operation within SGCE, part of the existing 330 kV cross-border lines connecting the Baltic States with the power systems of Russia and Belarus will have to be connected by means of direct current back-to-back converters. To secure synchronous operation within SGCE and to meet the N-1 criterion of system's reliability, a new 330 kV power transmission line Vilnius–Vilnia–Neris will have to be constructed, and additional 110 kV lines will be required to increase the reliability in East Lithuania's 110 kV grid. If a decision on later synchronisation with SGCE is adopted, the construction of these lines can be planned for a later period.

7.4 Connection of the New Nuclear Power Plant

Development of 330 kV transmission grid will be required on completion of construction of Visaginas NPP and considering the projected interconnection of the Lithuanian PS with SGCE, in order to secure the reliable operation of the transmission grid and the transfer of the VNPP capacity to the system:

- construction of a new 330/110 kV switchyard at VNPP;
- construction of a 330 kV line VNPP–Kruonis HPSP (provided that the Baltic States operate synchronously within SGCE and that the VNPP is put into operation);
- construction of a 330 kV line VNPP-Latvia (subject to a bilateral agreement of the countries).

All these system facilities have to be installed prior to putting the VNPP into operation. Should a decision on abandoning the VNPP project is adopted, installation of the facilities will not be necessary.

7.5 Development of 330–110 kV Transmission Grids in Lithuania

Considering the projected synchronous operation of the Baltic States within the grid of Continental Europe and the potential increase in the demand for electricity in Vilnius after 2023, construction of a new 330 kV Vilnia TS is recommended. The most suitable location would be at the existing 110/10 kV Vilnia TS. The new 330 kV Vilnia TS is planned to be connected to the Vilnius–Vilnia–Neris to be constructed in the future. The timing of construction of the new substation will depend on the completion of the Vilnius–Vilnia–Neris line and the VNPP.

Litgrid does not intend to initiate construction of new 110 kV transformer substations. The demand for new 110 kV TS usually arises due to emergence of new customers and higher rates of growth in the demand for electricity. The following 110 kV TS are planned to be constructed in 2014–2023:

• Šnipiškės TS and Kuprijoniškės TS. The new transformer substations will be built in the territory of the Vilnius City and will be connected to the system through cable branches;

• Lazdėnai TS, to be connected to the existing 110 kV line Vilnius TEC3*–Vievis;

• Strėva TS, which is planned for the connection of a new customer in the territory of Kruonis HPSP;

• Sitkūnai TS, to be connected to the existing 110 kV line Kaunas–Vandžiogala;

• 110 kV switchyard and power transformer at 330 kV Bitėnai distribution station.

As Rail Baltica railway electrification project gains pace, four traction substations are planned to be constructed by 2020. The following traction substations will ensure electrification of railway section Kaišiadorys–Radviliškis: 110/27.5/10 kV Jonava TS, 110/27.5/10 kV Radviliškis TS, 110/27.5/10 kV Gudžiūnai TS and 110/27.5/10 kV Kėdainiai TS.

The transmission system operator is obliged to connect to the transmission network the electrical equipment of customers, distribution grid operators, and power generating companies. For this purpose, construction of new 20/110 kV substations for wind farms needs to be planned. **

Construction of 330–110 kV lines is connected to the increase in the power system's reliability, the emergence of power links, and the plans of synchronous operation within SGCE and construction of VNPP.

Construction of 110 kV lines Šilas–Varėna, Neris–Baltupis, and Kaunas–Eiguliai 2 is planned for ensuring the requisite voltage levels and for increasing reliability of supply (Figure 7.5.1).

Preparations for the construction of 110 kV lines: Klaipėda–Marios 3, Kretinga–Benaičiai, and Pagėgiai–Bitėnai double-circuit line (Figure 7.5.2) are underway with the aim of securing the operating reliability of West Lithuanian transmission grids:

A map of the transmission grids that will form the Lithuanian power system in 2023 is provided in Annex 1.

Thermal power plant No 3 operated by Vilniaus Energija UAB

***Electricity generating companies are connected to the PS according to Order of the Ministry of Energy of the Republic of Lithuania No 1-127 of 12 July 2004 'Concerning approval of the Procedure for the Connection of Electrical Equipment of Electricity Generating Companies and Customers to Electrical Grids'*

Figure 7.5.1 Construction of new 110 kV electricity transmission lines in Mid Lithuania and East Lithuania

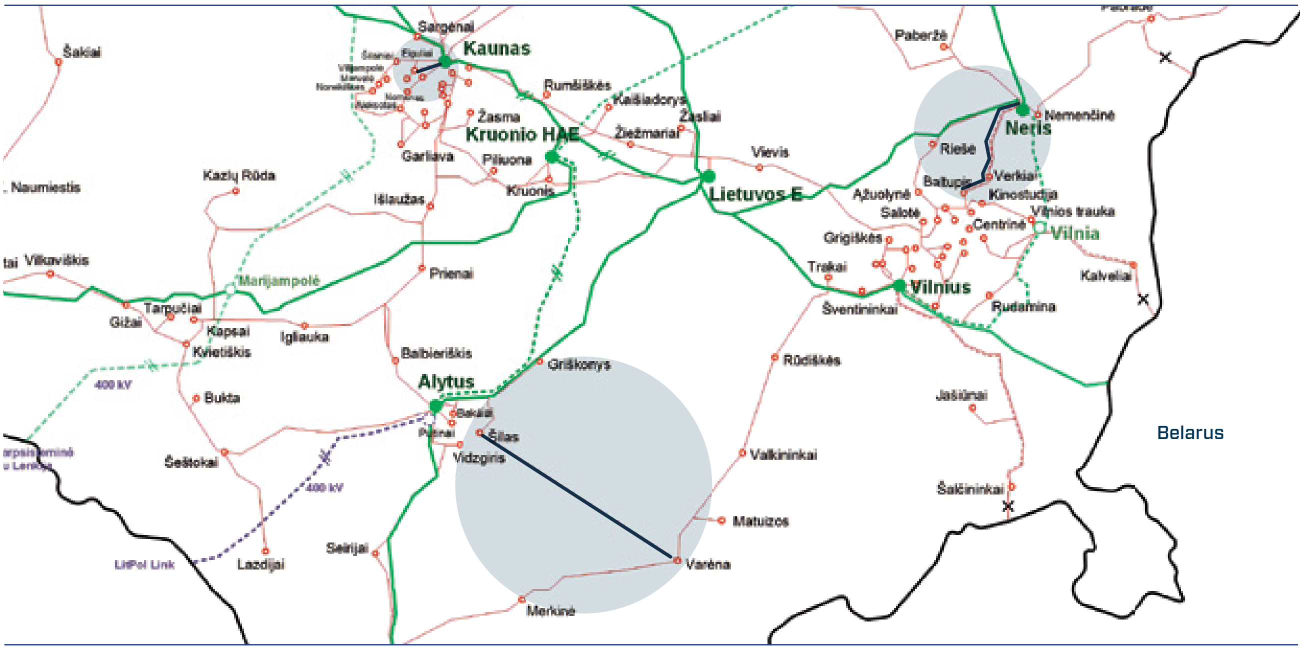
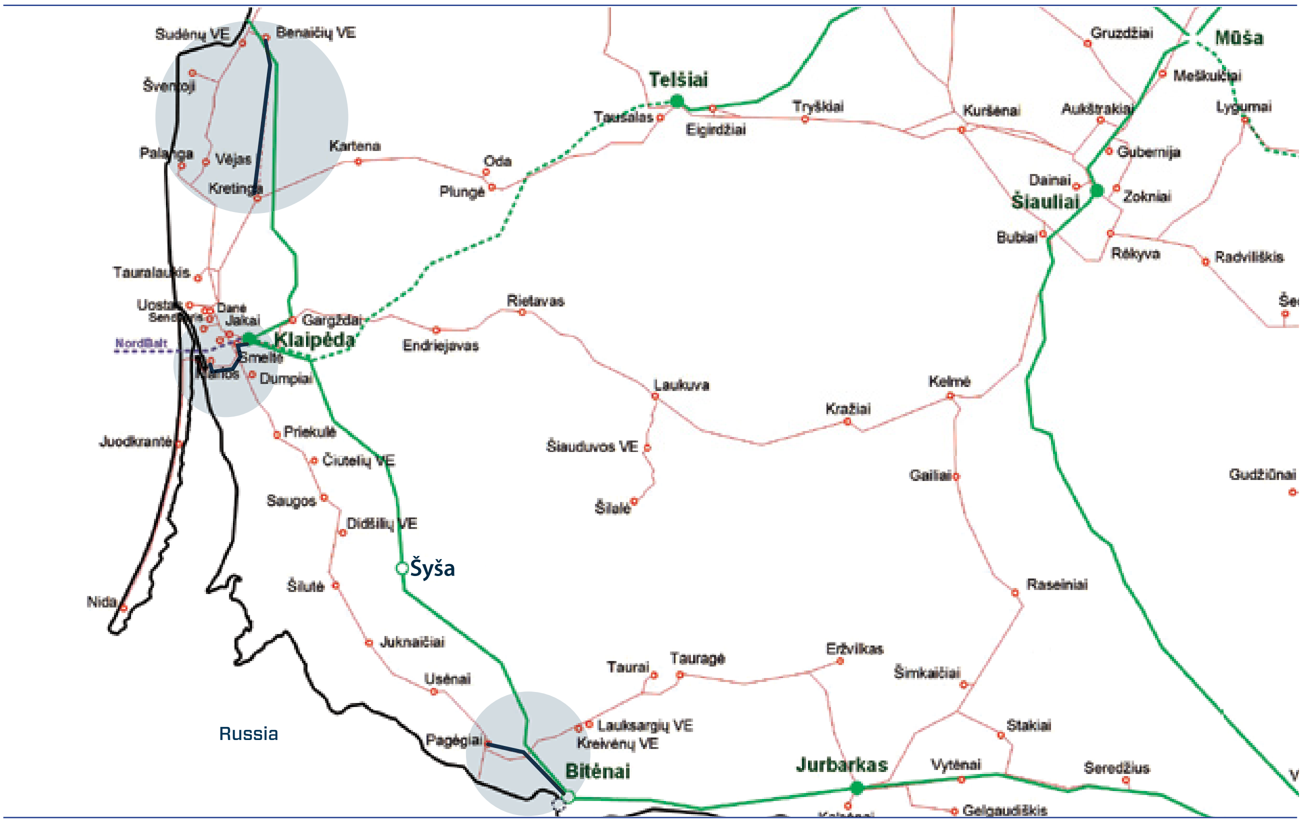


Figure 7.5.2 Construction of new 110 kV electricity transmission lines in West Lithuania



7.6 Reconstruction of 330–110 kV Transmission Grids in Lithuania

Reconstruction of the following 330 kV TS is planned to be completed by 2015:

- 330 kV Klaipėda TS – the reconstruction project is planned to be completed at the end of 2014;
- 330 kV Šiauliai TS – reconstruction of the 330 kV switchyard was completed in 2002; the current reconstruction of the 110 kV switchyard is planned to be completed at the end of 2014;
- 330 kV Panevėžys TS – reconstruction and replacement of equipment are planned to be completed in 2014.

After 2015, reconstruction of Neris, Jurbarkas and Jonava TS will be started (all 330 kV).

The 110 kV TS reconstruction plans are being formulated while bearing in mind that a sufficient reliability level has to be ensured for a maximum number of customers at minimal investments. Reconstruction of 110 kV TSs is carried out according to the company's methodology for the assessment of the condition of 110 kV transformer substations and determination of the scope of reconstruction. Upon assessment of the condition of 110 kV TSs, a list of the TSs requiring reconstruction has been compiled. Sixty eight 110 kV TSs are to be reconstructed in 2014-2023.

330–110 kV transmission lines are reconstructed according to the company's methodology for the determination of the technical condition of the main components of 330–110 kV overhead lines and the scope of reconstruction adopted in 2013. Reconstruction of 330 kV line Šiauliai–Jelgava (up to the Lithuanian-Latvian border) is planned in 2014-2023. In addition, reinforced concrete towers will be replaced in the 330 kV overhead line from the Lithuanian Power Plant to Alytus and in Jonava–Panevėžys sections. Full reconstruction of the following 110 kV lines is planned in 2014–2023: Merkinė–Varėna–Valkininkai–Rūdiškės–Trakai and Rašė–Zarasai. In other lines, only some components will be replaced (e. g., a lightning-protection cable will be replaced Pasvalys–Parovėja line).

Reconstruction or construction of new 110 kV lines in urban areas or settlements must be carried out with due regard to the existing infrastructure. In cases where there is no space for the overhead lines' protection lines due to the build-up or engineering solutions, underground cable lines are laid. In other cases, overhead lines are replaced by cable lines only at the expense of natural or legal persons initiating the project.*

** According to Order of the Ministry of Energy of the Republic of Lithuania No 1-127 of 12 July 2004 'Concerning approval of the Procedure for the Connection of Electrical Equipment of Electricity Generating Companies and Customers to Electrical Grids*

8 Investments in Transmission Grids in 2014–2023

Investments in the power system consist of the investments earmarked for the implementation of strategic projects, for ensuring the system's reliability, for the implementation of IT and similar projects, and for the projects launched on the initiative of customers and electricity generating companies.

It is estimated that the total amount of investments in the PS development and reconstruction in 2014–2023 may reach approx. LTL 3,316.8 million.

Litgrid's investments in the PS development and reconstruction may amount to approx. LTL, 3 161.2 million (the amount is limited to the PS strategic, PS reliability, IT projects and similar projects).

The largest share of investments planned for 2014–2023 will be earmarked for the construction of the cross-border power links with Poland and Sweden and the preparations for synchronous operation within SGCE (Table 8.1).

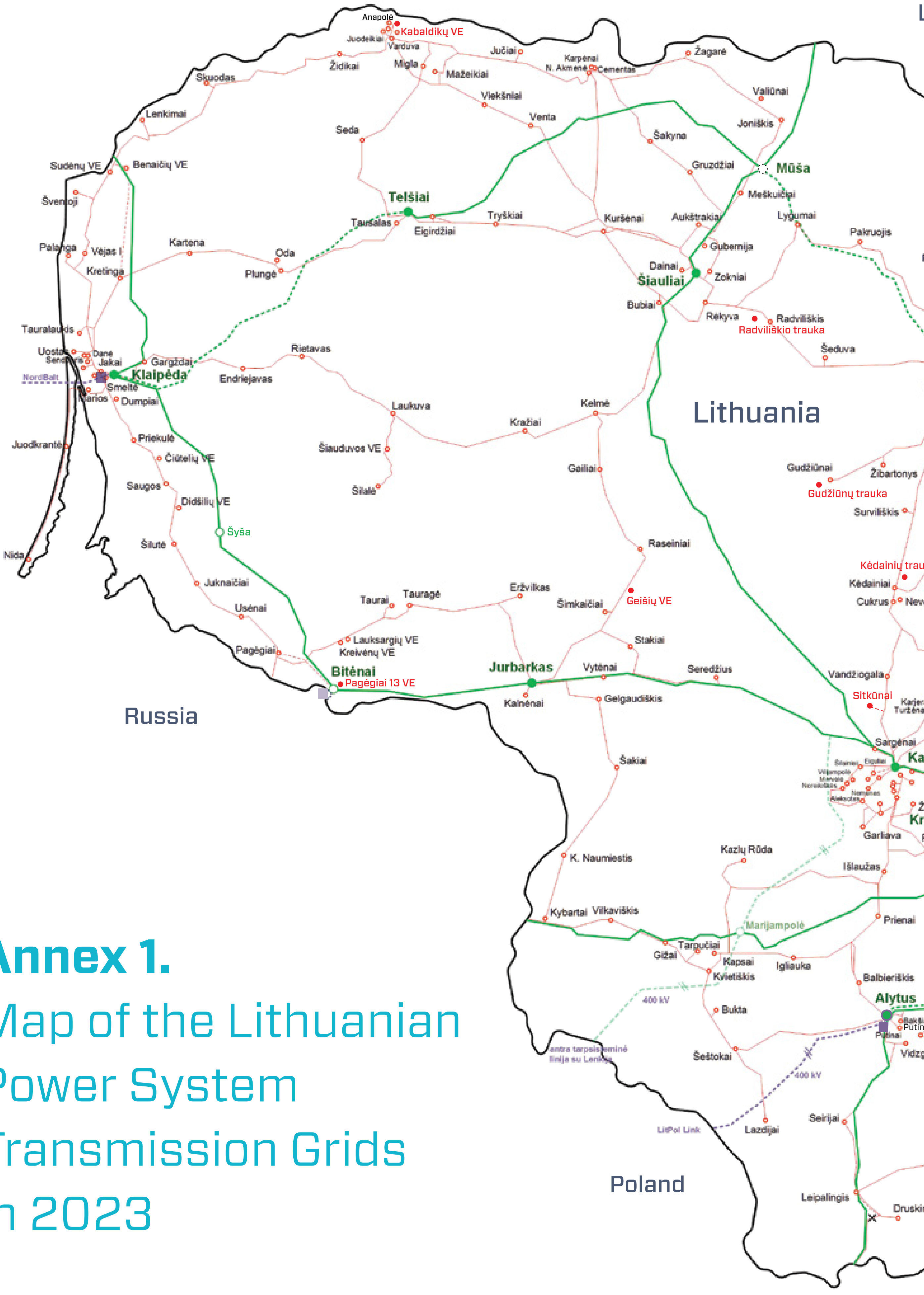
Table 8.1. *Planned investments in the transmission grid development and reconstruction*

Main investment groups	Planned investments for 2014–2023. LTL m	Planned investments for 2014–2023. EUR m
Strategic power system projects	**2,360.4**	**683.6**
Cross-border power link Lithuania-Sweden and the related projects: construction of the cable and the back-to-back converter. construction of 330 kV lines Klaipėda–Telšiai and Panevėžys–Mūša as well as Mūša switchyard	636.6	184.4
Cross-border power link Lithuania-Poland and the related projects: construction of a 400 kV line Alytus– Ełk (up to the Lithuanian-Polish border) and a 500 MW back-to-back converter station, construction of a 400 kV Alytus switchyard, reconstruction of 330 kV and 110 kV switchyards at Alytus TS. and construction of a new 330 kV line Kruonis HPSP–Alytus	427.6	123.8
Grid preparations for synchronous operation within SGCE*: construction of additional lines to increase system reliability in 110 kV grid in East Lithuania. construction of a second cross-border link Lithuania-Poland, construction of a back-to-back converter station, construction of 330 kV lines Vilnius–Vilnia–Neris and VNPP–Kruonis HAE. installation of the automated generation control and primary regulation monitoring systems, and a feasibility study	1,296.3	375.4
Projects necessary for the system's reliability	**755.6**	**218.9**
ICT and other projects	**45.2**	**13.1**
Litgrid investments total	**3,161.2**	**915.6**
PS projects on the initiative of customers and power generating companies	155.6	45.1
Total investments in PS development and reconstruction	**3,316.8**	**960.6**

At the present regulation of the transmission tariff, the transmission infrastructure share in the electricity price (i. e. depreciation costs, return on investment and public-interest service funds for NordBalt implementation will vary from 2.01 cents/kWh in 2014 to 2.07 cents/kWh in 2023**.

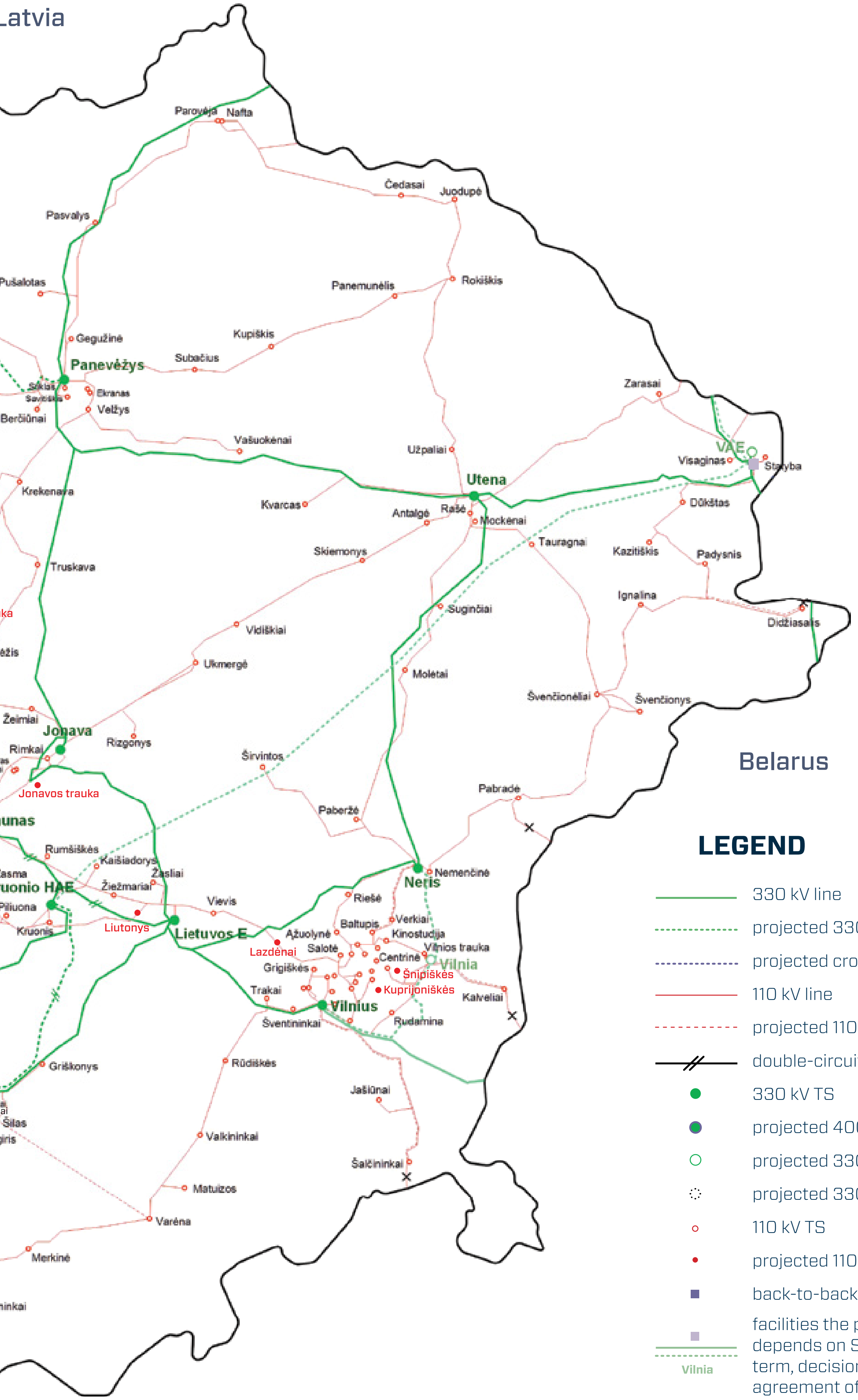
** Implementation of the projects will depend on the decision on the new nuclear power plant and/or the term for synchronisation with SGCE*

***Prices in Euro at the official exchange rate in 2014 (EUR 1 = LTL 3.4528): from 0.069 Eurocents per kWh in 2014 to 0.050 Eurocents per kWh in 2022 and 0.071 Eurocents per kWh in 2023*



Annex 1.

Map of the Lithuanian Power System Transmission Grids in 2023



LEGEND

- 330 kV line
- projected 330 kV line
- projected cross-border line
- 110 kV line
- projected 110 kV line
- double-circuit line
- 330 kV TS
- projected 400 kV TS
- projected 330 kV TS
- projected 330 kV DS
- 110 kV TS
- projected 110 kV TS
- back-to-back-converter
- Vilnia — facilities the provision of which depends on SGCE integration term, decision on VNPP or bilateral agreement of the countries

Annex 2.
Strategic Projects' Implementation Schedule

<table>
<tr><th></th><th></th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th></tr>
<tr><td rowspan="3">Nord Balt</td><td>Construction of direct current cable Klaipėda–Nybro and of back-to-back converter at Klaipėda TS</td><td colspan="2">Construction</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Construction of 330 kV ETL Klaipėda–Telšiai</td><td>Con-struction</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Construction of 330 kV ETL Panevėžys–Mūša* and of a 330 kV Mūša switchyard</td><td></td><td colspan="2">Preparatory works</td><td colspan="3">Design</td><td colspan="4">Construction</td></tr>
<tr><td rowspan="4">LitPol Link</td><td>Construction of a 400 kV ETL Alytus-Elk (up to the Lithuanian-Polish border)*</td><td colspan="2">Construction</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>300 kV ETL Kruonis HPSP-Alytus</td><td>Design</td><td colspan="3">Construction</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Reconstruction of a 330 kV switchyard in 330/110/10 kV Alytus TS</td><td colspan="2">Construction</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Reconstruction of a 110 kV switchyard in 330/110/10 kV Alytus TS</td><td>Con-struction</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">Grid preparation for synchronous operation in SGCE</td><td>330 kV ETL VNPP– Kruonis HAE*</td><td></td><td></td><td></td><td></td><td>Prepa-ratory works</td><td>Design</td><td colspan="4">Construction</td></tr>
<tr><td>Construction of 110 kV lines to ensure supply reliability in East Lithuania *</td><td></td><td></td><td>Prepa-ratory works</td><td>Design</td><td colspan="4">Construction</td><td></td><td></td></tr>
<tr><td>Second cross-border link Lithuania-Poland*</td><td></td><td></td><td></td><td>Prepa-ratory works</td><td>Design</td><td colspan="4">Construction</td><td></td></tr>
<tr><td>Arrangement of connections through back-to-back converters*</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Construction</td><td></td></tr>
<tr><td>Construction of a 330 kV ETL Vilnius–Vilnia–Neris*</td><td></td><td></td><td></td><td></td><td>Prepa-ratory works</td><td>Design</td><td colspan="4">Construction</td></tr>
</table>

** Implementation of the projects will depend on the decision on the new nuclear power plant and/or the term for synchronisation with SGCE*

Annex 3.

Schedule of Implementation of Projects on 330 kV and 110 kV Electricity Transmission Lines and Transformer Substations

<table>
<tr><th></th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th></tr>
<tr><td>Construction of 330/110/10 kV VNPP TS*</td><td></td><td></td><td></td><td>Preparatory works</td><td>Design</td><td colspan="4">Construction</td><td></td></tr>
<tr><td>Construction of 110/10 kV Vilnia TS 330 kV switchyard*</td><td></td><td></td><td></td><td></td><td></td><td>Preparatory works</td><td>Design</td><td colspan="3">Construction</td></tr>
<tr><td>Extension of 330 kV Bitėnai DS (Phase I)</td><td>Design</td><td>Construction</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Construction of 110 kV ETL Pagėgiai- Bitėnai and extension of 330 kV Bitėnai DS (Phase II)</td><td>Preparatory works</td><td>Design</td><td colspan="5">Construction</td><td></td><td></td><td></td></tr>
<tr><td>Construction of 110 kV ETL Kretinga–Benaičiai TS</td><td>Design</td><td colspan="2">Construction</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Construction of 110 kV ETL Klaipėda–Marios 3</td><td>Design</td><td colspan="2">Construction</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Construction of 110 kV ETL Kaunas–Eiguliai</td><td></td><td></td><td>Preparatory works</td><td colspan="2">Design</td><td colspan="2">Construction</td><td></td><td></td><td></td></tr>
<tr><td>Construction of 110 kV ETL Neris–Baltupis</td><td></td><td></td><td></td><td>Preparatory works</td><td>Design</td><td colspan="3">Construction</td><td></td><td></td></tr>
<tr><td>Construction of 110 kV ETL Šilas–Varėna</td><td></td><td></td><td></td><td></td><td>Preparatory works</td><td>Design</td><td colspan="2">Construction</td><td></td><td></td></tr>
</table>

** Implementation of the projects will depend on the decision on the new nuclear power plant and/or the term for synchronisation with SGCE*

LITGRID AB
Electricity Transmission System Operator

A. Juozapavičiaus g. 13,
LT-09311 Vilnius
Tel.: +370 5 278 2777
Fax: +370 5 272 3986
Email: info@litgrid.eu
www.litgrid.eu

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