1 Expansion path of renewable energies

1.1 Development to date

Lithuania has set ambitious targets under the National Energy Independence Strategy to contribute to the Energy Union and the EU's 2030 energy and climate policy goals, with a target of 45% of final energy consumption to be from renewable energy sources.

The largest share of renewable energy comes from solid biofuels, such as firewood and wood and agricultural residues for fuel. In 2022, biofuels accounted for 51.8% of electricity and district heating consumption, and 34.1% of household consumption. Energy producers produced 67.2% of all heat produced in power plants and boiler houses and 17.1% of all electricity produced in power plants from biofuels.

In 2022, Lithuania's existing wind farms, together with small wind farms, generated 1.5 TWh of electricity, representing just over a third of the country's total electricity generation, or 11.3% of electricity consumption.

Renewable solar power plants generated 342.2 million kilowatt hours (kWh) of electricity in 2022, or 79.4% more than in 2021.

Hydropower plants generated 464.4 million kWh of electricity in 2022, 21% more than in 2021.

In 2022, electricity generation from biogas increased by 1.3% compared to 2021, reaching 158.7 million kWh.

The use of biofuels reduces environmental pollution. Two types of biofuels are used in Lithuania: biodiesel and bioethanol. In 2022, 113,200 tonnes of biodiesel and 30,500 tonnes of bioethanol were used in the transport sector.

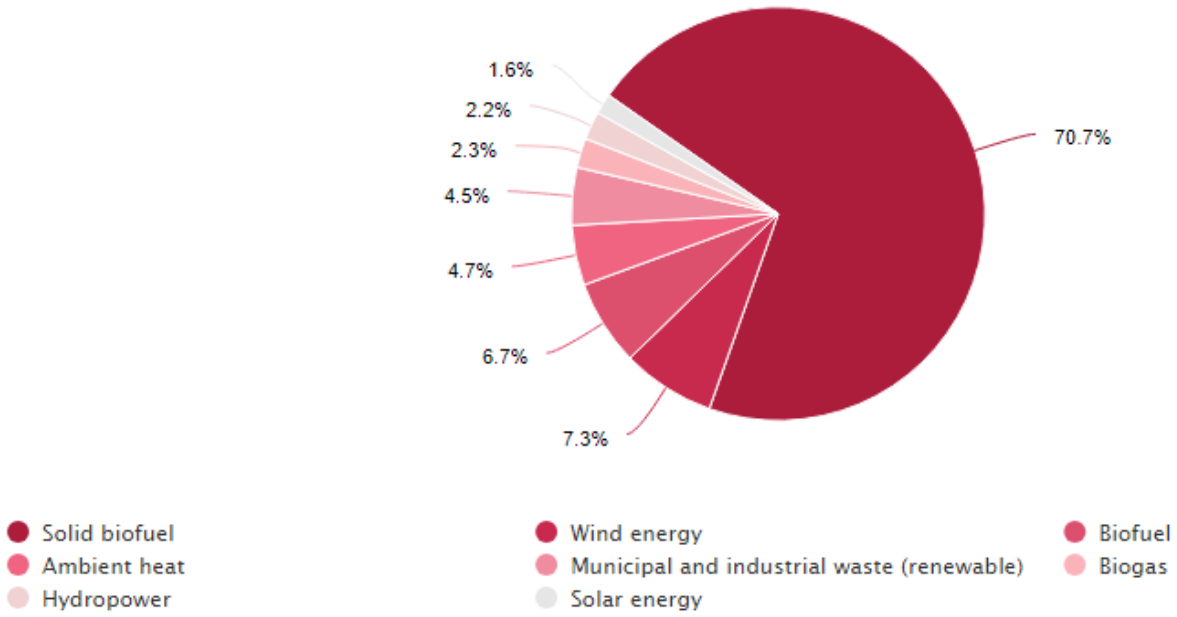

Figure 1: RES consumption structure in 2020, in percent (Source: Atsinaujinantys energijos ištekliai - Oficialiosios statistikos portalas)

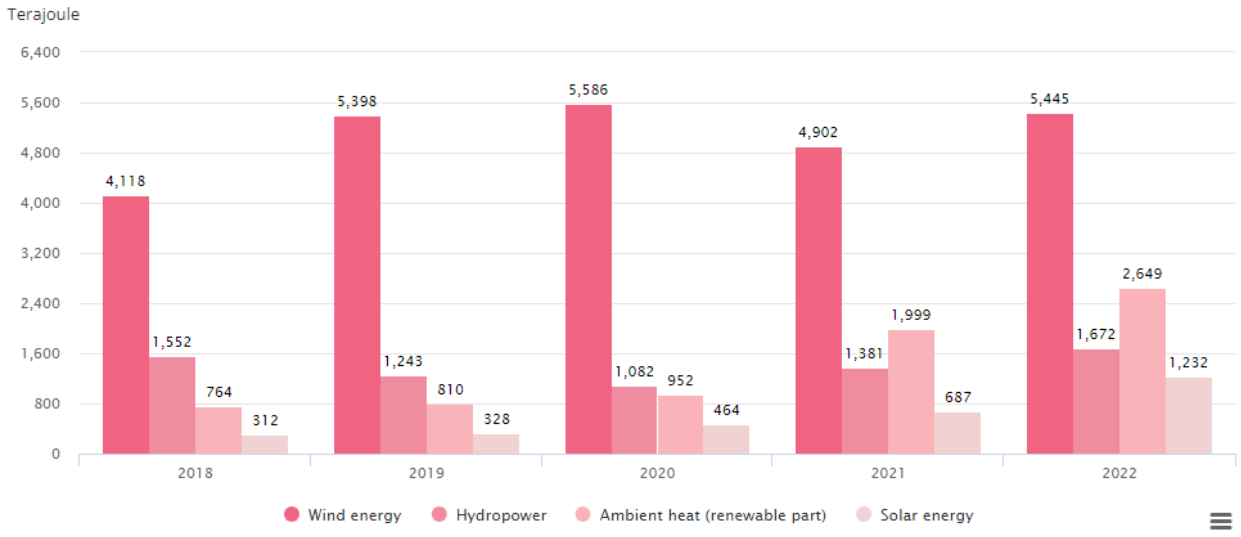

Figure 2: ***Gross consumption by type of renewable energy, 2018–2022, in Terajoule*** *(Source: Atsinaujinantys energijos ištekliai - Oficialiosios statistikos portalas)*

The share of renewable energy sources in consumption during 2018-2022 is presented in Table 1

Table 1: The share of RES in consumption 2018-2022, ***in percent*** *(Source: Atsinaujinantys energijos ištekliai - Oficialiosios statistikos portalas)*

	2018	2019	2020	2021	2022
In final gross energy consumption	25.5	25.5	27.4	28.1	29.6
In final energy consumption for heating and cooling	46.0	47.4	50.2	48.6	51.8
In gross consumption of electricity	18.4	18.8	20.2	20.9	25.5
In final energy consumption in the transport sector	4.3	4.0	5.5	6.7	6.3

Further development: In the first half of the year 2024. solar and wind power plants generated almost 70% more electricity than in the same period in 2023 and twice as much as in 2022. Preliminary data show that these plants will generate 2.31 GWh of electricity in 2024. This compares with 1.36 GWh in 2023 and 1.00 in 2022.

Also in the year 2024. the renewable energy sources' allowed generation capacity on the grid increased by one fifth to 2 885 MW on 1 July. and the national electricity generation doubled to fully cover the country's population's electricity needs in half a year. This was recorded on Sat. On 11 March and 3 May.

According to Litgrid's (Lithuania's electricity transmission system operator) preliminary data. in the first half of the year 2024, the national electricity generation amounted to 3 783.4 GWh, of which RES accounted for 2 990.1 GWh. The generation was dominated by wind power plants with 1.703.1 GWh, thermal power plants with 793.3 GWh, solar power plants with 627.4 GWh, hydropower plants with 539.0 GWh, biomass plants with 64.8 GWh, biogas plants with 48.8 GWh, and battery technology with 7 GWh.

According to EPSO-G. the grid's renewable energy capacity increased by 549 MW in the first half of the year 2024 from 2.336 MW to 2.885 MW. In the first quarter of the year 2024, two solar farms were

connected to the grid for the first time, with a total capacity of 145 MW. (Source: Ministry of Energy of LR).

Biomethane has been fed into the transmission grid by the newly opened Tube Green biomethane plant in Pasvalys district since 2023, whose facilities have been connected to the gas transmission system following a joint project between Amber Grid and Tube Green. Around 100,000 megawatt hours (MWh) of biomethane is expected to be injected into the transmission system from the plant each year. This will represent up to 1% of Lithuania's total gas demand.

Source: Lietuvos dujų perdavimo tinkle – pirmosios žaliosios dujos - Lietuvos Respublikos energetikos ministerija (lrv.lt).

1.2 Expansion plans

Lithuania will generate about 75-80% of electricity demand in 2025. In 2025, green electricity production in Lithuania should reach 8 gigawatts (GW), or 75-80% of the country's consumption.
(Source: Energetikos ministras: 2025 metais Lietuva pasigamins apie 75–80 proc. elektros - LRT)

Following 2023 year's public consultation on the National Energy and Climate Action Plan 2021-2030 (NECAP) and the comments received from the European Commission, the Ministries of Energy and Environment have prepared an updated document and are resubmitting it to the general public and social partners for consultation by 5 August. The NECSAP is an action plan for the implementation of the National Climate Change Management Agenda and the National Energy Independence Strategy, implementing the objectives of the Green Deal.

According to the Environmental Protection Agency, Lithuania is on track to meet its national target of reducing greenhouse gas emissions by 21% by 2030 compared to 2005. 120 measures have already been adopted in the NECSAP for climate, with 43 additional measures foreseen, and 66 and 35 additional measures respectively for energy. Preliminary estimates suggest that a total of over €31 billion of private and public funding will be needed to implement all the measures in the NECSAP by 2030 (Fig. 3).

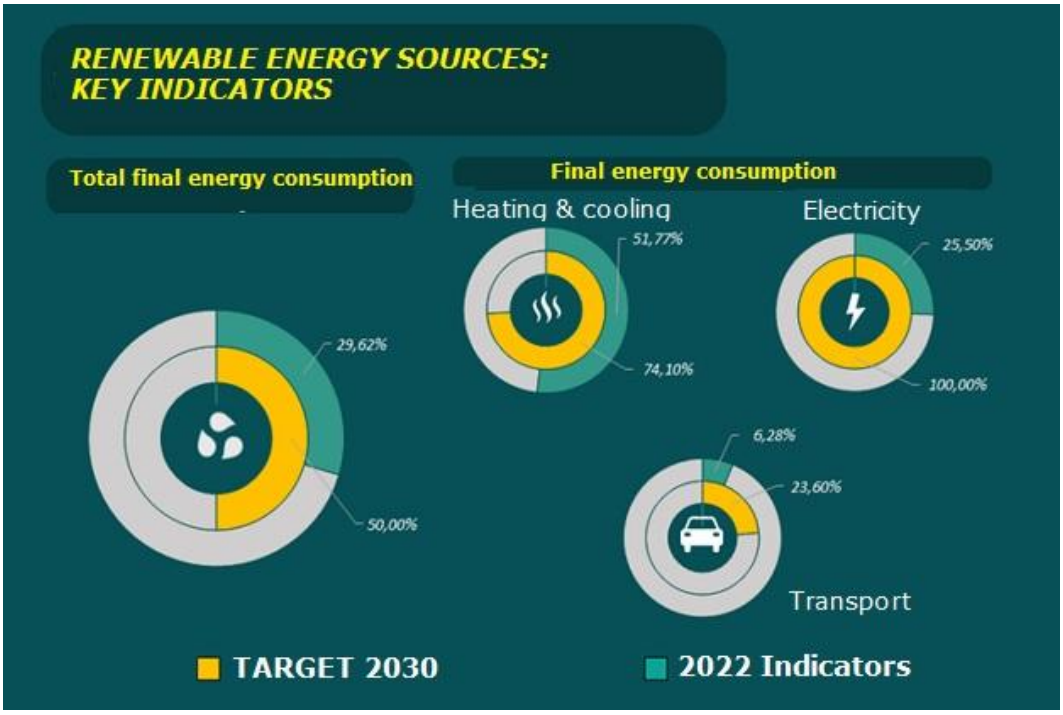

Figure 3: National Energy and Climate Action Plan 2021-2030 (Source: Lithuanian Energy Agency www.ena.lt *))*

Lithuania aims to reach 50% of GDP by 2030. The target for RES in final energy consumption is 50%. This will be achieved through the widespread deployment of small-scale renewable energy installations owned by private energy consumers and communities. To successfully integrate higher volumes of renewable energy and a large number of electricity generating consumers, investment in smart energy systems, including transmission, distribution and storage infrastructure, and in increasing the amount of balancing capacity needed is foreseen. (Source: Lithuanian energy agency

Source: [Aktuali AEI statistika - Lietuvos energetikos agentūra (ena.lt))]

1.3 Challenges

1.3.1 Volatility and storage requirements

The grid reservation and letters of intent, the grid reservation contracts are in place, huge deposits have been made and the solar power plants and wind farms have to be built within three years. In 2024, electricity generation from solar and wind in Lithuania is expected to reach almost 3.5 GW and more than 12 GW of capacity is currently reserved in the transmission grid for these plants.

To help businesses and citizens make decisions on the construction of renewable energy power plants, the public institution Lithuanian Energy Agency, together with the State Enterprise Registers Centre and other partners - the Ministry of Energy of the Republic of Lithuania, the electricity transmission system operator LITGRID AB, the distribution grid operator Energy Distribution Operator AB and the Military Cartography Centre of the Lithuanian Armed Forces - has developed an interactive Renewable Energy Opportunity Map. The individual data layers are published in the interactive map of the geo-information environment - REGIA - created and developed by the State Enterprise Centre of Registers (Fig. 4).

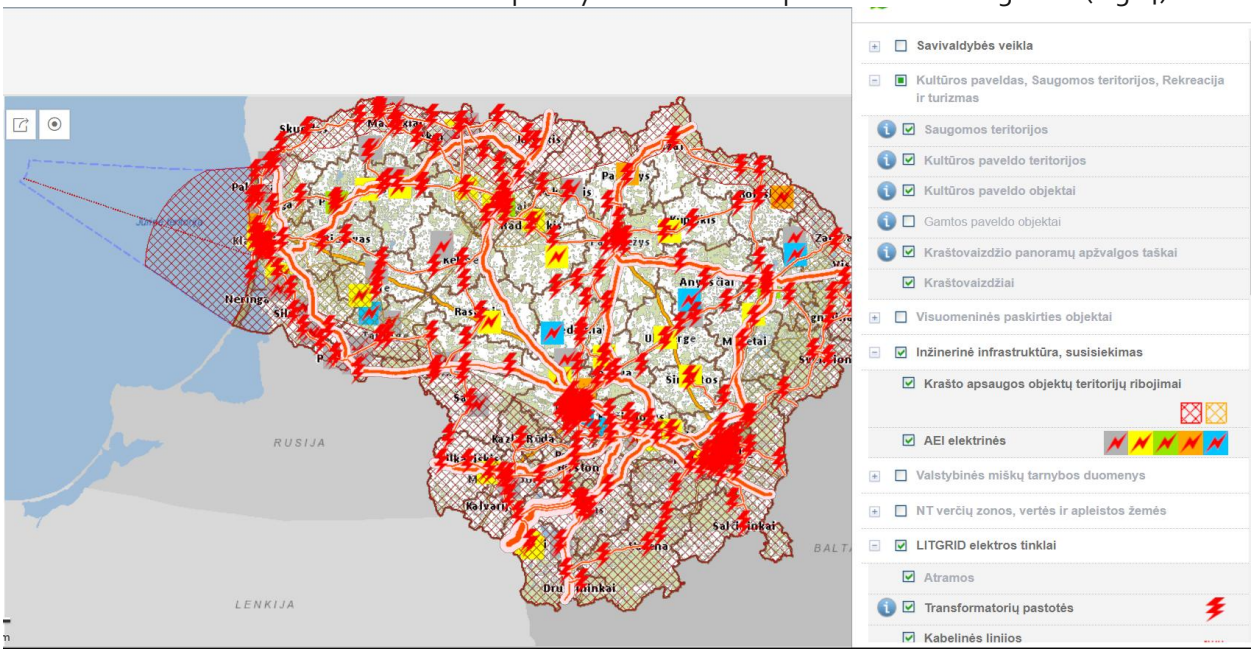

Figure 4: Renewable Energy Opportunity Map (Source: https://www.eso.lt/)

The RES map is for information only. It contains layers with information on protected areas. cultural heritage sites and objects. Lithuania's most valuable landscape areas and panoramic viewpoints where construction of RES plants may be restricted or prohibited. Areas, where the design and construction of

wind power plants (tall structures) is prohibited or must be coordinated with the Lithuanian Armed Forces, are also marked. To make the RES map as useful as possible. it provides information on the electricity transmission and distribution network. such as available line capacity and the capacity of transformer substations.

The RES map provides all relevant information on the feasibility of siting a RES power plant in the envisaged location. or to check what opportunities and constraints there may be due to the availability of protected areas. cultural heritage. national security requirements. or access to electricity infrastructure. The information on the AIE map is updated periodically.

For current information on available line capacities and capacities at transformer substations, the following should be used:

The electricity transmission system operator LITGRID AB provides the map with RES plants connection to 330-110 kW transmission network (Fig. 5);

Tipas	Laisva galia prijungimui prie PT, MW	Išduotų išankstinių prijungimo sąlygų galia, MW	Rezervuota galia pagal KP ir PS, MW	Prijungta (leistina generuoti galia) prie PT, MW
Saulės elektrinės (SE)	6926	2045	4185	162
Vėjo elektrinės (VE)	6493	3045	4200	1113
Kaupikliai	13937	3533	1698	200
Hibridinės elektrinės (hibE)		1671	2581	
Iš viso	27356	8623	10082	1475

Figure 5. RES plants connection to 330-110 kW transmission network (source: Elektros (AEI) perdavimo aplikacija (arcgis.com))

The distribution grid operator AB ESO (energy distribution operator) provides the map with Transformation substations free capacities for consumers;

The map below shows the preliminary information on the available capacities at 110/35/10 kV 110/10 and 35/10 kV transformer substations. In the absence of spare capacity, the connection of new facilities is also possible but would require a significantly higher investment for the connection service. Given this, we recommend that investors looking for potential sites for the development of facilities with high electricity demand use the preliminary information in this map as a basis for their initial assessment (Fig. 6).

- Substations with free capacities and connection of new capacities will not need significant investment related to the development of new transformation substations.

- Substations without free capacities and new connections will require the development of transformation substations, which defines significantly higher investment and longer service-providing terms.

Figure 6. Transformation substations free capacities for consumers (source: Transformatorių pastočių laisvų galių žemėlapis vartotojams - Elektros linijų žemėlapiai - ESO - Energijos skirstymo operatorius)

Transformation substations free capacities for consumers

This map is published following Article 39(24) of the Electricity Act. The purpose of the map is to provide easily accessible and transparent information on the availability of electricity networks for the development of electricity generation or energy storage capacity.

The information has been prepared based on the Description of Procedures for the Use of the Electricity Distribution Networks (hereinafter referred to as the Description or PETA) (Fig.7 and Fig. 8).

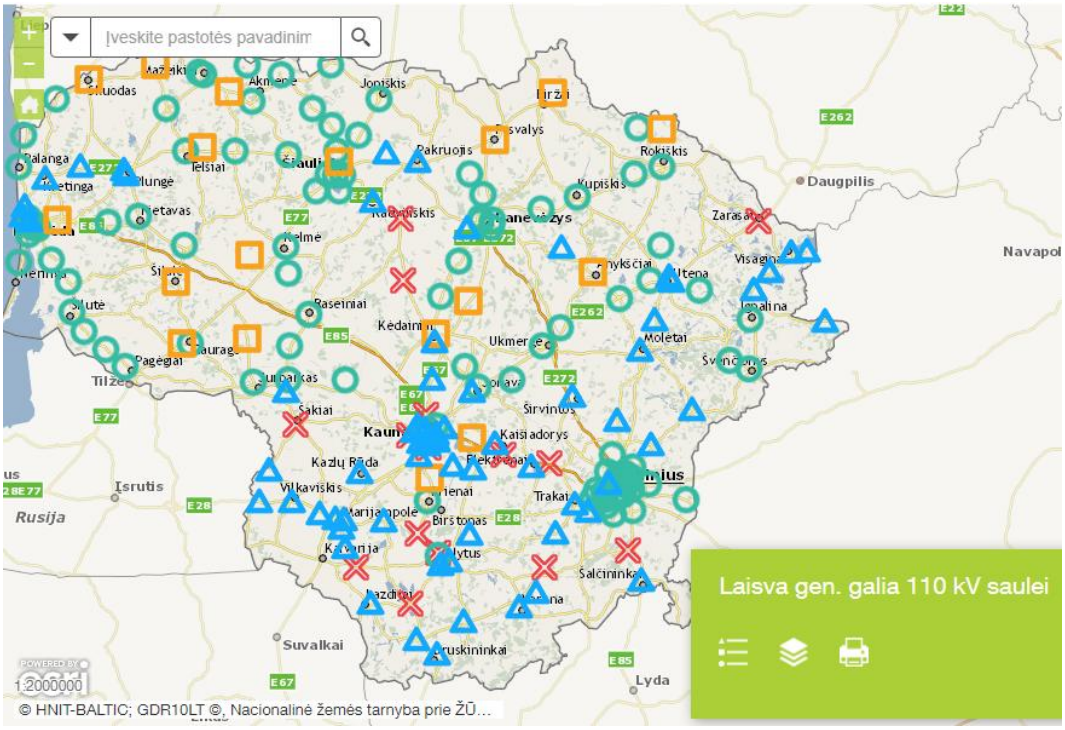

Figure 7. Transformation substations free capacities for PV producers (source: Transformatorių pastočių laisvų galių žemėlapis vartotojams - Elektros linijų žemėlapiai - ESO - Energijos skirstymo operatorius)

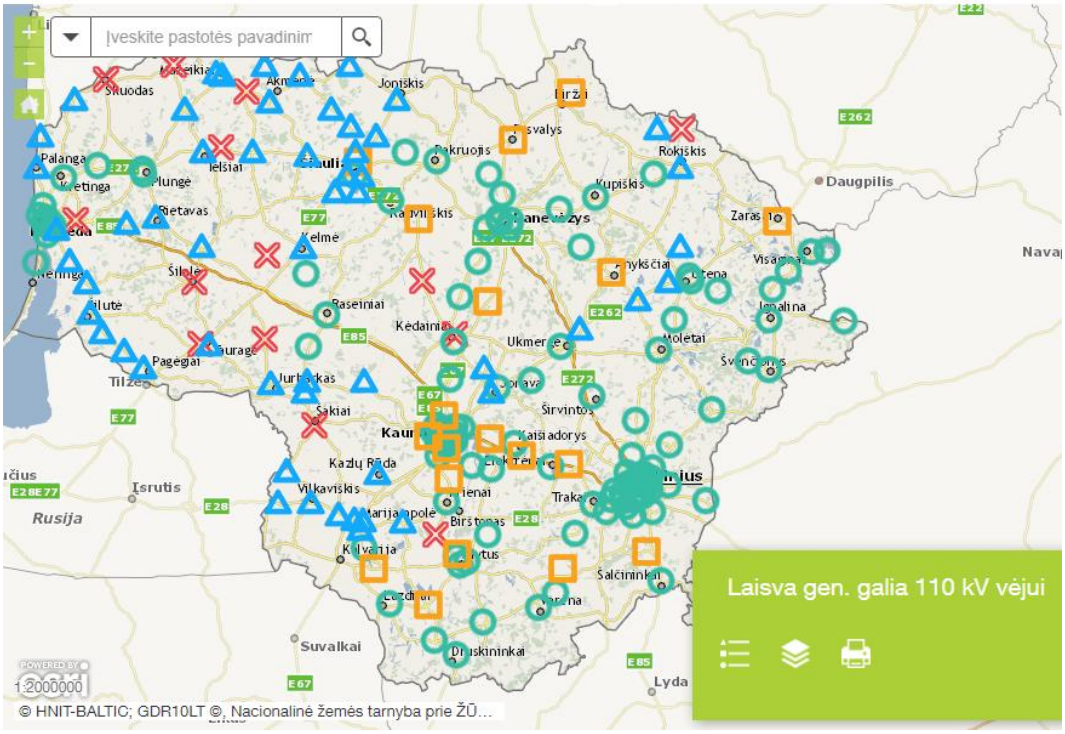

Figure 8. Transformation substations free capacities for wind producers (source: Transformatorių pastočių laisvų galių žemėlapis vartotojams - Elektros linijų žemėlapiai - ESO - Energijos skirstymo operatorius)

Here:

△ - There is free technical capacity in the ESO substation, but there is no free technical and balanced technical capacity in the LITGRID AB 110 kV grid section

- There is no spare technical capacity in the ESO substation, there is spare technical and balance technical capacity in the 110 kV section of the LITGRID AB grid

- There is free technical capacity in the ESO substation, there is free technical and balance capacity in the 110 kV section of the LITGRID AB grid

- No free technical capacity in ESO substation, no free technical and balance capacity in LITGRID AB 110 kV grid section

Network Expansion Cost - an additional charge applied following the methodology approved by the State Energy Regulatory Board: if your property is located in or close to a Network Expansion Zone where ESO has previously installed more capacity than is needed for the customers connected in that area so that subsequent capacity increases and new customer connections do not require costly network reconfigurations. The prices on the map are after applying a 50% customer discount (Fig. 9).

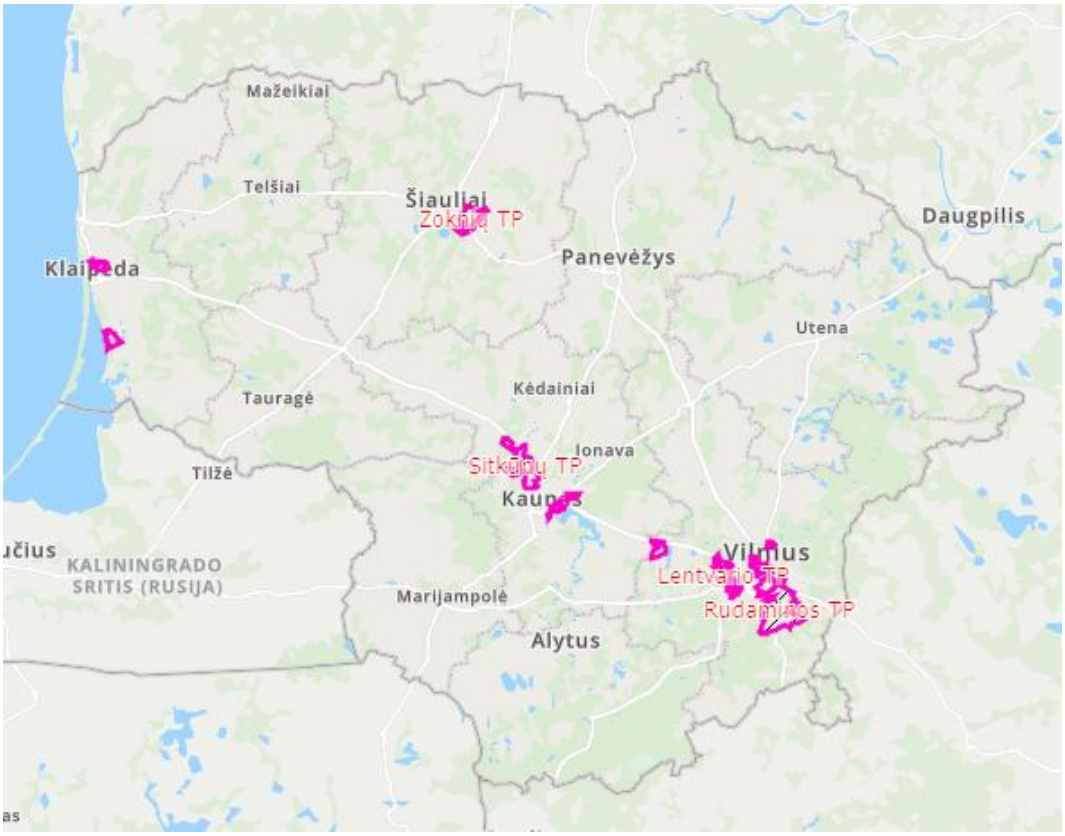

Figure 9. Grid development zones (source: Transformatorių pastočių laisvų galių žemėlapis vartotojams - Elektros linijų žemėlapiai - ESO - Energijos skirstymo operatorius)

The age of overhead and overhead electric cable lines map provides information on overhead and overhead cable lines installed more than 20 years ago. If you decide to reconstruct or relocate 0.4-10 kV electricity lines belonging to ESO that were installed more than 20 years ago, you will have to pay 50% of the total cost of the reconstruction or relocation. If you decide to reconstruct or relocate the 35 kV lines shown on the map, you will have to pay the full cost of the reconstruction or relocation work incurred by ESO (Fig. 10).

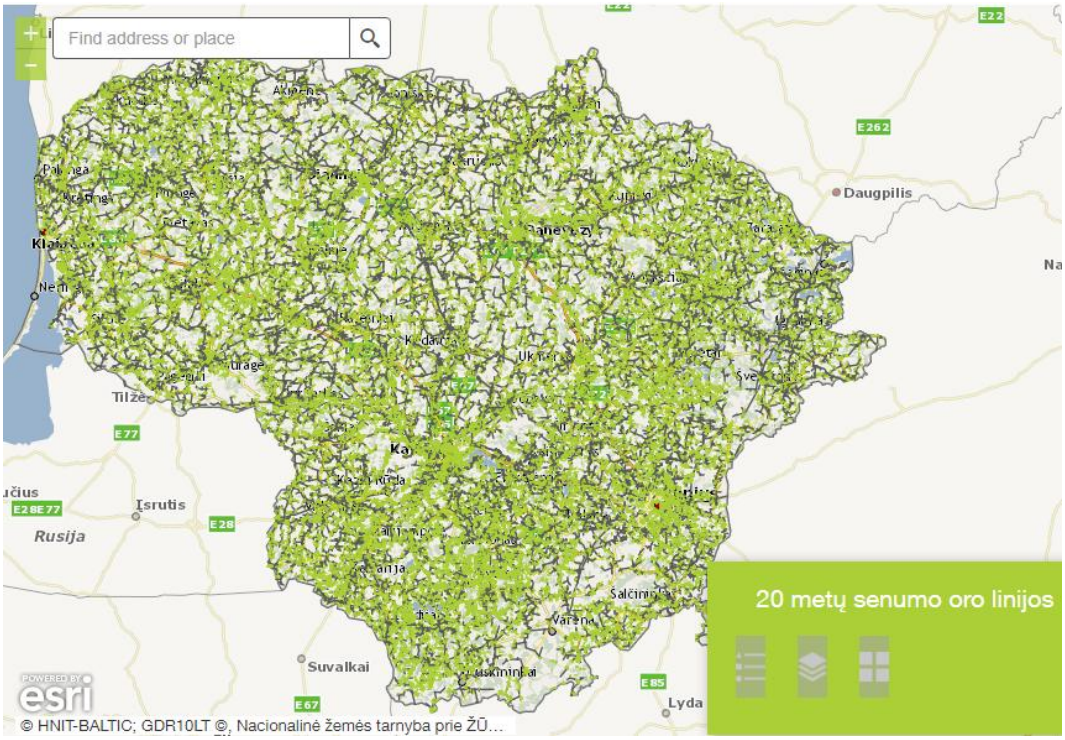

Figure 10. The Age of overhead and overhead electric cable lines (source: Transformatorių pastočių laisvų galių žemėlapis vartotojams - Elektros linijų žemėlapiai - ESO - Energijos skirstymo operatorius)

Here:

- 0,4 kV overhead electric cable lines
- 6 - 10 kV overhead electric cable lines
- 35 kV overhead electric cable lines

Measurements of power line network loads map provide preliminary information on low voltage (0.4 kV) power lines that are already connected to the maximum capacity of power plants (solar power plants) and where the connection of new power plants would require investments to increase the capacity of the grid. The grid capacity upgrades are needed to ensure that the electricity generated by the new plants meets the standard. Failure to do so would result in sub-standard electricity generation from the power plants, which significantly increases the risk of failure of the new power plant as well as of existing customer installations. For residents planning to generate their electricity, we recommend in these cases purchasing generation equipment from remote power plants, i.e. to become a remote-generating customer (Fig. 11).

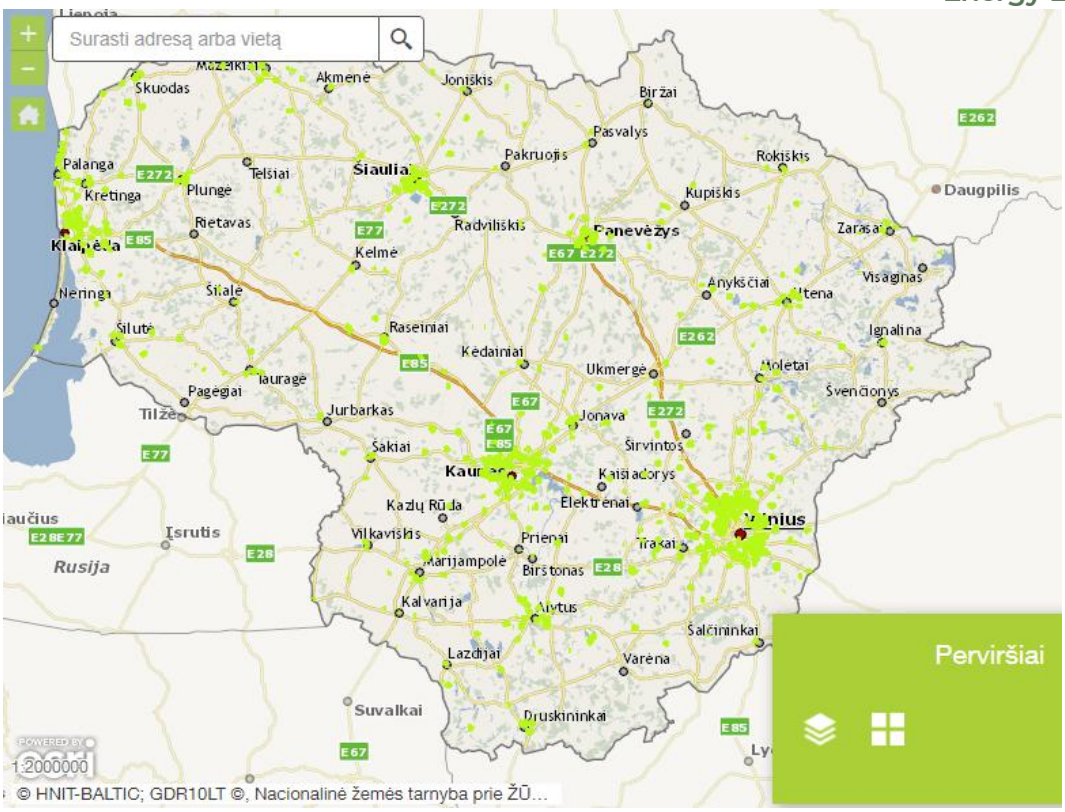

Figure 11. Measurements of power line network loads (source: Transformatorių pastočių laisvų galių žemėlapis vartotojams - Elektros linijų žemėlapiai - ESO - Energijos skirstymo operatorius

Here:

- Overhead and cable lines are already connected to the maximum capacity of power plants (solar power plants) and connecting new power plants would require investments to increase grid capacity.

1.3.1 Previous lockdown and redispatch

Historically. Lithuania's electricity system operates in synchrony with the IPS/UPS system connecting the systems of Belarus. Russia. Estonia. Latvia. Lithuania and other countries. The energy isolation of the Baltic States in the EU will only be fully eliminated once the electricity system becomes a full participant in the European electricity infrastructure. market and system. i.e. synchronously operating in the continental European electricity grids. This is being achieved through the development of legislation. the implementation of grid codes and the restructuring of the electricity system by grid operators. The synchronisation project is scheduled to be completed by February 2025 at the latest.

As part of its integration into the continental European grids and the Single European Electricity Market. Lithuania aims to ensure that all power plants from which electricity is sourced are subject to European Union-level requirements. including power plants in third countries. The aim is to prevent electricity generated in unsafe power plants. which do not comply with environmental and other international requirements and standards. from entering the European internal electricity market. The interconnection of the electricity system of the Republic of Lithuania with the CET for synchronous operation must not allow electricity from countries outside the European Economic Area to enter the electricity system of the Republic of Lithuania.

To stimulate investment in Lithuania. high-capacity power generation sources are planned by 2050. Competitive electricity prices will be one of the key factors for Lithuania to compete with other countries

to attract investment in the production of new technologies and the development of future industries and services. The electrification of the energy sector and the growth in electricity demand are forecast to be the most significant trends in the energy sector. Electricity will become the new oil in energy and will open up opportunities for countries whose economies have so far been unable to rely on natural gas and oil production. The rapid development of RES generation facilities will create conditions for the emergence of new solutions and technologies in Lithuania. increase competences in the management of electricity transmission and distribution networks. create additional incentives for the emergence of new competitive sources of electricity generation. new market models and new ways of operation of market players.

Source: Sektoriaus strategija - Lietuvos Respublikos energetikos ministerija (lrv.lt)

2 Energy Infrastructure

2.1 Transmission network

"Litgrid is the electricity transmission system operator (TSO). It manages Lithuania's electricity transmission network and is responsible for its development. Its main function is to ensure the efficient and reliable operation of the Lithuanian electricity system. In this capacity. we take care of the integrity and compatibility of the country's electricity system. as well as the management. operation and coordinated development of the transmission network and interconnectors with other electricity systems (Fig. 12).

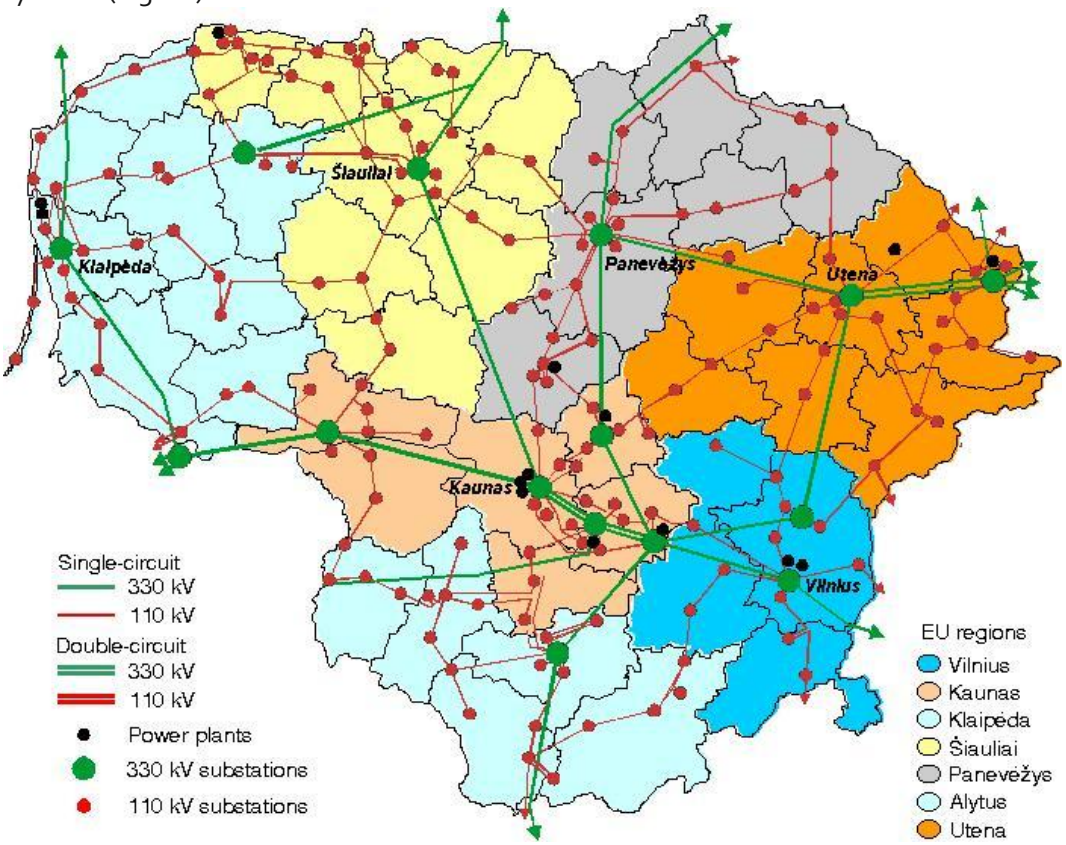

Figure 12. Map of Lithuanian Electricity Grid – Lithuania – National Energy Grids

Lithuania's 400-330-110 kV electricity transmission network comprises 239 transformer substations and switching stations and 7289.3 km of electricity transmission lines and cables. The installed capacity of 400 kV transformers is 3163.5 MW. that of 330 kV transformers is 5448.5 MW and that of 110 kV transformers is 92.6 MW.

"Litgrid plans the development of the Lithuanian electricity transmission network every year. reconstructs network facilities such as high-voltage transmission lines. transformer substations. and builds new high-voltage overhead and cable power lines. In addition. the company is implementing the country's strategic goal of reorienting the electricity system for synchronous operation with continental European electricity networks.

Lithuania's electricity transmission network is well connected to some of its neighbouring electricity systems: four 330 kV and three 110 kV lines connect Lithuania to Latvia. four 330 kV and seven 110 kV lines connect Lithuania to Belarus. three 330 kV and three 110 kV lines connect Lithuania to the

Kaliningrad region, one 300 kV DC cable connects Lithuania to Sweden and two 400 kV lines connect Poland.

The transmission scheme and key data are provided in Fig. 13 and Table 2 below.

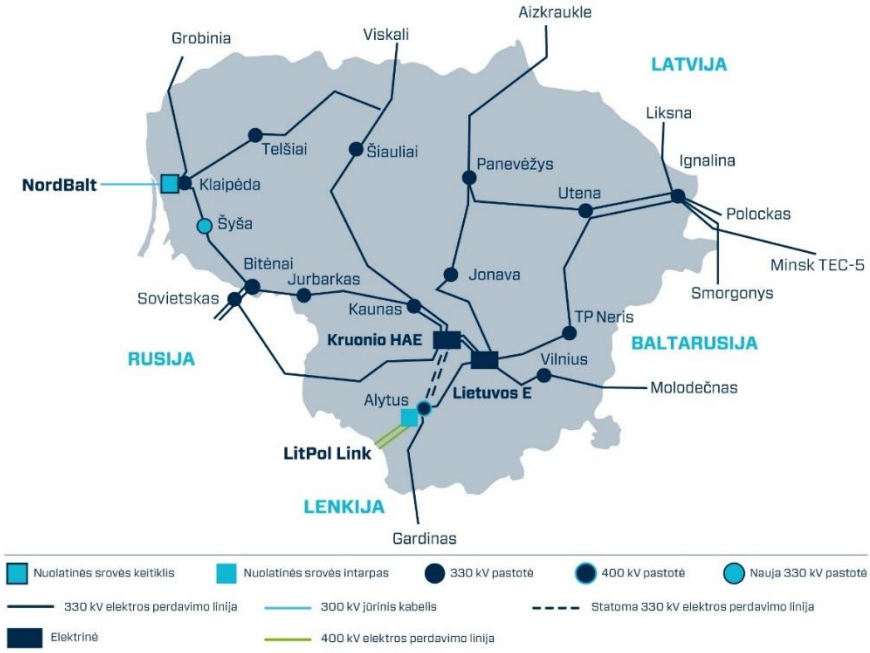

Figure 13. Electricity transmission scheme (330 kV) in Lithuania (Source: Litgrid)

Table 2:Key data on electricity transmission grid in Lithuania (Data on Dec. 31, 2022) (Source: Litgrid)

Transmission grid region		East	South	West	North	Total:
Length of Air Cable lines (by capacity), km	110 kV	1351.1	1288.7	867.1	1461.4	4968.3
	330 kV	495.0	694.0	283.5	423.3	1895.7
	400 kV	0.0	102.8	0.0	0.0	102.8
	In total:	1846.1	2085.4	1150.6	1884.7	6966.8
Length of Cable lines ((by capacity), km	110 kV	41.9	18.5	48.5	2.8	111.7
	300 kV underwater *	0.0	0.0	197.5	0.0	197.5
	300 kV terrestrial	0.0	0.0	12.9	0.0	12.9

	330 kV	0.0	0.3	0.0	0.0	0.3
	In total:	41.9	18.9	258.8	2.8	322.5
Transformation sub-stations and distribution centers, units.	110 kV	62	60	48	50	220
	330 kV	5	4	5	3	17
	400 kV	-	2	-	-	2
	In total:	67	66	53	53	239
Transformers, units	110 kV	-	-	4	-	4
	330 kV	6	7	5	6	24
	400 kV	-	3	-	-	3
	In total:	6	10	9	6	31
Transformer capacity, MVA	110 kV	-	-	92.6	-	92.6
	330 kV	1250	1350	1100	1150	4850
	400 kV	-	1800	-	-	1800
	In total:	1250	3150	1192.6	1150	6742.6
AAL converters /converter station, units		-	1	1		2
	In total:	-	1	1	-	2
AAL converters /converter station capacity, MW		-	500	700	-	1200
	In total:	-	500	700	-	1200
No of transformers in AAL converters, units	300/330 kV	-	1	-	-	1
	400 kV	-	1	1	-	2
	In total:	-	2	1	-	3
Capacity of transformers in AAL converters, MVA	300/330 kV	-	598.5	-	-	598.5
	400 kV	-	595.5	768	-	1363.5
	In total:	-	1194	768	-	1962

AAL converters/reactive capacity of converter station, MVar		-	-	350	-	350
*197,489 km – to agreed border with Swedesh operator Svenska Krafnat 134.3 km – the length of Nordbalt cable in Lithuanian territorial waters.						

19 April 2024 the total installed capacity of power plants in the Lithuanian electricity system amounted to 5442 MW. The table below shows the installed capacity of the power plants (MW) (Table 3):

Table 3:The installed capacity of the power plants in Lithuania (MW): (Source: Litgrid)

Installed capacity 2024.04.19	MW
Non-renewable resources	
Power plants with fuel mix	*338*
Kaunas CHP plants	170
ORLEN power plant	160
Petrašiūnai CHP plants	8
Natural gas power plants	*1166*
Lithuanian CHP plant (Elektrėnai complex)	1055
Panevėžys CHP plant	35
Achema CHP plant (T-1; T-2)	71
Other CHP plants	5
MSW CHP plants	68
Kruonis hidro-accumulation plant	900
Other non-renewable plants	37
Renewable resources	
Wind plants	*1284*
Onshore wind power plants on the transmission grid	1109

Onshore wind power plants on the distribution grid	175
PV plants	*1297*
PV plants on the transmission grid	145
PV plants on the distribution grid	1152
Hydro plants	*130*
Kaunas hydro plant	101
Other small hydro plants	29
Solid Biomass plants	*221*
Biogas plants	*1*
TOTAL:	**5442**

2.2. Distribution system operators / municipal utilities

"The Energy Distribution Operator (ESO), managed by the state-owned Ignitis Group, distributes electricity and gas, maintains distribution networks to ensure their reliability and efficiency, troubleshoots network faults and connects new customers. By managing infrastructure efficiently, ESO aims to enable competition in the energy market. Licensed activities include electricity distribution and natural gas distribution.

Main activities and functions: introduction of electricity and gas, operation, management and development of distribution networks, ensuring their safety and reliability, and guaranteeing the supply of electricity and gas. ESO serves 1.8 million customers throughout Lithuania. The company's service area in square kilometres amounts to 65.3 thousand km².

The main services are provided on a national scale and are as follows:

- Introduction of electricity for temporary (various events and short-term purposes up to 12 months), new objects and fast track;
- Capacity change;
- Technical electricity supply solutions for the renovation of buildings and relocation of electrical equipment;
- Lease of infrastructure assets;
- Connection of prosumers;
- Providing power line maps;
- Providing smart meter P1 interface and web service;
- EV charging.

Administrative territorial division of the Republic of Lithuania. The territorial administrative units of the Republic of Lithuania are counties and municipalities. Counties are formed from the territories of the municipalities characterized by common social, economic and ethno-cultural interests. The territory

of the Republic of Lithuania currently comprises 10 counties and 60 municipalities. The majority of municipalities are divided into smaller territorial units – wards.

There are mainly two main energy-related activities, which are operating on the municipal level district heating (individual heating) as municipalities are responsible for providing heat to their population, and public transport.

District heating sector. There are 45 municipal and regional district heating companies and 14 associated partners, which operate in some towns, settlements and locations (Fig. 14).

Figure 14. Companie responsible for heat supply on municipal level in Lithuania's municipalities (Source: Lietuvos šilumos tiekėjų asociacija (lsta.lt))

Lithuanian DH systems meet the efficiency criteria set by the European Union and are therefore considered energy-efficient. From 2021, connecting to DH systems is also encouraged by the new building requirements that have come into force, whereby district heating in Lithuania is recognized as suitable for A++ class buildings, as the majority of district heat is produced from renewable sources.

The total number of consumers is 727,000. The structure of consumers supplied with district heating remains unchanged and here residential consumers are the main consumers, consuming around 70% (5 174 GWh) of the total district heating energy supplied. State organizations purchased around 15% (1 077 GWh) and businesses another 15% (1 104 GWh) of the total heat.

The average annual heat consumption in residential buildings in 2022 was 135 kWh/m2, which is around 15% lower than in 2021 due to milder winter weather. Different buildings consume different amounts of

heat to maintain the same indoor temperature. Uninsulated and non-renovated apartment buildings, where the internal heating and hot water systems have not been upgraded, consume the most heat.

Typical DH networks are presented in Fig. 15

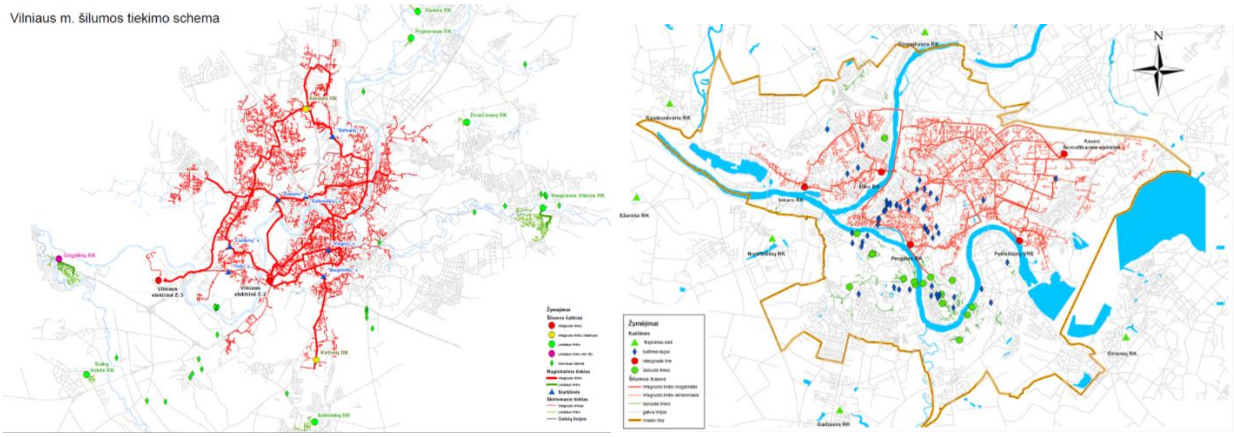

Figure 15. Typical DH networks in Lithuania's municipalities (a) Vilnius, (b) Kaunas. (Source: Lietuvos šilumos tiekėjų asociacija (lsta.lt))

Public transport. Most of Lithuania's bus fleets are owned by municipalities, but the role of the Ministry of Transport and Communications is to shape the country's transport policy. The organisation of passenger transport on local routes and the calculation and payment of compensation for preferential passenger transport is an autonomous municipal function. It is up to the municipal councils to decide whether it is better for them to maintain their bus fleets or to privatise them and purchase passenger transport services from private carriers.

The specific fare levels for the carriage of passengers on regular local transport routes are set by municipal councils. The situation of companies therefore depends primarily on the decisions taken by municipalities. The Road Transport Code stipulates that passenger tariffs must be reviewed at least once a year, the revenue generated and the obligations laid down in the public service contracts between municipalities and carriers. It is up to the municipalities to choose which public transport model, with or without competition, is the most acceptable to them.

Buses, trolleybuses and shuttles are used for public transport in Lithuania. The largest public transport systems in Lithuania are in Vilnius, Kaunas and Klaipėda.

Figure 16. Public transport map in Lithuania (Source: Lietuvos viešojo transporto maršrutai - Visi maršrutai (visimarsrutai.lt)*)*

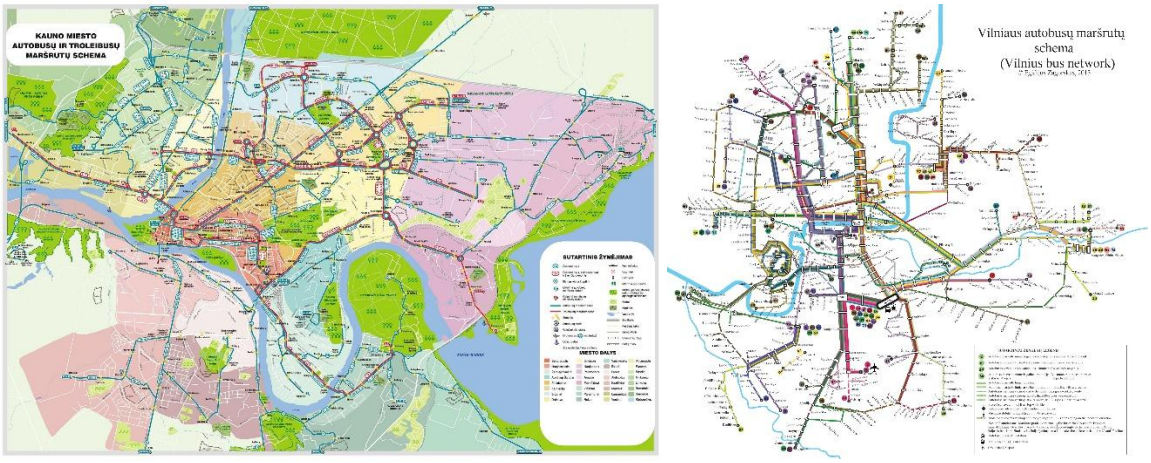

Figure 17. City Public transport schemes (a) Kaunas, (b) Vilnius (Source: https://phototrans.eu/20,72,0,Kaunas__city_transit_scheme.html ; Viešasis transportas - Vilniaus transporto maršrutų schema / Vilnius public transport network scheme (nvtka.lt)*)*

2.3. Stakeholders active in energy storage in electricity and heat

The following electricity storage and accumulation systems are currently in operation in Lithuania:

Kruonis pumped storage power plant. The main objective of this power plant is to ensure efficient electricity generation and trading on the NordPool exchange during peak and off-peak periods, to provide balancing capacity services and to trade balancing electricity on the regional market, while allowing the use of other renewable energy sources and the development of new generation capacities in the country.

Figure 18. Kruonis pumped storage power plant (Source: Kruonio hidroakumuliacinė elektrinė (Kruonio HAE) | Ignitis gamyba)

Additional services provided to the Kruonis HPP transmission system operator (TSO)

- The Frequency Restoration Reserve service is used when imbalances occur in the system due to imbalances between generation and consumption and when the largest grid or generation element goes offline. The frequency restoration reserve is activated within 12.5 minutes and balancing electricity can be supplied continuously for up to 12 hours on-demand to compensate for a shortage or surplus of electricity due to a system emergency. This additional balancing capacity service is provided by two units of the Kruonis HPP.

- The voltage regulation service, which is not related to frequency regulation and balancing, is provided by the Kruonis HPP units operating in synchronous compensator mode. The service is activated when the capacity of the voltage control equipment in the transmission network is insufficient to ensure the quality of electricity, i.e. when the voltages at the relevant points in the transmission network are not within the specified limits.

- A power system restart service to restore electricity generation after a complete system shutdown. In such cases, the Kruonis HPP diesel generator is started up and the capacity of Kruonis HPP is activated. It maintains the voltage in the Lithuanian transmission grid and supplies the electricity needed to restore power supply after an accident.

Main technical characteristics of Kruonis HPP

- Total capacity 900 MW, 4 units of 225 MW each.
- Cycle efficiency factor 0.74.
- Capacity in generating mode 160–225 MW. Maximum capacity 225 MW.
- Capacity in pumping mode fixed 220 MW.

KHPP is currently undergoing an expansion with the installation of Unit 5. The technical capabilities of the new unit, both in generator and pump modes, will expand the power plant's capacity utilisation

spectrum and allow the plant to participate more effectively in the common European balancing market. In addition, the new unit will ensure greater competitiveness in the provision of system services by enabling the company to participate in the market for frequency management reserve services following synchronisation with the continental European grid. Unit 5 will significantly contribute to enhancing the security of the electricity supply in the country, the reliability and stability of the electricity system, and will help to balance Lithuania's rapidly expanding, but uneven, generation of electricity from renewable energy sources.
Source: Kruonio hidroakumuliacinė elektrinė (Kruonio HAE) | Ignitis gamyba

One of the most important energy projects in terms of national security - **Europe's largest 200 MW battery system** - has been officially launched at the Vilnius Transformer Substation from October 2023, enabling it to react in just one second in the event of a disturbance and helping to ensure the uninterrupted transmission of electricity.

The system consists of four 50 MW battery parks, installed at electricity transformer substations in **Vilnius, in Šiauliai, Alytus and Utena**. They can provide continuous power for about one hour or until other sources of power generation come online, Kruonis HAE.

Recent attacks on European energy infrastructure projects show that the threats are real, making energy security an absolute necessity. Until synchronization, the system will ensure uninterrupted power supply in the event of any disturbances, the project marks a new qualitative level of grid resilience and will help Lithuania to meet one of the most important objectives before synchronisation - the ability to operate in isolated mode, i.e. autonomously.

The 200 MW and 200 MWh storage systems will contribute to the integration of renewable energy after synchronisation with the continental European electricity grid. Battery parks will then be able to store electricity from solar and wind generation above consumption levels, and, if necessary, when consumption increases, to feed back into the grid the energy stored from renewable generation sources.

Energy Cells, which has been appointed as the operator of the energy storage system, is 100% owned by the EPSO-G group of energy transmission and exchange companies. "The Ministry of Energy of the Republic of Lithuania exercises the rights and duties of the sole shareholder of EPSO-G.

There is also a number (though no statistics yet) of businesses and private consumers, which have installed PV plants. State support is being provided for residential batteries up to 10 kW capacity.

Future development

Construction **of two geothermal thermal power plants** in Lithuania could start by 2028, as planned by Lavastream and Sage Geosystems. Currently, the first plant is planned for Klaipėda and the second for Gelgaudiškės. Negotiations are currently underway with the municipalities of Klaipėda city and Šakiai district, both for the land and for the possible connection of the plants to the heat network.

Lavastream plans to install a thermal power plant with a capacity of around 30 MW in Klaipėda and 15 MW in southwestern Lithuania by 2028, as well as a geothermal-geological long-range electricity storage system. These plants will use new geothermal technology, which involves creating a reservoir at a depth of 3 to 6 kilometres and then injecting water or other liquid into it, which is warmed by the ground. This heated fluid would then be used for heating purposes.

The technology could also act as energy storage to help "balance" solar and wind farms. In the future, Lavastream plans to enable the installation of geothermal-geological storage with a potential of 1 GW. The thermal potential of geothermal power plants in Lithuania is estimated at 20 GW, while the potential of geothermal power plants for electricity generation is over 2 GW.

Source: Vakarų Lietuvoje iki 2028 m. gali būti įrengtos 2 šilumos jėgainės (ve.lt)

Some municipal district heating companies, using biofuels for heat generation, are planning and already installing **thermal storage** to smooth out fluctuations in demand in the event of sudden temperature changes during the winter, thus covering daily demand fluctuations. These are mainly DH companies in the largest cities like Vilnius, Kaunas, Klaipėda, as well as some smaller companies.

2.4. Role of local authorities for energy storage in connection to electricity

Municipalities have an important role to play in the implementation process by increasing the use of renewable energy sources. It's not just wind and solar power plants that are speeding up progress in municipal sustainable energy development. The contribution of each municipality is crucial to achieving the goals set out in the National Energy Independence Strategy and the National Energy and Climate Action Plan of Lithuania - to reduce greenhouse gas emissions, increase energy efficiency and promote the wider use of renewable energy sources. Municipalities elaborate municipal Energy and Climate Action Plans and are responsible for their implementation.

The capacity of renewable energy power plants in Lithuania in 2023 has been growing rapidly: at the end of last year, the capacity of wind power plants exceeded 1,200 MW, while solar power plants exceeded 1,000 MW. The results of the Lithuanian Energy Agency's fifth annual assessment of municipalities' sustainable energy development in the past year show. how municipalities are promoting the use of renewable energy sources. energy efficiency improvements. sustainable mobility and access to energy services. Wind energy development can't be implemented in all municipalities due to various environmental, national defence, protected areas and landscape and city restrictions. The distribution of photovoltaic plants is more even. Due to the defined growth of the number of purchased electric vehicles, municipalities also invest in the growing number of charging stations.

Municipal property tax rates do not hinder the development of RES and are not a determining factor for developers in deciding which municipalities to develop RES projects. On the contrary, the property tax revenue allows municipalities to spend more on reducing energy poverty. The annual Municipal

Sustainable Energy Progress Assessment aims to increase the role of municipalities in the energy field, to encourage their engagement and benchmark their progress, and to inform the public about it.
Source: www.ena.lt

2.5. Role of hydrogen and power to x in today's energy (electricity) system (if any and relevant)

Biomethane and green hydrogen. The first plants supplying biomethane to the natural gas grid have started operating, and green hydrogen will also be produced from biomethane. The development of biomethane would allow Lithuania to increase the use of renewable energy sources, reduce waste in agriculture and industry, and provide an economic boost to Lithuania's biogas sector.

By cleaning and upgrading biogas, biomethane can be produced with a methane concentration of 91%, which meets the quality requirements for natural gas. Biomethane can be fed into natural gas networks. for use in the transport sector.

Hydrogen production by electrolysis will be one of the key measures that will create the conditions for the further development of RES capacity in Lithuania. The aim is to install at least 350 MW of electrolysis or other technologies for green hydrogen production by 2030 and to produce at least 34,000 tonnes of green hydrogen per year. Five Lithuanian cities will also use green hydrogen in public transport and have at least one hydrogen-powered train. In addition. 15 per cent ammonia by 2030. of ammonia needed for fertiliser production. will be produced from green hydrogen.
Source : Pradžia - Lietuvos Respublikos energetikos ministerija (lrv.lt)

Hydrogen. The project "Assessment of Underground Hydrogen Storage in Lithuania: The Study of the Chemical and Mechanical Reactions of Geo-Hydro to Underground H2 storage and leakage" was launched in 2024 and should be completed in 2026.

Although H2 is a very efficient fuel, there are many challenges associated with its use. As H2 is a very light gas, a large storage volume is required, therefore, To effectively deploy H2-based technologies in Lithuania, H2 storage needs to be addressed. Underground gas storage has been common in Europe and even in Lithuania, methane is stored in an underground (Inčukalno UGS) form in summer, In Latvia, for winter use. Depleted gas fields, oil fields and saline aquifers offer the possibility of storing large quantities of gas, and these underground porous formations can be used to store large quantities of hydrogen. Thanks to Lithuanian geology, such opportunities exist in Lithuania both on land and offshore. Depleted hydrocarbon reservoirs and deep saline aquifers in the Lithuanian basin have already been explored for CO2 storage in the past, these reservoirs are equally suitable for hydrogen storage.

Source: Požeminės vandenilio saugyklos Lietuvoje įvertinimas: Geo-Hidro cheminių ir mechaninių reakcijų į požeminę H2 saugyklą ir nuotėkį tyrimas - Kauno technologijos universitetas | KTU

2.6. Business models for energy (electricity) storage

All energy projects in Lithuania are usually implemented with financial support:

Businesses and public sector companies with their own solar or wind farms can apply for support to install electricity storage facilities. The amount of e.g. the recent call is €48 million. In total, the Ministry of Energy has planned more than €150 million for legal entities' energy storage facilities in the year 2024.

Private and public legal entities, which already have or are planning to install solar or wind power plants, will be able to apply for support for an energy storage facility with a capacity of 4 MWh or more.

Today, solar and wind power already provide the majority of all electricity generation in Lithuania. and batteries are the cheapest way to balance the electricity system. compensating for the imbalance between solar and wind generation. It also makes it possible to even out electricity price peaks for all electricity consumers, which is why the state consistently supports businesses, the public sector and citizens to invest in energy self-sufficiency. As the number of solar and wind power plants grows in the country, there is also a growing interest from generation consumers to become an active participant in the balancing market and to invest in batteries, so support for these installations is particularly relevant.

Currently, 4,294 unique legal entities are operating 15,000 generating consumer facilities. The announced support measure will be administered by the Environmental Project Management Agency (EPA). Private and public sector legal entities can also benefit from the current calls for support of almost €600 million to install solar or wind power plants or to buy from parks. These are administered by INVEGA (the state-established financial institution with the following main objectives: provide financial services and implement and manage financial and other forms of financing business).

Esamiems ir būsimiems saulės ir vėjo elektrinių savininkams – 48 mln. Eur Energetikos ministerijos parama baterijoms - Lietuvos Respublikos energetikos ministerija (lrv.lt)

2.7. Organisation of other storage (biomethane. heat) if relevant

The Tube Green biomethane plant in Pasvalys has started operations and will produce 100,000 megawatt hours (MWh) of biomethane per year. This would be enough to supply 110,000 people in Lithuania with gas for a whole year or to fully meet 26% of the country's gas-powered transport needs. The biomethane production project is being implemented by Tube Green together with bioethanol and biogas producer Kurana. The investment amount of the project is EUR 15 million. Part of the investment is financed by the Climate Change Programme.

Tube Green biomethane plant, in cooperation with Amber Grid, Lithuania's gas transmission system operator, the biomethane plant has been connected to the country's gas transmission network and is already supplying biomethane to the system. Tube Green plans to expand its activities in the future by considering the possibility of launching the production of synthetic fuels and green hydrogen. There are also plans to expand biomethane production capacity, allowing other biomethane producers to bring their biomethane to Tube Green and pump it into the main gas pipeline.
Source: https://www.vz.lt/pramone/2023/09/18/pasvalyje-veikti-pradeda-15-mln-eur-kainavusi-biometano-gamykla#ixzz8iOSTjJky

A call for proposals to install biomethane gas production and purification facilities is launched. This measure has been allocated €11.8 million from the Recovery and Resilience Facility. Projects will be selected through a competitive selection process according to the priority selection criteria set out in the project financing conditions. Projects can qualify for a funding intensity of up to 45%. Projects will have to be implemented by Q1 2026.
Source: Paskelbtas kvietimas vystyti biometano gamybos ir valymo įrenginių įrengimo projektus - Lietuvos Respublikos energetikos ministerija (lrv.lt)

Transport sector. On July 1, 2024, a total of 23,003 passenger electric vehicles (M1 category) were registered in Lithuania, of which 13,481 were pure electric vehicles and 9,522 were externally charged hybrids. There were also 473 light commercial electric vehicles (category N1) on the register, of which 467

were pure electric vehicles and 6 were externally recharged hybrids. According to the Lithuanian Energy Agency, in June 2024, 733 light passenger electric vehicles were registered in the Lithuanian Road Vehicle Register (of which -363 were pure electric vehicles and 370 were externally charged hybrids). This is 19.45% less than in May this year, but 2.52% more than in June 2023.

One of the objectives of the National Energy and Climate Action Plan of the Republic of Lithuania for 2021-2030 is to increase the use of renewable and alternative fuels in the transport sector and to promote sustainable intermodal mobility. Currently, the transport sector is lagging behind the most. The objective is to achieve a 15% share of renewables in the transport sector by 2030.

The Law on Alternative Fuels of the Republic of Lithuania stipulates that by 2025. M1 electric vehicles must account for at least 10 per cent and N1 electric vehicles must account for at least 30 per cent of annual purchase transactions. Lithuanian legislation defines electric vehicles as vehicles that use electricity as the source of motor power. Electric vehicles can be either pure electric vehicles (BEVs - Battery Electric Vehicles). or externally charged hybrids (PHEVs - Plug-in Hybrid Electric Vehicles). which also have an internal combustion engine. which can be used to travel longer distances.
Source: www.ena.lt

Construction of the first charging park for electric vehicles started on the country's main road from Vilnius-Kaunas-Klaipėda in 2024. The Eldrive Lithuania charging park will be the first of its kind on a major national road and will be able to charge 40 electric cars at a time. The park is scheduled to be operational in the first quarter of 2025. Lithuania is aiming to have around 120,000 electric cars by 2030. A convenient and well-developed charging station infrastructure is a key prerequisite for this ambitious goal. The launch of an electric vehicle charging park on one of our most important highways marks a new trend in the development of such facilities and will significantly contribute to the development of the national infrastructure. To ensure convenient travel by electric vehicles in Lithuania. Around 60,000 public and private charging stations are needed.

Five 200 kW stations, each with two charging bays, are to be built on 1.5 ha of land. The first phase of the project will be completed next summer with five more 400 kW stations with two charging bays, bringing the total number of charging bays in the park to 20. The next phase of the park's development will be the installation of high-power charging bays as well as a number of charging points for trucks or buses.

This place on the road will allow drivers of electric cars to travel from Vilnius or Kaunas to Klaipėda or Palanga and back. Most of the electric cars on the road in Lithuania can cover a range of 250-350 kilometres. Eldrive Lithuania's investment in this charging fleet will amount to just over two million euros. The project is being implemented in partnership with Reitan Convenience Lithuania, a company that operates coffee shop chains. Currently, there are more than 1,000 slow (AC) charging stations and around 300 fast (DC) charging stations in our country.
Source: Pagrindiniame šalies kelyje pradedamas statyti pirmasis elektromobiliams skirtas įkrovimo parkas - Lietuvos Respublikos energetikos ministerija (lrv.lt)