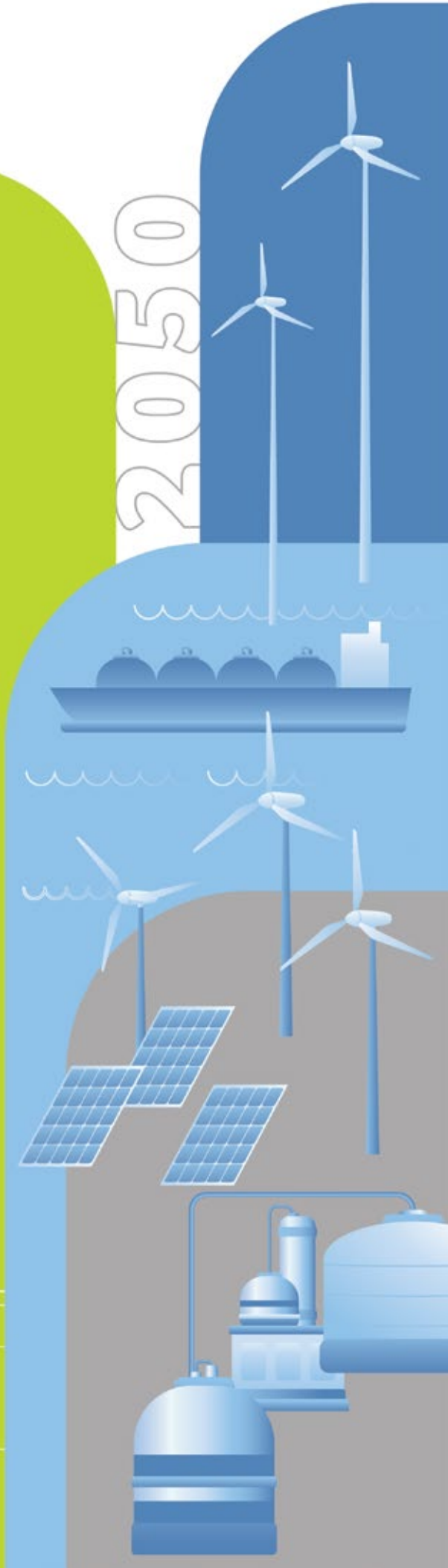
MINISTRY OF ENERGY
OF THE REPUBLIC OF LITHUANIA

National Agenda

NATIONAL ENERGY INDEPENDENCE STRATEGY



LIETUVOS RESPUBLIKOS
SEIMAS

RESOLUTION OF THE SEIMAS OF THE REPUBLIC OF LITHUANIA

REGARDING THE AMENDMENT TO THE SEIMAS RESOLUTION NO. XI-2133 OF JUNE 26, 2012, "ON THE APPROVAL OF THE NATIONAL ENERGY INDEPENDENCE STRATEGY"

June 27, 2024, No. XIV-2856, Vilnius

The Seimas of the Republic of Lithuania decides:

Article 1 To amend the Seimas Resolution No. XI-2133 of June 26, 2012, "On the Approval of the National Energy Independence Strategy" and present it in a new wording:

"THE SEIMAS OF THE REPUBLIC OF LITHUANIA RESOLUTION ON THE APPROVAL OF THE NATIONAL AGENDA 'NATIONAL ENERGY INDEPENDENCE STRATEGY'

The Seimas of the Republic of Lithuania, guided by part 2 of article 15 of the Law on Strategic Management of the Republic of Lithuania, decides:

Article 1 To approve the National Agenda 'National Energy Independence Strategy' (attached)."

Speaker of the Seimas, Viktorija Čmilytė-Nielsen

TURINYS

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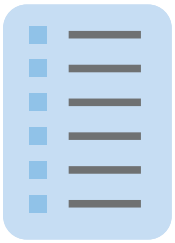
APPROVED By the Resolution of the Seimas of the Republic of Lithuania No. XI-2133 of June 26, 2012 (as amended by the Resolution No. XIV-2856 of June 27, 2024)

Chapter I
GENERAL PROVISIONS



1. The National Agenda „National Energy Independence Strategy“ (hereinafter – the Strategy) is designed to implement fundamental changes in the energy sector, ensuring that the amount of energy produced in Lithuania matches the amount consumed and that the energy sector becomes completely climate-neutral by 2050. These changes will accelerate economic development, transition to a new energy system, contribute to societal well-being, and ensure national security interests.

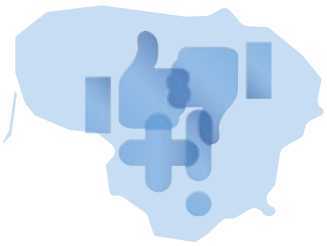
2. The Strategy is developed considering the State Progress Strategy „Lithuania 2050 Vision,“ approved by the Seimas on December 23, 2023, by Resolution No. XIV-2466, „On the Approval of the State Progress Strategy ‚Lithuania 2050 Vision‘,“ the National Security Strategy, approved by the Seimas on May 28, 2002, by Resolution No. IX-907, „On the Approval of the National Security Strategy,“ the National Climate Change Management Agenda, approved by the Seimas on June 30, 2021, by Resolution No. XIV-490, „On the Approval of the National Climate Change Management Agenda,“ the European Union's energy and climate goals by 2050, which are established in the European Parliament and Council Regulation (EU) 2021/1119 of June 30, 2021, „Establishing the Framework for Achieving Climate Neutrality and Amending Regulations (EC) No. 401/2009 and (EU) 2018/1999 (European Climate Law),“ the goal of energy independence – to produce all necessary energy in a climate-neutral manner, and national tasks for creating a climate-neutral economy by 2050.

3. To assess the impact of planned changes on Lithuania's economy and energy system, studies on energy sector changes and future prospects were conducted, and the modeling of the entire energy system continues. The Strategy is based on the study „Lithuania Energy System Transformation to 2050“ commissioned by the state-controlled energy transmission and exchange company group

UAB „EPSO-G," which outlines the main possible development scenarios for the Lithuanian energy sector until 2050 to achieve energy independence and climate neutrality. Additionally, the study „Lithuanian Hydrogen Sector Development Roadmap and the Action Plan for its Implementation" commissioned by the natural gas transmission operator AB „Amber Grid," the Comprehensive Assessment of Heat and Cooling Potential Study commissioned by the Ministry of Energy of the Republic of Lithuania, and the „Assessment of the Electricity Distribution Network's Readiness for Energy Transformation" study conducted by AB „Energijos skirstymo operatorius" were used. Further insights for the preparation of the Strategy were provided by the National Renewable Energy Laboratory (United States) and the public institution Lithuanian Energy Agency, evaluating the work and preliminary results of modeling Lithuania's energy system „LT100." Other state-controlled energy companies, energy sector companies, scientific and educational institutions also actively participated in the preparation of studies and the Strategy project. The Strategy is based on data from these studies and research.

4. The terms used in the Strategy shall be understood as they are defined in the Law on Energy of the Republic of Lithuania, the Law on Renewable Energy of the Republic of Lithuania, the Law on Alternative Fuels of the Republic of Lithuania, the Law on Electricity of the Republic of Lithuania, the Law on the Liquefied Natural Gas Terminal of the Republic of Lithuania, the Law on Natural Gas of the Republic of Lithuania, the Law on Crisis Management and Civil Protection of the Republic of Lithuania, and other legislative acts regulating the energy sector.

Chapter II
CURRENT SITUATION IN LITHUANIA'S ENERGY SECTOR



SECTION I
IMPLEMENTED CHANGES IN LITHUANIA'S ENERGY SECTOR

5. The National Energy Independence Strategy, approved by the Seimas on June 26, 2012, by Resolution No. XI-2133, "On the Approval of the National Energy Independence Strategy," and its new version approved by the Seimas on June 21, 2018, by Resolution No. XIII-1288, "On the Amendment to the Seimas Resolution No. XI-2133 'On the Approval of the National Energy Independence Strategy,'" outlines principles to reduce air pollution and the impact on climate change by 2050. Considering the new challenges and the need to address climate change more actively, Lithuania's and the EU's goals and commitments to transition to a climate-neutral economy become more ambitious, requiring fundamental changes in Lithuania's energy sector. One of the key changes is replacing fossil fuels with climate-neutral energy sources, changing the entire energy chain from production to transmission and consumption.

6. Since regaining independence, Lithuania has pursued a consistent energy security policy, liberating itself from the almost absolute dependence on energy supply from the Russian Federation. The first major step was the completion of the Būtingė Oil Terminal in 1999, ensuring an alternative oil supply to the "Mažeikių nafta" refinery and financially revitalizing the company after long-term oil supply disruptions from the Russian Federation.

7. In 2007, the first National Energy Strategy was approved, outlining the main energy independence guidelines and directions of changes. The agreement on a common direction in the state allowed for the consistent implementation of the largest changes in the energy sector. Since 2008, significant strategic projects requiring targeted and unified political will were initiated and implemented. The state regained control of the natural gas and electricity infrastructure, increased competition in the district heat supply market, permanently stopped the operations of the Ignalina Nuclear Power Plant (IAE), launched a new and efficient 450 MW combined cycle block at the Lithuanian Power Plant, adopted the Law on Synchronizing the Lithuanian Electricity System with the Continental European Electricity Networks, implemented the Klaipėda Liquefied Natural Gas Terminal project, built electricity interconnections with the Republic of Poland and the Kingdom of Sweden, strengthened gas pipelines in Lithuania and the interconnection with the Republic of Latvia, and established a new gas interconnection with the Republic of Poland. Significant changes occurred in the heat sector, where natural gas and fuel oil were almost entirely replaced by locally sourced biomass. Major changes occurred in the electricity generation sector using renewable energy sources since 2021, with electricity generation increasing by about 80%. All these measures

allowed Lithuania to secure energy resources from alternative sources and strengthen energy independence, enabling Lithuania to be one of the first in Europe to completely abandon electricity, gas, and oil imports from the Russian Federation on February 24, 2022, without compromising the country's energy supply security.

SECTION II
STRENGTHS, WEAKNESSES, OPPORTUNITIES, AND THREATS OF LITHUANIA'S ENERGY SECTOR

8. The strengths of Lithuania's energy sector include a well-developed natural gas and electricity transmission system, reliable electricity and gas supplies ensured by interconnections with EU member states, large-scale fossil fuel import terminals, well-developed district heat supply (DH) systems in all Lithuanian cities, favorable conditions for developing renewable energy sources (RES) production, the implementation of offshore wind projects, active promotion of RES-generating consumers (prosumers), and energy efficiency improvement involving businesses and residents. The main weakness is dependence on imported energy resources, primarily oil and natural gas, with main consumers being the transport and industrial sectors. By 2024, more than half of the electricity consumed was imported as Lithuania's energy production capacity is still insufficient or not competitive enough. This increases Lithuania's vulnerability to energy resource price fluctuations, decisions by other countries, and geopolitical risks. Lithuania annually spends about 6.3 billion euros on energy resource imports, most of which could remain in the national economy through energy sector decarbonization and local energy production expansion. Lithuania produces too few energy sector technologies, resulting in many imports. The development of new energy projects often depends on foreign suppliers' capabilities, and as a small market, Lithuania often does not receive adequate attention. Local industry development could contribute not only to the national economy but also to the implementation of large energy projects. Another significant weakness is the insufficient development of RES use in the transport sector, which is given much attention in the Strategy, particularly the development of alternative fuel infrastructure. Additional attention is also paid to the general protection of energy infrastructure, which has not been emphasized until now, but considering the geopolitical situation and increasing electrification pace, it becomes a priority.

9. Opportunities in Lithuania's energy sector are related to the rapid development of RES production facilities, primarily wind and solar. It is predicted that by 2050, the most significant trend in the energy sector will be electrification and the increasing demand for electricity. Electricity will become the new oil in the energy sector, opening opportunities for countries whose economies could not rely on local natural gas and oil production until now. The rapid development of RES production facilities create conditions for new solutions and technologies to emerge in Lithuania, increases competence in managing electricity transmission and distribution networks, and provides additional incentives for new competitive electricity generation sources, market models,

and market participants' actions. Planned high-capacity electricity generation sources also encourage investments in other types of energy production, such as hydrogen or its derivatives, in Lithuania. Competitive electricity prices will be one of the key factors for Lithuania to compete with other countries for investments in new technology production, future industry, and service development. There are also opportunities in energy efficiency, with public and private building renovations enabling significant energy savings in the future.

10. The main threat in Lithuania's energy sector is insufficient resilience to external (climate and hybrid) threats. Along with RES development, the need for electricity generation sources balancing capacity, flexibility of the electricity system, and energy storage solutions maintenance and development, as well as intersectoral and intersystem integration, increases. Their lack in the future poses a threat to the proper functioning of the electricity and integrated energy system. It is also necessary to assess external threats, both cyber and physical, and ensure readiness to counter them.

SECTION III
ANALYSIS OF LITHUANIA'S ENERGY SECTOR

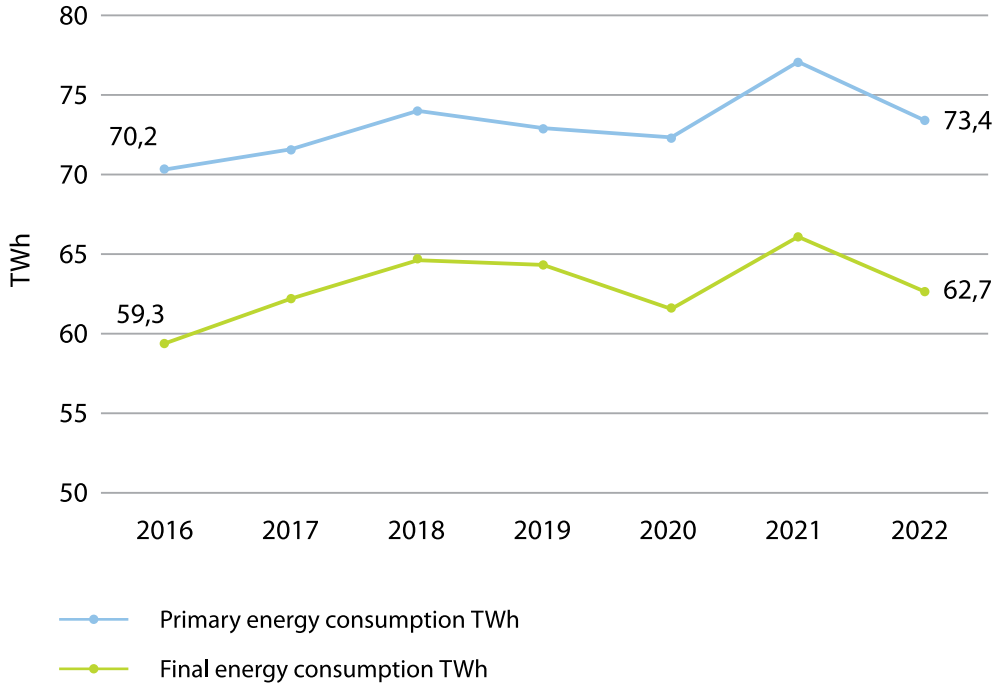
11. In 2022, the primary energy consumption in Lithuania was 73.4 TWh, and the final energy consumption was 62.7 TWh (excluding green hydrogen production and ambient energy). Compared to 2018, primary energy and final energy consumption decreased. In 2018, primary energy consumption was 74.1 TWh, and final energy consumption was 64.8 TWh.

12. The transport sector is the largest energy consumer in Lithuania, with energy consumption increasing from 39.6% in 2018 to 40.4% of total final energy consumption in 2022. The second-largest energy consumer is households, with energy consumption increasing from 26.9% in 2018 to 28.5% of total final energy consumption in 2022.

13. In 2022, RES accounted for 29.62% of total final energy consumption. These results were mainly due to RES accounting for 51.77% of final energy consumption for heating and cooling and RES accounting for 25.50% of total electricity consumption. The most challenging situation remains in the transport sector, where RES accounted for 6.28% of final energy consumption. In 2018, RES accounted for 25.51% of total final energy consumption, 46.02% of final energy consumption for heating and cooling, 18.41% of total electricity consumption, and 4.33% of final energy consumption in the transport sector. Over the analyzed period, the greatest progress was achieved in the electricity sector, where RES's share increased by 7.09 percentage points, while the least progress was in the transport sector, where RES's share increased by 1.95 percentage points.

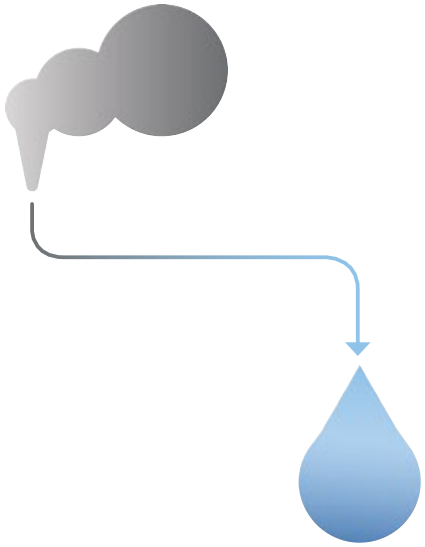
14. According to the electricity transmission system operator's data for 2023, the most significant breakthrough has been achieved in the electricity sector. In 2023, compared to 2018, local electricity production increased by 75.78% (from 3.22 to 5.66 TWh) and accounted for 45% of Lithuania's total electricity demand. In 2018, local electricity production accounted for 25.05% of Lithuania's total electricity demand.

Figure 1. *Primary and final energy consumption in Lithuania, 2016–2022, TWh*



15. The growth in electricity production was driven by increased RES production capacity. In 2023, compared to 2018, wind and solar power plants' production increased by 159% to 3.16 TWh. In 2023, wind power plants produced the most electricity – 2.52 TWh, or 121% more than in 2018, but the largest increase was in solar power plants' production, which reached 0.63 TWh, or nearly 7 times more than in 2018. Wind power plants' installed capacity increased from 533 MW in 2018 to 1 228 MW at the end of 2023, and solar power plants' installed capacity increased from 82 MW in 2018 to 1 108 MW at the end of 2023. The total installed capacity of wind and solar power plants increased nearly threefold.

16. According to the data of natural gas transmission system operator, natural gas consumption has decreased by more than 35% since 2022 due to the significant increase in natural gas prices. Natural gas consumption in transmission and distribution networks decreased from 24.14 TWh in 2021 to 14.9 TWh in 2023. Long-term trends suggest that natural gas consumption reduction may be temporary, and natural gas consumption may return to 2021 levels in the future, depending on industrial sector demand. Structural natural gas consumption reduction can be expected after 2030 due to international commitments, the development of climate-neutral energy sources, and energy efficiency improvement.



Chapter III
TRAJECTORY OF CHANGES IN LITHUANIA'S ENERGY SECTOR

SECTION I
GENERAL DIRECTION OF CHANGES IN LITHUANIA'S AND EUROPE'S ENERGY SECTOR

17. The Lithuanian energy sector must develop by considering not only national needs but also the international commitments aimed at managing the effects of climate change and reducing greenhouse gas (GHG) emissions. One of the main commitments is outlined in the 2015 Paris Agreement, which aims to make efforts to limit the increase in global average temperature to no more than 1.5°C above pre-industrial levels. To implement the goals of the Paris Agreement and maintain EU leadership at the international level in the fight against climate change, Lithuania, along with other EU member states, seeks to increase ambitions for the next decade and long-term climate and energy policy goals.

18. At the EU level, the need to transition to climate-neutral technologies in the energy sector is established in the European Commission's communication to the European Parliament, the European Council, the European Economic and Social Committee, and the Committee of the Regions "The European Green Deal" (COM (2019) 640 final) of December 11, 2019. This document outlines the goals to transform the EU economy into a modern, competitive, and climate-neutral one. The primary focus is on further development of renewable energy sources, strengthening energy security, improving energy efficiency – especially by taking into account energy efficiency first principle – reducing GHG emissions, protecting consumers, and increasing industrial competitiveness. Particular attention is given to hydrogen, which is expected to help reduce the dependence of the industrial and transport sectors on fossil fuels.

19. At the regional level, the direction of changes in the energy sector aligns with general EU goals and is often more ambitious. All regional countries aim to create climate-neutral economies by 2050, with some aiming to achieve this goal sooner. Priority is given to developing climate-neutral energy sources, reducing GHG emissions, maintaining industrial competitiveness, and protecting consumers.

20. Successful experience in implementing significant energy projects, favorable conditions for RES production facility development, international commitments, and a changing global energy market create opportunities for Lithuania to capitalize on future changes at the EU and regional levels.

SECTION II
POSSIBLE SCENARIOS OF CHANGES IN LITHUANIA'S ENERGY SECTOR

21. To assess future changes, challenges, and opportunities in Lithuania's energy sector, the study "Lithuania Energy System Transformation to 2050" was conducted, evaluating possible changes in Lithuania's energy system until 2050 based on three main future scenarios, each considering regional energy development trends, energy infrastructure development in Lithuania, market situation, and legal environment. According to the development trends and planned local electricity production, three scenarios were identified: climate-neutral energy, regional hydrogen production, and green energy products. The conclusions of these scenarios, along with contributions from other studies and insights from Lithuania's energy sector participants, helped shape the main scenario – the Lithuanian Energy Sector Transformation Roadmap (hereinafter – the Roadmap).

22. The scenarios presented should not be considered forecasts of how Lithuania's energy system will develop or be adopted as the best choices. The purpose of these scenarios is to present possible perspectives with varying ambitions to implement energy transformation and stimulate energy system development and decarbonization. Scenarios help analyze the impact of different factors on the energy system's development, considering strategic goals and providing a clear and unambiguous assessment. The scenarios of Lithuania's energy system in 2050 are described in the Strategy to transparently and impartially present information on how the main development directions of Lithuania's energy system were chosen.

23. The detailed scenarios for Lithuania's energy system transformation in 2050 are as follows:

23.1. **Climate-neutral energy (CNE) scenario.** Compared to the current situation, this would be the least ambitious energy sector development scenario. It is assessed that households, transport, and industrial sectors will rapidly transition to electricity consumption to achieve climate change management goals. The growing electricity demand will be ensured by RES development, primarily onshore wind power plants (installed capacity of 9 GW), offshore wind power plants (2.5 GW), and solar power plants (7 GW). The intermittent electricity generation from RES will require flexible production and load management solutions, such as hydrogen production, additional electricity storage parks, heat pumps, and/or electric boilers, electric vehicles (utilizing flexible charging and electricity return to the grid technologies), and possible additional electricity interconnections with other countries. Hydrogen production is planned but will be limited to meeting national needs. The need

for an international hydrogen pipeline connection to balance hydrogen demand and supply remains, as Lithuania, considering currently known long-term hydrogen storage technologies, will not have long-term hydrogen storage capabilities. A small growth in energy-intensive industries is expected. The CNE scenario ensures that Lithuania will be able to produce all the necessary electricity and utilize other national energy sources (biofuel, waste, etc.) to achieve climate change goals by 2030. According to the CNE scenario, the total electricity production in 2050 would reach 50 TWh per year.

23.2. **Hydrogen production region (HPR) scenario.** This is a significantly more ambitious scenario than the CNE scenario, with the main vision of producing enough hydrogen to meet needs. The assumptions about increased electricity consumption remain the same as in the CNE scenario, but larger local hydrogen production capacities and faster growth of electricity-consuming industries are planned. The growing electricity demand will be ensured by larger local onshore wind power plants (10 GW) and solar power plants (9 GW), as well as the introduction of small modular reactors (SMRs) in nuclear energy. The planned SMR capacity is 1 GW. Increased electricity production will require more flexible production, electricity storage, and load management solutions. These will be provided by more electricity storage parks and additional electricity interconnections with other countries. A new infrastructure – an energy center – is also planned, enabling the construction of additional offshore wind farms (approximately 4.5 GW). The energy center could be established either offshore or onshore, connecting electricity and hydrogen production infrastructure in one location. If it is decided not to build the energy center offshore after technical and economic assessment, the necessary hydrogen production infrastructure could be built onshore, connecting it directly with offshore wind farms. According to the HPR scenario, the total electricity production in 2050 would reach 71 TWh per year.

23.3. **Green energy products (GEP) scenario.** This scenario represents the highest ambition for energy system growth, aiming for the most significant growth in energy-intensive industries while maintaining high hydrogen production capacities. The main difference from the HPR scenario is the aim to maximize the potential of the industry in Lithuania by creating green energy product production infrastructure. According to this scenario, significantly less local electricity and hydrogen export is planned, using them for the production of higher value-added green energy products – green synthetic fuels or fertilizers. These products and their production in Lithuania create greater added value for the national economy, but their development also requires significantly higher investments in energy infrastructure, primarily carbon capture and utilization, as carbon dioxide is an essential element in producing some green energy products. According to this scenario, higher electricity demand is expected, which will be met by larger onshore wind power capacities (12.5 GW), maximum utilization of offshore wind potential (4.5 GW), and solar power plants (9 GW), along with additional SMRs (2.1 GW). In terms of electricity system flexibility services, balancing, and non-frequency-related additional services, this scenario is similar to the HPR scenario. According to the GEP scenario, total electricity production in 2050 would reach 85 TWh per year.

Table 1. *Main Features of Lithuania's Energy Sector Change Scenarios for 2050*

Main Criteria	Unit of Measure	2022	CNE Scenario	HPR Scenario	**GEP Scenario**	Roadmap Scenario
Electricity production	TWh	4.3	50	71	85	74
Onshore wind power plants	GW	0.7	9	10	12.5	10
Offshore wind power plants	GW	0	2.5	4.5	4.5	4.5
Solar power plants (capacity distribution: parks / rooftops)	GW	0.4	7 (4/3)	9 (5/4)	9 (5/4)	9 (5/4)
SMR	GW	0	0	1	2.1	1.5
Power plants using natural gas (with carbon capture technology), biomethane, or other gases from renewable energy sources (RES), and/or hydrogen	GW	1.1	0.5/0.5	0.26/0.5	0.26/0	1.1
Electricity storage devices (batteries)	GW	0	3	4	4	4
Hydrogen electrolysis	GW	0	4	8.5	8.5	8.5
Carbon capture and utilization	–	No	No	No	Yes	Yes

24. In assessing the transformation scenarios of Lithuania's energy system, the assumptions were made that by 2050, 40% of all households in Lithuania will use centrally supplied heat energy, and 60% will use heat pumps or other electric-powered technology. In the transport sector, it was assumed that 80% of all transport will be electrified, and 20% will use hydrogen or its derivatives. Notably, considering Lithuania's climate conditions and available biofuel resources, biofuel usage will remain by 2050 according to the Roadmap scenario.

25. All evaluated scenarios allow achieving net-zero carbon dioxide emissions in Lithuania's energy sector by 2050, but some unavoidable GHG emissions remain.

26. According to the HPR and GEP scenarios, the energy independence indicator increases more than in the CNE scenario due to uranium imports. However, diversified uranium supply chains do not contradict Lithuania's goal of reducing energy dependence.

Table 2. *Assessment of Lithuania's Energy Sector Change Scenario Indicators Considering Strategic Goals*

Scenario Indicators	Unit of Measure	2022	CNE Scenario	HPR Scenario	**GEP Scenario**	Roadmap Scenario
Energy dependence	%	73%	11%	25%	32%	30%
Electricity dependence	%	67%	2%	3%	–4%	0%
GHG emissions	million t CO2 eq	11.7	0	0	0	0
Hydrogen export	TWh	0	–3.0	4.4	1.4	1.4
Derivative hydrogen product export	TWh	0	5.0	6.1	11.9	9.1
Projected infrastructure needs (2022-2050)	billion EUR	–	49	68	79	71

1. The energy dependence indicator is obtained by dividing the amount of imported energy by the total primary energy consumption (including non-energy consumption).

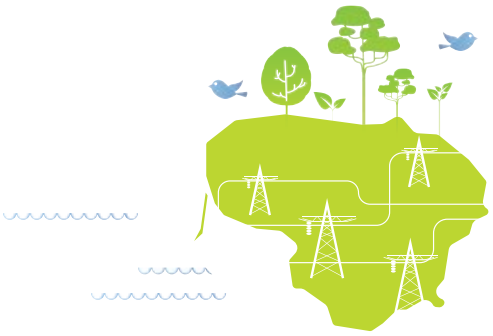
2. The electricity dependence indicator is obtained by dividing the amount of imported electricity by the final electricity consumption.

27. **Roadmap scenario.** Considering the results obtained by analyzing the CNE, HPR, and GEP scenarios, as well as other studies and insights from Lithuania's energy sector participants, a comprehensive Roadmap scenario was developed, evaluating each scenario based on energy and electricity dependence on imports, GHG emissions, hydrogen export and derivative hydrogen product export levels, and the overall energy system cost, including new infrastructure investment needs.

28. According to the Roadmap scenario, it is planned that by 2050, Lithuania will produce 74 TWh of electricity per year, with the main sources being onshore wind power plants (installed capacity – 10 GW), offshore wind power plants (installed capacity – 4.5 GW), and solar power plants (installed capacity – 9 GW). It is planned to install 1.5 GW of SMR capacity and maintain existing natural gas plants (installed capacity – 1.1 GW), considering the development of new flexible generation capacities and the application of carbon capture technology due to stricter environmental requirements. Lithuania will also need 4 GW of electricity storage device parks (batteries), and hydrogen electrolysis capacity will need to reach 8.5 GW. Considering the planned electricity production and electricity system balancing capacity needs, the need for intersystem connections with Central Europe and the Baltic countries will increase – it is planned that Lithuania could be connected to Central Europe with additional 4 GW interconnections, and electricity

interconnections with the Baltic countries could increase by additional 3.8 GW. Electric vehicles, heat pumps, and industrial electricity consumption represent additional flexible consumption sources that can contribute to RES balancing. According to the Roadmap scenario, carbon capture, transportation, and utilization infrastructure will be developed in Lithuania and used for derivative hydrogen product production. Additionally, consistent implementation of electricity use in the district heat supply sector and seasonal heat storage development will result in electric transport accounting for 80% of the transport sector, and hydrogen or hydrogen derivative-powered transport vehicles – 20%.

29. Based on the Roadmap scenario, Lithuania's energy vision for 2050 was developed.



Chapter IV
LITHUANIA'S ENERGY VISION FOR 2050

30. Lithuania's energy vision for 2050 – a country producing energy for its needs and exporting it, having created a climate-neutral and high value-added energy industry.

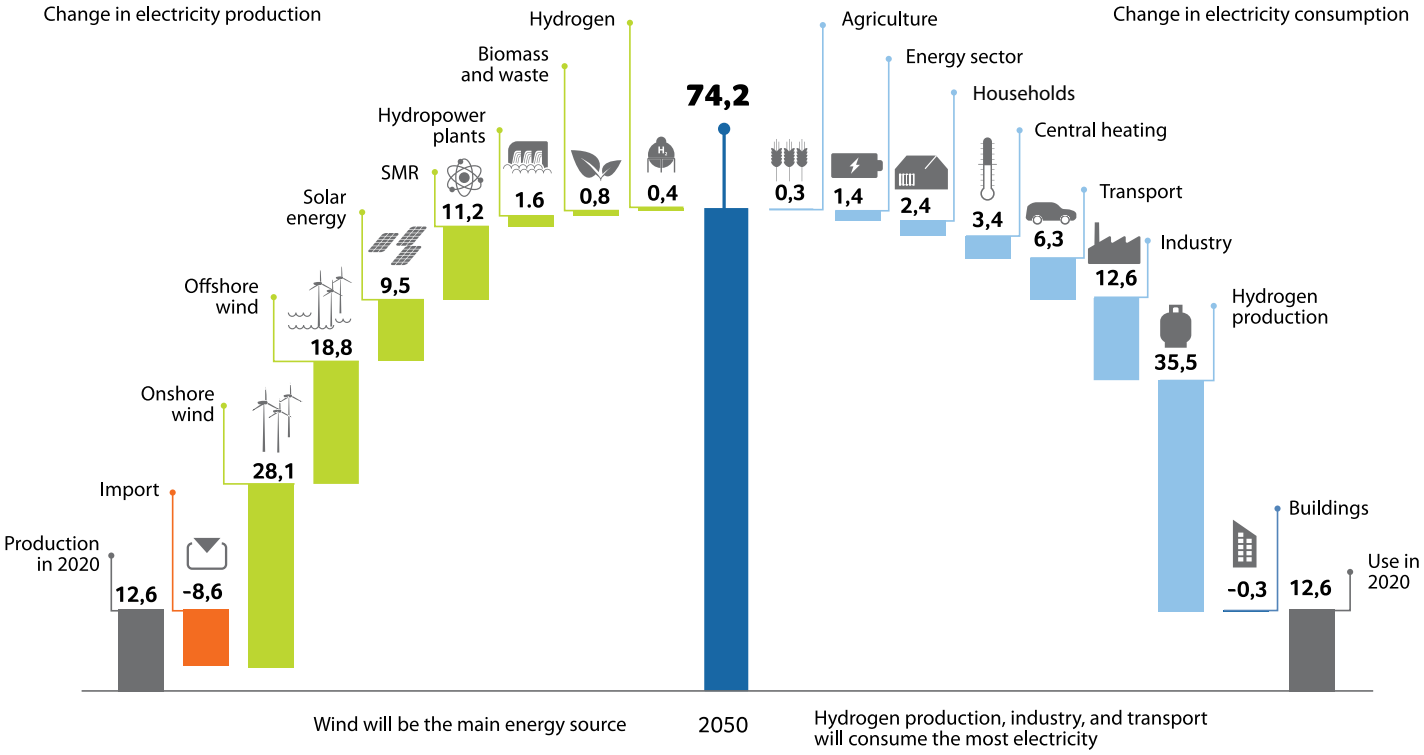
31. By 2050, it is planned to consistently develop Lithuania's energy sector, considering the EU's climate change management goals and the goal of a climate-neutral economy, aiming to be self-sufficient in energy resources and eliminating their imports (except for uranium imports), creating added value for Lithuanian society, enabling the development of energy production capacities, and attracting new investments.

32. By 2050, Lithuania will not only produce the necessary electricity for its needs but also be an exporter of electricity in the region. Significant attention will be paid to derivative hydrogen products: green synthetic fuels, methanol, ammonia, synthetic methane, or others. Competitive conditions will be created for developing new sustainable electricity and other energy source production and storage capacities, aiming for their maximum utilization in Lithuania.

33. The majority of electricity consumed in Lithuania will be produced in wind and solar power plants. The electricity generated in these plants depends heavily on meteorological conditions, and electricity production is not constant, so the electricity system will need significantly higher balancing and reserve capacities than was usual with fossil fuel sources. Flexible energy demand measures and technologies that promote additional electricity demand when there is surplus production and prices are low, and reduce consumption when electricity is scarce and prices are high, will need to be implemented.

34. Lithuania will have the opportunity to participate not only in the usual European electricity trading market but also in the markets of hydrogen and its derivative products produced from green electricity, creating derivative hydrogen product export capacities and utilizing the potential of Klaipėda State Seaport. Developing economically justified electricity system balancing and reserve capacities, as well as flexible demand measures, will create conditions to use the country's

Figure 2. *Projected changes in electricity production and consumption by 2050. The difference between sectors from 2020 to 2050 is presented (in TWh).*



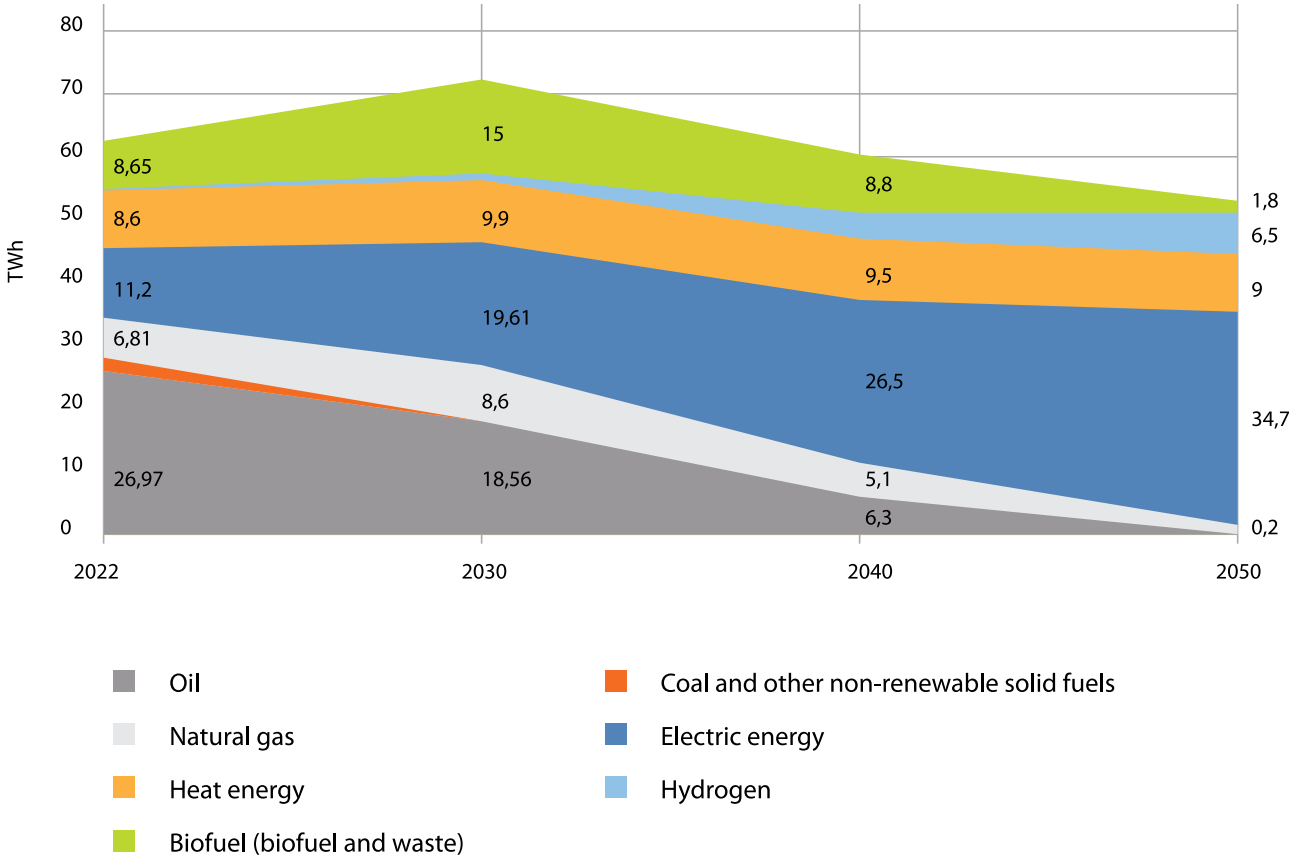
geographical advantage by connecting European countries that generate an energy surplus with energy-deficient industrial regions.

35. Considering international trends, Lithuania's economy will transition from fossil fuel use to relying on electricity and other clean energy sources. A new electricity economy will form. Broad transition to electricity consumption will occur in the transport sector by electrifying light transport and part of heavy transport; in the industrial sector by transitioning to electrification and attracting new high value-added companies that require large amounts of electricity (hydrogen production, data centers, electricity storage device manufacturing, etc.); in the energy sector by creating new derivative hydrogen product production capacities; and in the heat supply sector by expanding electricity use for heat production and storage. Significant electricity consumption is also planned in other sectors, which will become the primary energy source in the overall energy system. It is predicted that electricity consumption will increase from the current 12 TWh demand to 74 TWh by 2050, a more than sixfold increase.

36. The annual final energy demand for energy and non-energy purposes will decrease from 93 TWh in 2022 to 75 TWh by 2050. The reduction in primary energy demand will be driven by higher energy efficiency and the transition to electricity as a more efficient energy source. It is planned that electricity will ensure half of the total final energy demand by 2050. The other dominant energy source will be hydrogen, used in industry, transport, and the production of derivative hydrogen products. The industrial sector (including hydrogen production capacities) will become the largest energy consumer, consuming more than half of the required final energy. Electricity

and hydrogen supply will create conditions for industrial growth based on derivative hydrogen products. Households, the transport sector, and other sectors will account for a smaller share of final energy demand due to improved energy efficiency and the use of alternative fuels.

Figure 3. *Projected Change in Final Energy Consumption by Fuel Type, 2022–2050 (TWh).*



37. Energy changes will be aimed at continuously reducing the energy sector's impact on the environment and climate, consistently transitioning to the goal of zero pollution, including air, water, and soil pollution, protecting biodiversity, ecosystems, and landscapes, and ensuring the health and well-being of Lithuania's residents. The development of new energy production facilities and related industry must be carried out ensuring a healthy and clean environment, rational use of natural resources, circular economy principles, and preservation of existing ecosystems and landscapes. A data- and science-based approach to energy changes and their implementation will be assessed for their impact on the health of Lithuanian people and on air quality. Energy sector companies, when developing their projects, must adhere to, and ensure, sustainability and circular economy, as well as biodiversity sorting and recycling principles.

Chapter V
STRATEGIC ENERGY GOALS OF LITHUANIA UNTIL 2050

38. To implement Lithuania's energy vision, the following strategic energy goals are set until 2050:

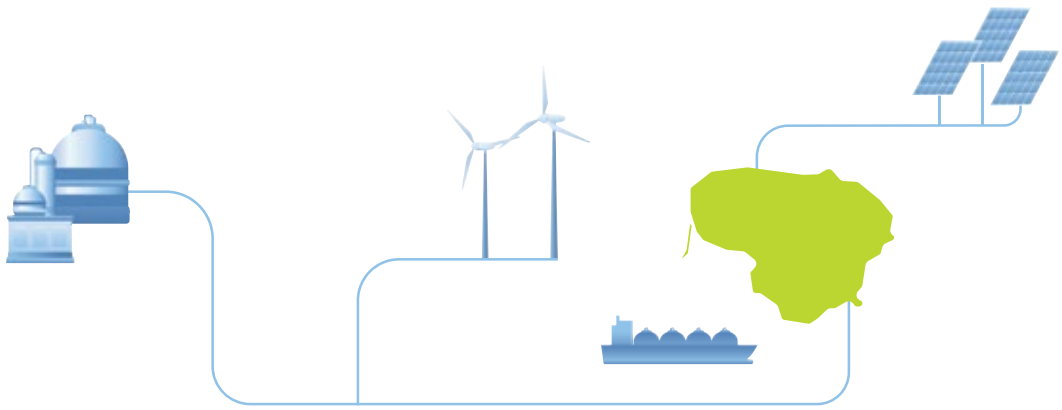
38.1. Safe and reliable energy supply. Reliable energy and energy resource supply will be ensured in Lithuania, maintaining already created infrastructure that enables energy supply source diversification and implementing new energy development projects primarily required to integrate new local energy production sources into the energy system. Particular attention is given to electricity infrastructure, which will be crucial for energy system transformation – electricity transmission and distribution networks will be developed, reserve and balancing capacities will be ensured, and smart grid technologies will be implemented. Lithuanian energy will also be resilient to physical and cyber threats.

38.2. 100% climate-neutral energy for Lithuania and the region. To achieve the Green Deal goals, Lithuania will transition only to climate-neutral energy sources. RES production capacities will continue to be developed both offshore and onshore, and the use of new electricity generation sources will be evaluated. Sufficient electricity production capacities will be built in Lithuania to create conditions for energy product export. The transition of heat production, transport, industry, and other sectors to climate-neutral energy sources and the use of alternative fuels will be promoted. A positive energy balance in the electricity sector, ensuring that more electricity is produced in the country than consumed, must be achieved by 2030. The ultimate goal is climate-neutral energy based on local energy production by 2050.

38.3. Transition to an electricity economy and development of a high value-added energy industry. A favorable environment for business and ensuring energy resource availability at competitive prices will promote economic sector electrification, transition to clean energy sources, and the emergence of new industries. The focus is on green hydrogen and its derivative product manufacturers, sustainable biogas and biomethane producers, fuel cell network technology manufacturers, heat pump manufacturers, electricity storage device manufacturers, data centers, wind and solar power plants or their component manufacturers, and other industries that could significantly contribute to Lithuania's economic prosperity.

By developing RES production capacities, implementing electricity flexibility measures and measures for the integration of national energy systems into the EU's energy systems, fostering a favorable investment environment, and ensuring appropriate infrastructure, Lithuania will create conditions for energy resource export, which should be no less than 3 TWh of various energy products per year. The main priority is the export of higher value-added energy products (hydrogen, methanol, ammonia, synthetic methane, and others) and attracting high-tech industries and services to Lithuania to utilize cheaper electricity in the region and create added value for the Lithuanian economy.

38.4. Energy resource availability for consumers. Suitable conditions must be ensured so that the benefits of energy transformation are felt by both residents and businesses. It is also aimed that socially vulnerable residents experience as little energy poverty as possible. By developing local energy production and electricity system flexibility capacities, the goal is to reduce energy resource price and supply fluctuations dependent on the global energy resource market and its fluctuations. During the green transformation, it is important to ensure that the state incentive and support system for abandoning fossil fuels, renewable energy development, and energy efficiency improvement can be utilized not only by high- and middle-income segments of society but also be oriented towards low-income residents, thus reducing social inequality in the energy sector.



Chapter VI
IMPLEMENTATION OF LITHUANIA'S ENERGY GOALS

SECTION I
SAFE AND RELIABLE ENERGY SUPPLY

39. The first strategic energy goal of Lithuania is to ensure a safe and reliable energy supply for all consumers.

40. State security and competitiveness, economic growth, and the well-being of all citizens depend on reliable energy supply. Energy security is ensured by the integration of EU and Lithuanian energy infrastructure, markets, systems, and sectors, the development of sustainable local energy production from renewable energy sources (RES) to meet energy consumption needs, the maintenance and expansion of balancing and reserve generation capacities of the electricity system, and the expansion of the flexibility and capacity of the electricity system through the creation and implementation of necessary mechanisms.

41. Safe and reliable energy supply for all consumers will be ensured by implementing the following tasks:

41.1. Synchronization of Lithuania's electricity system with the Continental European electricity networks (KET). It must be ensured that the Lithuanian electricity system is prepared by the end of 2024 and connected to the KET for synchronous operation through the Polish electricity system by February 2025, ensuring the continued implementation of the "Harmony Link" electricity interconnection project between Lithuania and Poland.

41.2. Ensuring electricity system capacity and flexibility. Ensuring electricity system adequacy and creating mechanisms to maintain and develop reserve electricity generation capacities, along with efficient electricity system flexibility, balancing, and non-frequency-related additional services market development and operation, flexible electricity demand measures, and technology implementation.

41.3. Development of electricity transmission and distribution infrastructure to ensure reliable and safe electricity supply, meet the need for connecting facilities enabling new electricity production, consumption, and electricity system flexibility measures.

41.4. Ensuring natural and other gas, oil, and oil product supply during the transition to a climate-neutral economy, maintaining the Klaipėda LNG terminal and reliable gas infrastructure network, liquid energy product (oil, biofuel, chemical product, and synthetic fuel) handling terminal in Klaipėda, Būtingė Oil Terminal, and other necessary infrastructure.

41.5. Preparation for crises and ensuring resilient Lithuanian energy sector infrastructure: strengthening the ability to respond to military, economic, political, and climate crises, accumulating natural gas, crude oil, and oil product reserves required by international commitments and other necessary reserves for energy supply disruptions or failures. Additionally, strengthening physical and cyber security capabilities of the energy sector to prevent any physical and cyber security breaches.

42. The essential conditions, prerequisites, and directions for implementing the goal of safe and reliable energy supply for all consumers are indicated in the Strategy points 43–102.

Synchronization of the electricity system with KET

43. Sufficient energy security level for Lithuania and the Baltic States and comprehensive integration of energy systems into EU markets will only be ensured when the Lithuanian electricity system is desynchronized from the electricity system of the Commonwealth of Independent States (IPS/UPS), currently connecting Belarus, Russia, Estonia, Latvia, and Lithuania, and connected to the KET for synchronous operation, and all synchronization projects with KET are completed.

44. Synchronization with the KET will allow the Baltic States to become completely independent from decisions made by the Russian Federation and eliminate the possibility of technically influencing the operation of the Baltic electricity system, as well as monitoring, and obtaining information about the Lithuanian electricity system. Additionally, the infrastructure installed during the synchronization project with the KET will help integrate more RES production capacities into the Lithuanian electricity system.

45. The Lithuanian electricity system must be prepared for connection to the KET for synchronous operation by the end of 2024, and to achieve this goal, Lithuanian electricity system security enhancement projects and necessary technical and organizational measures must be implemented.

46. Desynchronization from the IPS/UPS system and connection of the Lithuanian electricity system to the KET for synchronous operation must occur no later than February 2025, considering the conditions for connection to the KET for synchronous operation issued by the European Network of Transmission System Operators for Electricity (ENTSO-E) Continental Europe Regional Group (RGCE).

47. Upon synchronization of the Lithuanian electricity system with the KET for synchronous operation, no opportunities should remain for electricity from non-European Economic Area countries to enter the Lithuanian electricity system.

48. Upon synchronization of the Lithuanian electricity system with the KET for synchronous operation by the end of 2025, all electricity system stability enhancement projects must be completed. Synchronization with the KET will be implemented once the second "Harmony Link" electricity interconnection project between Lithuania and Poland is completed, ensuring integration into the EU internal electricity market and enabling more efficient use of local RES generation capacities. When implementing the "Harmony Link" electricity interconnection project, priority should be given to the alternating current electricity interconnection on land. A 700 MW alternating current interconnection on land would ensure more stable and reliable electricity system operation, resolving disruptions more effectively compared to a marine direct current interconnection. Additionally, it would utilize synergies in the overlapping sections of transport infrastructure corridors ("Rail Baltica" or "Via Baltica") connecting Poland and Lithuania, installing a 220 kV alternating current cable interconnection in Poland and a new electricity transmission line in Lithuania, significantly reducing project costs compared to laying the interconnection on the seabed.

Ensuring electricity system capacity and flexibility

49. When assessing electricity system adequacy, the variability of energy generated from RES, which may cause significant energy shortages or surpluses at different times, should be considered. The required available generation and/or energy storage and flexible load capacities should be assessed in advance, and their capacity and energy production potential should be publicly announced. In the absence of sufficient economic justification for such capacity availability in the market, legal, financial, and other necessary prerequisites should be created to develop and/or maintain them. Existing and newly created strategically important energy infrastructure must remain owned by state-controlled companies.

50. According to the 2022 electricity system adequacy assessment conducted by the Lithuanian electricity transmission system operator, the commissioning of the "Harmony Link" electricity interconnection significantly influences the adequacy of the electricity system between 2026 and 2030. Until the commissioning of this interconnection, considering the capabilities of the Lithuanian electricity system to operate in isolated mode, the required reliably available and controlled electricity generation capacity is at least 1,100 MW (2024-2025), which means the capacity of all reliably available power plants in Lithuania (Lithuanian Power Plant, Kaunas Combined Heat and

Power Plant, "Orlen Lietuva" power plant, and AB "Panevėžio energija" power plant) is needed.

51. Until the full implementation of the synchronization project with the KET – completion of the second "Harmony Link" electricity interconnection project with Poland – the adequacy of the Lithuanian electricity system will be ensured by maintaining existing reliably available electricity generation capacities and continuing the service of ensuring the availability of electricity generation facilities for isolated electricity system operation.

52. To ensure the adequacy of the Lithuanian electricity system and readiness for isolated electricity system operation after 2030, considering the rapid RES generation capacity development and increasing electricity demand, a capacity mechanism allowing to maintain existing and develop new electricity generation capacities necessary for the safe operation of the Lithuanian electricity system must be created by that time. Their need and importance will grow as RES generation capacities and electricity demand increase.

53. The 200 MW electricity storage system, commissioned in 2023, will play a crucial role in providing electricity system balancing services and the isolated electricity system operation reserve service at least until the synchronization project is completed (until the second electricity interconnection with Poland is completed). Upon completing the fifth synchronous unit project of the Kruonis Pumped Storage Plant in 2026, the Kruonis Pumped Storage Plant will be able to participate effectively in the additional services market, utilizing its full 1,010 MW potential.

Table 3. *Planned electricity system flexibility capacities (including intersystem interconnections), MW*

		2022	2030	2040	2050
Storage devices	Batteries	0	1,500	2,000	4,000
Storage devices	Pumped-storage power plant	900	1,010	1,010	1,010
Electricity connections	Intersystem electricity connections	2,150	3,150	5,400	10,650
Flexible generation	Biomass and waste cogeneration power plant	169	292	292	292
Flexible generation	Natural gas power plants (with CO2 capture or other sources of flexible generation)*	1,100	1,100	1,100	1,100
Flexible generation	SMR	0	0	1,000	1,500
Flexible demand	Heat production from electric energy (DH and industrial sectors)	0	230	943	1,118

Note. The natural gas plants' capacities should be maintained until 2050, depending on the development of other flexible generation sources and their capacity to ensure electricity system adequacy.

Flexible demand	Hydrogen electrolysis (connected with an electric energy transmission or distribution network)	0	1,300	4,000	6,500
Flexible demand	Flexibility services provided by electric vehicles	0	170	730	1,040
Flexible demand	Heat production from electric energy (heat-pumps in households and in the service sector)	210	770	1,750	2,500
	In total:	4,529	9,522	18,225	29,710

54. To maintain investors' interest in further developing Lithuanian electricity generation capacities from RES, the transmission system operator company (or a related company) must conduct geological studies of the Syderiai structure for its suitability for long-term energy storage and the implementation of electricity system flexibility measures using new technological solutions and ensure suitable conditions for such a project.

55. The Baltic States' electricity transmission system operators are developing a common electricity system balancing capacity market, which will start operating in 2025. According to the Baltic States' electricity transmission system operators, the initial demand for balancing capacities in this market will be up to 1,512 MW. The new electricity system balancing capacity market is being created in preparation for synchronization with the KET, after which the Baltic States will operate as a single frequency control block and jointly procure electricity system balancing services. As the Baltic States plan to operate synchronously with the KET, the increasing RES generation capacity and rapidly growing electricity demand create a significant need for electricity system balancing solutions – technical capabilities will be needed to both increase and decrease electricity generation and consumption. In addition to existing capacities, it will be sought that market participants with or planning such capacities will provide electricity system balancing services:

55.1. Electricity storage devices and other energy storage systems capable of storing energy and supplying it to the grid as needed.

55.2. Existing and new RES power plants with control systems adapted to automatically change production and storage modes.

55.3. Green hydrogen and its derivative product production facilities are capable of quickly starting up and storing the produced hydrogen or using it immediately.

55.4. Automated and robotized production enterprises capable of flexibly changing electricity consumption based on market prices.

55.5. Demand aggregators with smart and bidirectional electric vehicle charging infrastructure, high-power heat pumps, electric boilers, accumulation tanks, and other electricity users that meet technical requirements and can manage and aggregate their electricity consumption capacity based on distribution network load and market prices.

Table 4. *Planned electricity storage device (battery) demand by capacity and volume*

	2023	2030	2040	2050
Power, GW	0.2	1.5	2	4
Capacity, GWh	0.2	4.4	5.9	11.9
Average battery size (hr.)	1	2.93	2.95	2.98

56. Rapid RES development is possible only with favorable conditions for competing in the market with fossil fuels and traditional, proven technologies. To ensure that Lithuania's energy changes are sustainable, the regulatory role of the state, appropriately directing state aid, imposing taxes on polluting technologies, and applying administrative measures, will remain important.

57. Measures and technologies ensuring the flexibility of energy supply and demand in electricity networks should be recognized as strategically important state projects. This list should include the Northwest and East electricity transmission network connection project, green hydrogen and its derivative product islands, and large-scale energy storage and storage capacity creation projects.

Development of electricity transmission and distribution infrastructure

58. The planning and operation of electricity transmission networks must be linked with the planning and operation of electricity distribution networks, new hydrogen infrastructure, energy storage, light and heavy electric vehicle charging infrastructure, industry, heat energy sector, cooling production electrification, and carbon dioxide infrastructure.

59. To adapt electricity transmission networks to future challenges, it is necessary to transition to more advanced integrated energy system planning, considering future electricity needs and integrating the necessary electricity generation and electricity system flexibility measures, ensuring coordination in grid planning, data exchange among different sector participants, and involving stakeholders in this process. This will increase the electrification of individual sectors and provide clarity on future electricity grid and system integration needs.

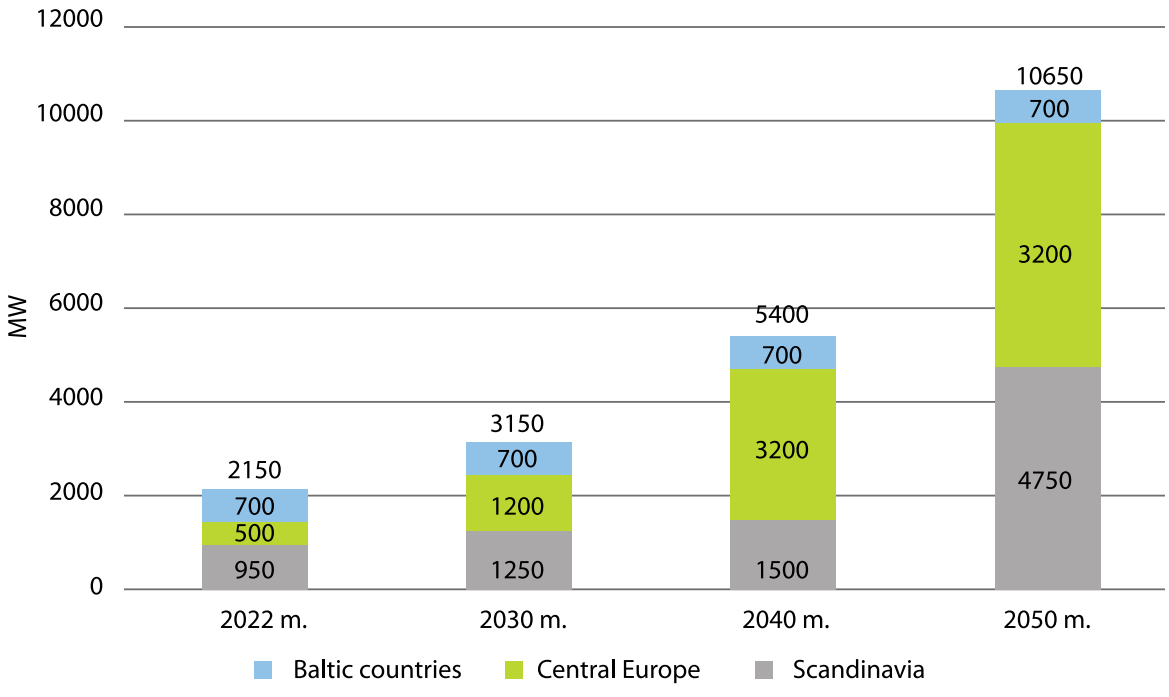
60. Based on electricity production and consumption forecasts until 2050, the amount of electricity produced in Lithuania may grow about 20-fold compared to 2022, consumption – about 6- to 7-fold, and the capacity of electricity system flexibility measures – about 15-fold. Changes in electricity production and consumption and electricity system flexibility capabilities from 2022 to 2050 will impact grid renewal solutions. It is important to develop grids considering the needs of producers and consumers, also considering the capabilities and location of electricity system flexibility measures.

61. Existing electricity transmission networks will need to be renewed and expanded. The need for rapid renewal and expansion of transmission networks is associated with a significant RES production potential (wind and solar energy plants) and the connection of electrolysis devices

to transmission networks. The development pace of offshore wind generation will determine the need for marine transmission networks and investment volume. RES potential is especially high in the western part of Lithuania, while the most intensive consumption takes place in the eastern part. This necessitates strengthening the connectivity between the eastern and western parts of Lithuania's electricity system, thus increasing national energy security and ensuring faster RES development.

62. Between 2030 and 2035, internal transmission networks in northern Lithuania need to be strengthened. This will ensure better conditions for transmitting electricity produced in RES plants to consumption centers and meeting the electricity needs of new technology users (such as hydrogen production through electrolysis). Strengthening the transmission networks in northern Lithuania due to increased capacity will also enable further electricity market integration with the Latvian transmission system (in both directions). As electricity production and consumption volumes grow, and to ensure continued RES electricity production development and the security of Lithuania's electricity system, considering the economic aspect, it will be necessary to expand intersystem electricity connections. The main priority is additional electricity connections with Central Europe and strengthening new and existing connections with the Baltic States, excluding already planned projects. By 2040, an additional 2 GW electricity connection could link Lithuania and Central Europe, and connections with the Baltic States could be increased to 1.5 GW. By 2050, another additional 2 GW electricity connection with Central Europe could be established, and connections with the Baltic States could be expanded to 4.75 GW. Final decisions on each electricity connection construction should only be made after thoroughly assessing the social and economic benefits for Lithuanian consumers and the impact on Lithuania's energy system and strategic goals.

Figure 4. *Perspective on the development of Lithuania's intersystem electricity connections and the forecasted capacity, MW*



63. In the coming decades, the electricity transmission infrastructure will be developed in two directions: 63.1. Physical transmission infrastructure development to update, strengthen, and expand it, considering the changing electricity production and consumption situation, the development of offshore and onshore RES production facilities, sectoral integration, and the transition to an electricity economy. 63.2. Smart transmission infrastructure development, which will be based on digitization and the latest technologies to better monitor and control electricity grids, creating a more flexible and secure electricity system.

64. Public and private entities implementing offshore wind farm and electricity grid infrastructure projects, electric vehicle charging infrastructure projects, electricity supply from shore in seaports, electrolysis device development, heat pumps, boilers, and heat storage installations, partial electrification of district heating systems, and other initiatives will increase the need to strengthen electricity grids and open up new electricity system flexibility markets.

65. In developing transmission networks, the increasing need for short-term and long-term electricity system flexibility measures must be considered. By 2050, electricity storage in the Lithuanian energy system will be ensured by a 1 GW pumped storage plant and 4 GW capacity electricity storage devices. Both types of storage devices will be able to store up to 17.5 GWh of energy.

66. To encourage the use of electric vehicles, it is necessary to implement the required charging infrastructure power across all Lithuanian regions in a coordinated manner, closely aligned with grid development. Road electric transport can become an additional source of electricity system flexibility. Therefore, the development of smart and bidirectional charging infrastructure must be ensured and promoted.

67. Examining possible scenarios of energy sector changes reveals a significant investment need to renew existing infrastructure and build new infrastructure facilities. Therefore, the investment and financing capabilities of electricity transmission and distribution network operators must be ensured, and the regulatory environment updated to allow for grid development in advance (anticipatory development principle), ensuring the connection of new RES facilities, energy storage devices, and consumers (including hydrogen producers and electric vehicle charging infrastructure) and aiming to make financing decisions more quickly and efficiently.

68. One of the biggest challenges for electricity distribution and transmission networks is the energy system transformation and the connection of generating consumers, electrification of the heat sector, and the development of electric vehicle charging infrastructure. The rapid development of electric transport and charging infrastructure in the coming years will accelerate the need for anticipatory development of distribution and transmission networks.

69. The transformation of the energy system is significantly influenced by long-established grids. Existing grid capacities are limited considering the need to ensure mass electrification and achieve high climate change management goals. Future grids will be developed by promoting anticipated and proactive investments, long-term grid planning, digitization, flexibility, and more advanced data exchange. When creating new infrastructure, existing grids will be maximized and optimized. Additionally, future grid challenges are directed towards increasing the flexibility of the entire electricity system, seasonal energy storage, and active grid management.

70. During the transformation of Lithuania's energy system, the electricity distribution infrastructure will be developed in the following directions:

70.1. Transition from passive to active electricity system management – active management includes: grids using digital technologies, sensors, and software to better align real-time electricity supply and demand while reducing costs and maintaining grid stability and reliability. Smart grid technologies provide opportunities to flexibly integrate new energy market participants, reducing costs and ensuring operational resilience. Seeing all grid elements virtually will change grid management completely remotely, ensuring isolated problem-solving by reconfiguring necessary segments in real-time. Grid management will increasingly transition to local optimization solutions, abandoning centralized system management.

70.2. Market empowerment and data exchange – efficient energy market operation and competitiveness are inseparable from well-organized and digitized energy data exchange between market participants, distribution, and transmission network operators. Currently, market participants exchange data through a centralized data exchange platform, whose functionality will be expanded based on new market participant needs. Implementing the smart electricity metering system in 2022 opened unique opportunities for all market participants. Smart electricity meters become a tool for easily viewing consumption data in an easy to understand way, as well as analyzing and changing consumption habits. These devices remotely transmit consumption data and grid parameters, allowing distribution network operators to detect and eliminate faults more quickly and accurately, improving grid efficiency. The planned completion of the first phase of the smart electricity metering system in 2026 will ensure remote data collection for consumers using more than 1,000 kWh of electricity per year.

70.3. Integrated energy ecosystem – the lifecycle of grid components is often 40 years or more, so these grids cannot be developed based solely on current needs. Considering increasing electricity demand, a transition from reactive, incremental planning to proactive, future-oriented grid development strategy is necessary. Grid planning methodologies will be adapted to a consumer-oriented model. Grid development will be pursued considering the electricity consumption situation and creating scenarios that allow optimal grid utilization. Additionally, more attention will be paid to coordinating grid planning and data exchange carried out by transmission system operators, distribution network operators, producers, aggregators, and other market participants to create resilient grids.

70.4. Increasing resilience and adapting to climate change – climate change impacts not only the number of incidents in the electricity system but also the overall system stability. As weather conditions become more extreme, different grid parts wear out faster, requiring investment in more resilient components where economically viable, such as underground lines and remotely controlled switching devices and grid solutions that operate without dispatcher involvement during faults. This remote access to essential grid components increases cyber threat risks, emphasizing the comprehensive approach to IT infrastructure implementation and configuration to ensure compliance with cybersecurity requirements.

71. Electricity transmission system and distribution network operators must ensure that the necessary infrastructure development projects are prepared, planned, and implemented to meet the 2030, 2040, and 2050 infrastructure needs, considering the goals indicated in the Strategy and measures outlined in the National Energy and Climate Plan 2021-2030 (NECP). In cases where grid development needs are identified but specific projects are lacking, the national energy sector regulatory authority should encourage grid operators to create and implement new project concepts.

72. As distributed electricity generation expands and more electric vehicles and other devices capable of using energy flexibly from distribution networks emerge, flexible supply and demand measures, smart technologies, and other flexibility measures must be implemented in distribution networks. Given the limited capacity of distribution networks, this will allow for increased permissible connection capacity for consumers and/or producers, utilizing better existing grid capacity opportunities.

73. Energy sector regulation and electricity tariff setting must allow grid operators to:

73.1. Efficiently utilize existing network infrastructure and adapt the regulatory environment to ensure and promote the implementation of energy transformation. This includes changes and adaptations to network tariffs.

73.2. Coordinate possible anticipatory investments in grid projects during planned network reconstruction, considering both current and future infrastructure needs, tolerating situations where the created infrastructure may not be fully utilized from the moment of commissioning but would provide cost optimization and benefits of creating a climate-neutral economy in the long term.

73.3. Implement smart grids and the latest technologies, improving grid efficiency. Operational cost compensation must appropriately reflect not only human resource costs but also increasing digitization, data processing, and implementation and procurement costs of electricity system flexibility services.

Ensuring the supply of natural and other gases, oil, and oil products during the transition to a climate-neutral economy

74. Since the Klaipėda LNG terminal began operating in 2014, supply sources have been diversified, and Lithuania has become capable of supplying natural gas from international LNG markets. To ensure the continuity of the Klaipėda LNG terminal's operations, considering its strategic importance to Lithuania's energy system, a decision was made to acquire the leased FSRU "Independence" as property. The Klaipėda LNG terminal is planned to operate at least until 2045.

75. Maintaining the intersystem natural gas connections with Latvia and Poland is essential to ensure reliable and safe natural gas supply to consumers in Lithuania and the Baltic region, continue the Klaipėda LNG terminal's operations, and ensure the potential use of infrastructure for the needs of both Lithuania and the entire Baltic region.

76. The share of natural gas in the country's total fuel and energy consumption structure is decreasing – in 2022, this share was 10.1% (14.2% in 2021), and from 2018 to 2021, the country's natural gas demand was about 24 TWh. However, due to the price increases caused by the war in Ukraine, natural gas-saving measures, and temporary shutdowns of industrial enterprises, consumption decreased by a third: in 2022, 16.5 TWh was consumed in Lithuania.

77. The development of climate-neutral energy production and consumption technologies, green course policies, and energy efficiency improvement will lead to a structural decline in natural gas consumption after 2030. It is expected that in Lithuania, as in the EU, natural gas will remain an important energy resource during the transition to a climate-neutral economy, but its role in energy production will increasingly focus on balancing electricity generation from RES.

78. From 2025 to 2040, the country's methane (natural gas and biogas) demand will be 13.8–20.4 TWh, with about 50% of the demand for gas as a raw material in the fertilizer manufacturing industry. It is planned that by 2050, the demand for natural gas should disappear, and the entire remaining methane supply should be biogas, produced from biomass resources in Lithuania, and possibly synthetic methane if its production from green hydrogen and biogenic carbon dioxide becomes competitive with other fuels. Efforts will be made to exploit the potential of waste and residues generated in Lithuania and consistently increase biogas production, reaching about 1.4 TWh by 2030 and 3.4 TWh by 2040.

79. Ensuring the supply of natural gas and other energy resources during the transition to a climate-neutral economy will aim to decarbonize the gas market and ensure reliable supply to national consumers of natural and green gases or other low-carbon footprint gases at competitive, cost-based prices.

80. By 2050, the EU climate-neutrality goal will be pursued by integrating gases from RES and consistently replacing natural gas usage with green energy – through electrification, biogas, synthetic methane, hydrogen, or other fuels produced from RES.

81. Lithuania's natural gas infrastructure will continue to be used for import, transport, and transit, and this infrastructure will be adapted for future hydrogen transport. To strengthen the security of natural gas supply and reduce dependency on natural gas imports, conditions will be created to use more green gases and low-carbon footprint gases in Lithuania's gas system.

82. Lithuania has the only oil refinery in the Baltic region with an annual capacity of 10-11 million tons of oil. The annual design capacity of the import and export terminal through the Baltic Sea at Būtingė is 14 million tons of oil, and one of the most modern liquid energy product (oil, biofuels, chemical products, and synthetic fuels) export and import terminals in the region, located in Klaipėda, has a capacity of 7.1 million tons per year. Currently, Lithuania has sufficient technical capabilities to import oil and oil products and other liquid energy products from various countries, with diverse supply options and technical protection against potential supply disruptions from any single country.

83. Ensuring the supply of natural gas and other energy resources and a consistent transition will be

implemented in the following directions: 83.1. Promoting the integration of green gases and low-carbon footprint gases into existing gas markets and infrastructure. It will be aimed that, as natural gas consumption decreases, the cost of existing gas infrastructure will not be borne by users of RES and low-carbon footprint gases. 83.2. Establishing regulations for decommissioning unused gas infrastructure as the energy sector transitions to climate-neutral solutions, determining which parts of the infrastructure should be mothballed or transferred to other infrastructure operators, and which should be decommissioned. 83.3. Promoting competition and consumer participation, especially in the transport sector, in the biogas market. 83.4. Utilizing integrated network planning opportunities to adapt gas transportation infrastructure for hydrogen, biogas, carbon dioxide, and other gases. 83.5. Creating favorable conditions for the development of biogas production capacities in Lithuania: integrating produced biogas into gas systems and promoting the collection of biogenic carbon dioxide from biogas production sites for use in the production of derivative hydrogen products. 83.6. Assessing under what conditions it would be competitive to produce synthetic methane from green hydrogen and biogenic carbon dioxide. 83.7. Ensuring a diversified supply of oil, oil products, and other liquid energy products by effectively utilizing existing infrastructure.

Preparation for crises and ensuring resilient energy infrastructure

84. Unpredictable geopolitical circumstances and security situations, resulting from the unjustified and unprovoked war of the Russian Federation against Ukraine, require special attention to the resilience of energy systems, threat prevention, and crisis preparedness. Lithuania must continue to apply and implement already established energy security measures and allocate additional attention to threat prevention, reliability of energy supply, resilience of energy systems, physical protection of energy facilities, and cybersecurity issues.

85. Lithuania accumulates natural gas, oil products, and other energy resource reserves, fulfilling national, EU, and International Energy Agency commitments. The energy security measure – the accumulation of existing reserves – remains important and must be continued, and during the energy system transformation, a consistent transition to other energy storage methods should be ensured.

86. According to EU and International Energy Agency requirements, Lithuania must accumulate and continuously maintain oil and oil product reserves equivalent to 90 days of net oil product import demand. Lithuania accumulates oil and oil product reserves at the state level sufficient for at least 30 days, based on average consumption. The remaining oil and oil product reserves are accumulated by obligated companies.

87. Natural gas reserves are accumulated for vulnerable consumers, stored in Latvia's underground natural gas storage facility, implementing the EU supply reliability standard.

88. Implementing national requirements, energy sector companies with heat and/or electricity generation facilities of more than 5 MW capacity and producing heat and/or electricity for sale must have a reserve of energy resources sufficient for 10 calendar days of consumption during the cold season, considering the technical characteristics of the production sources.

89. Implementing national requirements, energy sector companies providing the availability service of electricity generation facilities necessary for isolated operation of the electricity system are recommended to have fuel reserves for electricity generation up to 60 calendar days.

90. To achieve other goals outlined in the Strategy, increase RES production volume, and use electricity more widely in industry and other sectors transitioning to a climate-neutral economy, it is necessary to assess the possibilities of replacing existing fossil fuel-based energy reserves with climate-neutral energy reserves. The main replacement of these energy resources is planned after 2030. Additionally, it is important to promote the development of energy storage infrastructure and use short-term and long-term (seasonal) heat storage tanks more widely in the district heating sector.

91. Other necessary parts of energy resource supply security include physical protection of facilities and resilience of energy systems. Understanding the importance of ensuring physical protection of energy facilities, Lithuania also plans to raise and emphasize resilience requirements for energy sector companies.

92. Physical protection requirements for energy sector companies managing strategically important energy facilities must be continuously reviewed and updated to improve the protection of facilities and assets important for national security. The focus will be on threats arising from hybrid warfare measures used by countries unfriendly to Lithuania, additionally implementing measures to ensure infrastructure protection.

93. Energy sector companies managing strategically important energy facilities are required to implement protection systems against unmanned aerial vehicles and improve monitoring of underwater infrastructure parts. In later stages of strengthening physical protection, installing protective structures to hide or protect important facilities from mechanical and/or explosive impacts is planned.

94. Lithuania must aim to accumulate the main components needed for repairing energy infrastructure, which would allow performing essential repair works if critical parts of the electricity or natural gas systems are damaged or destroyed.

95. Sabotage cases of marine underwater energy infrastructure in the Baltic Sea in 2022 and 2023 revealed the vulnerability of marine underwater infrastructure to both intentional and unintentional actions and unequivocally encouraged energy sector companies managing such infrastructure to review their protection organization and update the set of applied measures.

96. Lithuania must aim to establish a system for protecting facilities and assets important for national security, operating based on threat and readiness levels determined by a competent authority, meaning physical protection measures planned and applied in the energy sector companies' security plans would be adjusted according to the threat level identified at a specific time at the

facility or territory. Lithuania, aiming to properly implement the Directive (EU) 2022/2557 of the European Parliament and the Council of 14 December 2022 on the resilience of critical entities, repealing Council Directive 2008/114/EC, plans to identify critical entities and apply resilience enhancement requirements established in this directive:

96.1. Appointing a competent (coordinating) authority, increasing non-financial state support, and strengthening mutual cooperation between EU member states.

96.2. Accumulating reserves of equipment and materials necessary to ensure the activities of energy sector companies. Such a reserve must ensure the rapid restoration of infrastructure managed by energy sector companies after technical accidents, natural phenomena, or intentional activities causing damage and the necessary resumption of energy activities.

96.3. Reviewing planning assumptions and intended actions for the restoration of the electricity system, including energy sector companies carrying out essential energy activities (generation, transmission, and distribution), after a total electricity system accident. The concept of isolated transmission and distribution network parts and technical requirements for implementing such a concept must be ensured. This concept could be used to ensure electricity supply to critical entities (consumers) performing vital state functions in case of significant transmission network damage.

97. District heating companies must be prepared to ensure business continuity in emergencies. It is especially important to foresee and implement measures that would ensure heat production and supply to critical consumers in the event of a total electricity system accident and maintain the functionality of heat production and supply systems.

98. Implementing the Strategy will aim to diversify the markets of components needed for RES power plants to reduce Lithuania's dependence on third countries posing a threat to national security.

99. The negative effects of climate change increase risks related to energy security, primarily the risk of electricity supply disruptions, as heat waves, forest fires, droughts, and floods negatively affect electricity demand, production, storage, transportation, and distribution. Extreme climate phenomena can also negatively impact the production and consumption of other types of energy. Planning the demand, production, storage, transportation, and distribution of electricity and other types of energy must consider and foresee specific measures to enhance infrastructure resilience and adapt to the negative effects of climate change, focusing on extreme weather events, forest fires, prolonged periods without sun and/or wind, floods, and heatwaves during warm seasons. Transmission and distribution operators, RES producers, both maintaining existing infrastructure and planning new, must assess the impact of the negative effects of climate change.

100. Protecting energy facilities must also include cybersecurity. Energy sector companies must be prepared to respond to cyber threats, continuously update cybersecurity measures, acquire new equipment, organize periodic training involving all employees of companies, institutions, and agencies, and specialized exercises for cybersecurity specialists. Continuous cooperation and information exchange must be ensured not only with state institutions but also with different

energy sector companies. The aim will be to implement the Directive (EU) 2022/2555 of the European Parliament and the Council of 14 December 2022 on measures for a high common level of cybersecurity across the Union, partially amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972 and repealing Directive (EU) 2016/1148 (NIS2 Directive). Energy sector entities operating in the electricity, district heating and cooling, oil, gas, and hydrogen subsectors will be classified into groups of essential or important entities according to the criteria established in the NIS2 Directive, ensuring a high level of cybersecurity in Lithuania's energy sector and contributing to a high level of cybersecurity across the EU.

101. Measures implemented at the state and energy sector company levels to prevent cyber threats must ensure the management of risks associated with imported energy technologies and reduce dependency on technologies and management systems from third-country manufacturers that pose a threat to national security and are used in energy facilities.

102. To strengthen the preparedness of workers in the energy sector to respond to cyber threats and ensure the proper protection of strategic energy infrastructure, international cooperation, primarily with US national laboratories, will be developed, and the transfer of good practices will be promoted.

SECTION II
100 PERCENT CLIMATE-NEUTRAL ENERGY FOR LITHUANIA AND THE REGION

103. The second strategic goal of Lithuania's energy sector is 100 percent climate-neutral energy for Lithuania and the region.

104. In implementing climate change management goals, to create a climate-neutral economy by reducing greenhouse gas emissions in the transport, industry, and other sectors, there will be a transition to climate-neutral energy types, with electricity being one of the main ones. Electrifying various processes currently using fossil fuels and using electricity for the production of hydrogen and its derivatives will increase electricity consumption. To ensure sufficient electricity production for national needs, further rapid development of renewable energy production facilities is necessary.

105. To achieve the goal of 100 percent climate-neutral energy for Lithuania and the region, the following tasks will be implemented: 105.1. Ensure the development of offshore wind farms and the creation of an energy hub in the exclusive economic zone of Lithuania in the Baltic Sea; 105.2. Ensure the development of renewable energy sources on land, focusing primarily on the development of wind and solar power plants and ensuring the optimal development of electrical grid capacities; 105.3. Prepare for the potential development of nuclear energy by assessing the prospects for the construction of safe fourth-generation small modular reactors (SMRs) in Lithuania; 105.4. Ensure

the development of the use of hydrogen and its derivatives; 105.5. Ensure that the heat energy sector abandons the use of polluting fuels and transitions to renewable energy sources, and promote the development of the cooling sector; 105.6. Promote the transition of the transport sector to non-polluting modes of transport and fuels.

106. The essential conditions, assumptions, and directions for the tasks implementing the goal of 100 percent climate-neutral energy for Lithuania and the region are indicated in points 107-183 of the Strategy.

Offshore Wind Farm Development and Creation of an Energy Hub

107. Lithuania has the opportunity to utilize its exclusive economic zone in the Baltic Sea for electricity production by developing offshore wind farms. The development of these farms will allow Lithuania to meet its national electricity demand, create hydrogen production capacities, and establish itself as an energy resource exporter in the regional market.

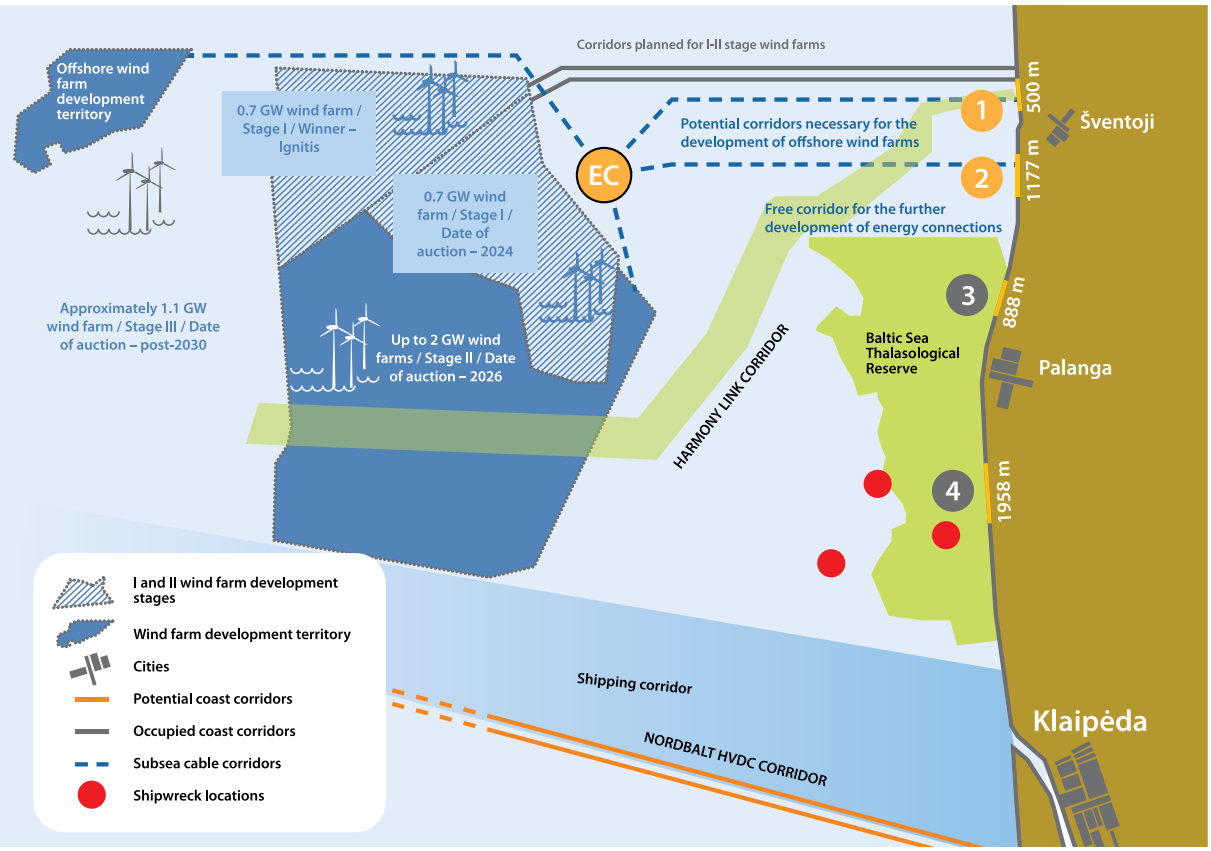
108. The largest amount of electricity from renewable energy sources in the Lithuanian territory of the Baltic Sea is planned to be generated from proven offshore wind energy technologies. It is also essential to monitor the progress of new or improved energy technologies – alternative ways of generating electricity. Timely implementation of improvements will increase the efficiency of electricity production and the amount of electricity generated, contributing to energy security by diversifying electricity generation sources.

109. In the first phase, by 2030, Lithuania plans to develop two offshore wind farms. The total capacity of these wind farms will reach 1.4 GW, and they will be connected to the Lithuanian electricity transmission system. Both wind farms will produce about 6 TWh of electricity per year.

110. In the second phase, the development of offshore wind farms will continue, organizing a tender (or tenders) in 2026 for up to 2 GW capacity, aiming to increase the installed capacity of offshore wind farms to at least 2.8 GW by 2040.

111. In the third phase, by 2050, organizing a tender (or tenders) for about 1 GW capacity after 2030, a total of about 4.5 GW of offshore wind farms will be built in Lithuania's exclusive economic zone in the Baltic Sea.

Figure 5. *Planned Dates and Areas for Offshore Wind Farm Tenders*



112. Due to the high supply of renewable energy, it is expected that it will be economically efficient to develop production capacities for converting electricity into hydrogen and its derivatives in the Northern and Baltic states, also creating conditions for further development of renewable energy in these states.

113. With the increasing demand for electricity in Lithuania, given economic viability and sufficient balancing capacity of the electricity system or the extent of flexibility technologies in the electricity system, an energy hub should be established in the economic zone of the Baltic Sea or onshore, where electricity flows would be distributed via connections to Lithuania to meet the energy needs for green hydrogen production and/or transmitted to other countries' electricity systems via intersystem connections.

114. To achieve the goals set out in the Strategy and utilize Lithuania's geographical position between regions in Europe with energy surpluses and deficits, Lithuania should aim to create such an energy hub that primarily allows the use of offshore and onshore renewable energy potential, receive electricity from distant offshore wind farms, use renewable energy for the production of hydrogen and its derivative products, and create a competitive environment for developers and consumers.

115. To create the energy hub infrastructure, business model, technical, economic, and socio-economic analyses must be prepared. These analyses should evaluate the economic feasibility of the project, the benefits to Lithuania, infrastructure needs, costs, implementation timelines, and possibilities for financing and cross-border cost-sharing.

Development of Renewable Energy Sources on Land

116. The share of renewable energy sources (RES) in Lithuania's domestic electricity production and final electricity consumption balance will continue to increase until it reaches 100 percent, thereby reducing dependence on fossil fuel imports, increasing local electricity production capacities, and helping Lithuania become a regional green energy hub.

117. The development of RES in the electricity sector will continue to focus on sustainable RES development under market conditions, ensuring social welfare, environmental stability, and economic growth. By improving legal regulations, favorable conditions for RES development will continue to be created, reducing administrative and regulatory burdens, encouraging a positive public attitude towards RES development, and not having a significant impact on local ecosystems.

118. The development of RES in Lithuania's electricity sector should be carried out based on the following principles: 118.1. Consistent integration of RES into the market – the most economically efficient technologies should be developed, considering their maturity, assessing their near-future progress trends, and cybersecurity requirements; 118.2. Affordability and transparency – the model for promoting RES should be based on market principles, distorting them as little as possible, ensuring the lowest financial burden on energy consumers, clarity, and a non-discriminatory competitive environment; 118.3. Active participation of energy consumers – as the share of RES in the total energy balance increases, decentralized electricity production should be encouraged, utilizing existing building infrastructure, allowing consumers to use the electricity generated from RES for their own needs, and receiving market-based compensation for excess electricity supplied to the grid. Additionally, consumer behavior and energy demand and supply management solutions should be implemented.

119. Decentralized electricity production from RES will have a significant impact on the increase of the RES share in the electricity sector. The number of electricity consumers capable of producing electricity for their own needs will be consistently increased, encouraging the establishment of renewable energy communities (REC) and citizen energy communities (CEC), the creation of prosumers and active electricity consumers (active consumer).

120. The share of electricity from RES, compared to the country's total final electricity consumption, will reach 100 percent by 2030.

121. The main measures to achieve RES development on land include the intensive development of wind and solar power plants. The target indicators are: 121.1. By 2030, develop 4.5 GW of onshore wind power plants and 4.1 GW of solar power plants; 121.2. By 2040, develop 6.5 GW of onshore wind power plants and 7 GW of solar power plants; 121.3. By 2050, develop 10 GW of onshore wind power plants and 9 GW of solar power plants.

Opportunities for the Development of Nuclear Energy

122. As countries implement changes in their energy systems and transition from fossil fuels to non-polluting energy sources, the need for new, efficient, low or zero greenhouse gas (GHG) emitting, and controllable electricity generation increases, which renews the perspective on nuclear energy.

123. Nuclear reactors are categorized into four generations based on their construction period, technologies used, and safety measures. The first generation typically includes the first commercial prototype reactors built in the 1950s and 1960s. It is anticipated that the latest fourth-generation nuclear reactors will start operating in the early 2030s. However, considerable experience in designing and operating reactors based on similar technology has been accumulated in France, the United Kingdom, the United States, Japan, and other countries. Measures implemented at the state and energy sector company levels to prevent cyber threats must ensure the management of risks associated with imported energy technologies and reduce dependency on technologies and management systems from third-country manufacturers that pose a threat to national security and are used in energy facilities.

124. Planned fourth-generation nuclear reactors are expected to achieve even better nuclear safety and reliability indicators, higher efficiency, and economic competitiveness compared to previous generations. They will produce less nuclear waste. In fourth-generation nuclear reactors, using an advanced nuclear fuel cycle where the nuclear fuel is reprocessed and reused, uranium utilization is improved up to 100 times, significantly reducing the amount of radioactive waste, its radioactivity, the need for deep geological disposal of spent nuclear fuel, and the risks of nuclear material proliferation. One of the most promising directions in nuclear energy is fourth-generation small modular reactors (SMRs), which, due to their relatively small capacity, reactor technology, and passive safety measures, allow the emergency planning zone to coincide with the power plant site area. Commercial fourth-generation SMRs can be constructed by 2030 and begin commercial operation in the following decade.

125. One of the main advantages of fourth-generation SMRs is their ability to respond flexibly to changes in the electricity system and adapt to the amount of production from renewable energy sources (RES). Some SMRs being developed will be able to store heat generated by the nuclear reactor in a nearby thermal storage (e.g., molten salt) and use this heat for electricity generation as needed, increasing turbine capacity. It is projected that, for example, a turbine of an SMR with a capacity of about 350 MW, using heat stored in a thermal storage, could operate in a range of 100 to 500 MW of generated power depending on electricity market prices and the need to balance RES and other electricity system requirements.

126. Considering the ongoing technological changes in nuclear energy, the future electricity needs in Lithuania, and the need for controllable electricity generation, Lithuania should consider exploiting the advantages offered by fourth-generation SMRs. The potential of SMR technology provides an opportunity to meet the electricity system's balancing needs during periods when there is no electricity from RES, but electricity consumption remains high.

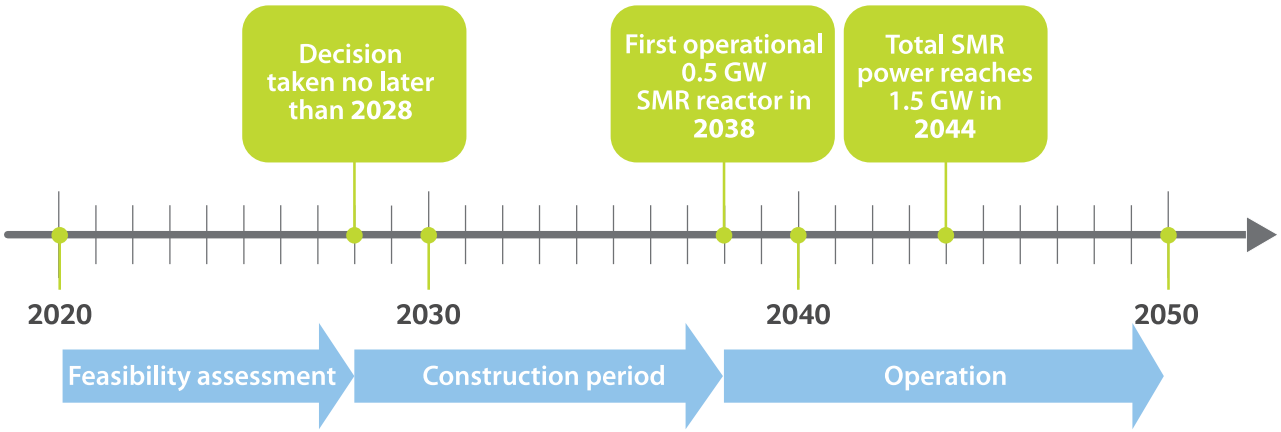
127. Assessing Lithuania's needs in the electricity sector after 2030, the initial total capacity of SMRs should be 0.5 GW (producing about 3.5 TWh of electricity per year) and gradually increase to 1.5 GW (producing up to or about 11.2 TWh of electricity per year). To ensure adequate electricity generation and reliable available capacity for the electricity system's needs, SMR operations should begin between 2038 and 2044, gradually constructing nuclear reactors with a capacity of 0.5 to 1.5 GW.

128. Currently, Lithuania has accumulated knowledge, competencies, and experience in the field of nuclear energy, but the average age of specialists is increasing, and the demand for such skills is decreasing (except for the decommissioning of the Ignalina Nuclear Power Plant (INPP) and radioactive waste management), thus these skills are dwindling. Lithuania already has a legal framework for nuclear energy due to the previously operated INPP, the State Nuclear Power Safety Inspectorate oversees nuclear energy safety, and, due to the previously planned Visaginas Nuclear Power Plant project, suitable sites for nuclear energy development have been surveyed, and other preparatory work has been carried out.

129. When planning the possible development of nuclear energy in Lithuania, the existing scientific potential, infrastructure for ensuring nuclear energy safety, preparedness, and human resources must be preserved and developed, aiming to use them in new nuclear power plant projects and current nuclear energy facility decommissioning, as well as radioactive waste and spent nuclear fuel management projects.

130. The infrastructure in and around the INPP site (the 330/110 kV substation near the INPP and high-voltage transmission lines connecting it to the rest of Lithuania's electricity system, roads, a railway line connecting the INPP site to the Dūkštas station, etc.) can be adapted for the implementation of new flexible and sustainable nuclear power plant projects. State-owned land plots near the INPP site (evaluated as potentially suitable for nuclear power plant construction according to the Visaginas Nuclear Power Plant project) should be maintained and protected for potential sustainable nuclear power plant projects. However, when evaluating potential sites for possible future nuclear power plant projects, not only the INPP area, but all potential sites in Lithuania should be considered.

Figure 6. *SMR Development Timeline*



131. To ensure that fourth-generation SMRs in Lithuania start operating by 2038, a preliminary analysis of the fourth-generation SMR business model and development feasibility assessment must be prepared by 2027. It is necessary to evaluate the operational model of fourth-generation SMR projects in Lithuania and their impact on RES development, the balancing potential of the electricity system, cost, sources of funding required for project implementation, including the need and amount of subsidies, project implementation timelines, the security of the nuclear fuel supply chain, the legal framework for nuclear energy development and safety assurance, and the safety regulation infrastructure. The possibility of utilizing existing nuclear energy infrastructure, the need for human resources, and other aspects should also be considered. Depending on the results of the preliminary business model and assessment of the fourth-generation SMRs, a bill on the construction of a new nuclear power plant could be submitted to the Seimas of the Republic of Lithuania, creating the prerequisites for the implementation of fourth-generation SMR projects.

Development of Hydrogen and Hydrogen Derivative Usage

132. The main focus is on green hydrogen produced from renewable energy sources (RES), which is considered a means to contribute to Lithuania's goals of reducing greenhouse gas emissions and increasing energy independence. The local raw material potential also provides the conditions to significantly increase biogas production. By 2050, Lithuania will produce the necessary energy resources and become an exporter of these resources. Hydrogen and its derivatives will be the basis of this export, and the residual heat generated during the production of these products can be used in district heating (DH) systems for building heating and hot water preparation.

133. The main directions for the development of hydrogen and its derivatives by 2030: 133.1. Development of surplus RES production capacities; 133.2. Creation of a flexible green hydrogen and hydrogen derivative production, transportation infrastructure, and market; 133.3. Promotion of international cooperation to integrate hydrogen markets and create opportunities for Lithuania to export hydrogen and its derivatives; 133.4. Ensuring technical safety and health standards in the production, use, storage, and transportation of hydrogen and its derivatives; 133.5. Development, practical application, and export of green hydrogen technologies.

134. The main sectors where hydrogen development is planned are industry, transport, and energy. Hydrogen usage will also be encouraged in other sectors to contribute to Lithuania's climate change management goals and energy independence. In industry, transport, and energy sectors, hydrogen has the potential to replace polluting fossil fuels, reduce GHG and other pollutant emissions, and help balance the fluctuations in electricity production using RES.

135. The main indicators for hydrogen and hydrogen derivatives by 2030: 135.1. Install 1.3 GW of electrolysis equipment and produce 129,000 tons of green hydrogen per year, which will be used directly or for the production of its derivatives. The required electricity demand for this production is planned to be 6.51 TWh; 135.2. Ensure that at least 2 TWh of hydrogen derivatives are produced from the amount of green hydrogen indicated in Strategy point 135.1.

136. The main indicators for hydrogen and hydrogen derivatives by 2050: 136.1. Install 8.5 GW of electrolysis equipment, capable of producing 732,000 tons of green hydrogen per year. The planned electricity demand for this production is 36 TWh; 136.2. Produce at least 9 TWh of hydrogen derivatives per year from the amount of hydrogen indicated in Strategy point 136.1.

137. To increase the competitiveness of hydrogen and its derivatives, separate funding measures need to be created for the development of hydrogen and its derivatives. The aim is to use these support mechanisms as effectively as possible in conjunction with the development plans of private companies.

138. The main priority is the use of hydrogen locally – for the production of hydrogen derivatives. However, the development of hydrogen transportation pipeline infrastructure is also sought. It is expected that this infrastructure will allow the export of pure hydrogen, ensure greater energy security, provide access to hydrogen storage facilities in other countries, and help Lithuania integrate into the EU hydrogen market.

139. The main project in developing hydrogen transportation pipeline infrastructure is the Baltic region hydrogen network development initiative, which aims to create hydrogen gas system connections between countries with predicted high hydrogen resource supply (Republic of Finland) and countries with predicted high hydrogen resource demand (Federal Republic of Germany, Republic of Poland) that will be able to import hydrogen from neighboring or other European countries to ensure hydrogen storage and demand.

140. At the same time, the highest possible synergy between hydrogen production and consumption infrastructure is sought – it is planned to establish at least one hydrogen valley in the first phase (by 2030) and another one by 2050. Hydrogen valleys could also be places for scientific research related to hydrogen use and the development of new products.

141. To ensure the smooth development of hydrogen and its derivatives, the development plans of electricity transmission system and natural gas infrastructure system operators, hydrogen, and hydrogen derivative transportation and storage infrastructure developers, and the needs of industry sectors demanding hydrogen and its derivatives will be coordinated.

142. Examining possible hydrogen market development scenarios, there is a significant need for investments in building new infrastructure objects. Therefore, the investment and borrowing capacities of the hydrogen network operator will be ensured, and the regulatory environment will be updated to allow the development of hydrogen transportation infrastructure, ensuring the possibility of connecting hydrogen production, storage facilities, and consumers in advance and making financing decisions faster and more efficiently.

143. The broadest application of green hydrogen in the energy sector will be the use of surplus electricity from RES to exploit low and negative market prices, thus achieving competitive hydrogen production costs. The production of green hydrogen by electrolysis will be used for electricity generation flexibility, electricity system flexibility services, and grid stability, while implementing hydrogen storage and/or other hydrogen system flexibility solutions. With limited hydrogen storage capabilities, to ensure participation in energy system flexibility markets, the production of hydrogen derivatives should also be flexible.

144. Low electricity prices provide the opportunity to produce green hydrogen at a competitive price and use this hydrogen for the production of its derivatives. Higher added value hydrogen derivatives are one of the main goals in expanding hydrogen use in Lithuania. The aim is to create favorable conditions for the production, transportation, and storage infrastructure of green ammonia, methanol, synthetic methane, aviation fuels, and other products. The growing demand for these products, easier transport than hydrogen, and developed or adapted infrastructure provide the opportunity to offer competitive products in the global market.

145. After 2030, with the formation of the green hydrogen market, the creation of synthetic green fuel production infrastructure, and the significant annual production of green hydrogen, given favorable economic conditions, hydrogen or synthetic methane, which can be used in the natural gas import (or export), storage, and transportation system, or adapting specific elements of this system for the use of these products, could be used for electricity generation and/or other purposes to achieve decarbonization goals.

Decarbonization of the Heat Sector

146. Changes in the heat supply sector by 2050 will be driven in the following main directions: increasing building energy efficiency, transitioning to technologies using ambient energy (e.g., heat pumps), and increasing the use of RES technologies. The overall consumption of heat will gradually decrease due to climate change and energy efficiency improvement. The aim is to abandon the use of fossil fuels in the heat sector, encouraging the transition to electricity (heat pumps, electric boilers), and the use of ambient energy. The demand for biofuels is expected to grow in the short term, but from 2040, the demand for biofuels will decrease, the use of solid lump fuel for individual heating in cities will be limited or completely banned. Due to the specific climate conditions in Lithuania, the complete abandonment of biofuels is not planned; their use is planned beyond 2050.

147. The developed district heating (DH) systems in Lithuanian cities are one of the strengths of the Lithuanian energy sector, enabling large-scale and relatively quick changes in decarbonizing heat supply at the municipal level, utilizing economies of scale. Without DH systems, these changes in cities would take decades.

148. The transformation of the DH sector by replacing heat energy production from natural gas with heat energy production from local biofuels has been one of the success stories of the Lithuanian energy sector, allowing the average price of centrally supplied heat to be reduced by almost half during 2012-2020 and reducing carbon dioxide emissions in the DH sector by about 73 percent compared to the 2000 level. Lithuania ranks second among EU member states (73 percent in 2022) in terms of the share of heat supplied to cities from RES.

149. As the energy sector undergoes decarbonization and electrification, and as the EU tightens sustainability requirements for biomass fuel, sustainable forestry, and air pollution caused by biofuel combustion, inevitable changes await the DH sector. In the long term, the DH sector, in order to survive, expand, and compete with the rapidly growing and competing decentralized

heating methods, must increase its competitiveness by utilizing economies of scale, reducing heat supply losses in networks, diversifying the RES used in heat production, and the structure of RES fuels – ensuring a diversity of RES and technologies used in heat production.

150. At the EU level, it is agreed that an efficient DH and cooling system will have to meet the criteria for the share of RES or waste heat in the system, which will gradually increase from 2028 to 2050 every 5 years. From 2050, an efficient DH and cooling system will be considered a system that uses only RES, only ambient energy, and waste heat, or only a combination of RES and ambient energy and waste heat.

151. In developing green hydrogen and its derivatives, the residual heat generated during the processes is intended to be used for city heating and hot water preparation in DH systems.

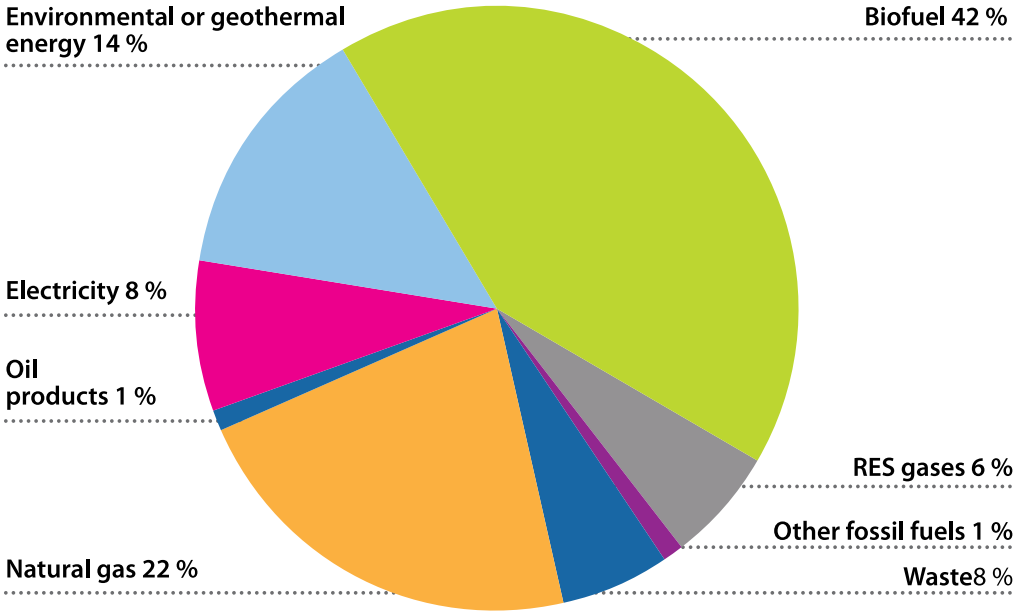
152. The district and decentralized heating supply sectors should develop similarly: abandoning the use of polluting fuels, transitioning to RES, using more waste heat and ambient energy, implementing seasonal heat storage solutions where technologically possible and economically beneficial, modernizing and expanding DH systems, and connecting new consumers.

153. The production of cooling energy by 2050 should grow about five times, as the demand for cooling energy will increase due to the established demand in new buildings and the effects of climate change.

Transition to electricity of consumers who provide their own heating and cooling

154. In Lithuania, about 91.5 million square meters of building space is individually heated, meaning it is not connected to district heating (DH) systems, consuming about 17.5 TWh of final energy. The three main sectors of individual heat energy consumption are the household sector – 8.89 TWh (50.8 percent), the industrial sector – 6.37 TWh (36.4 percent), and the service sector – 2.24 TWh (12.8 percent).

Figure 7. *Heat production in 2030 by energy source for consumers providing their own heating.*

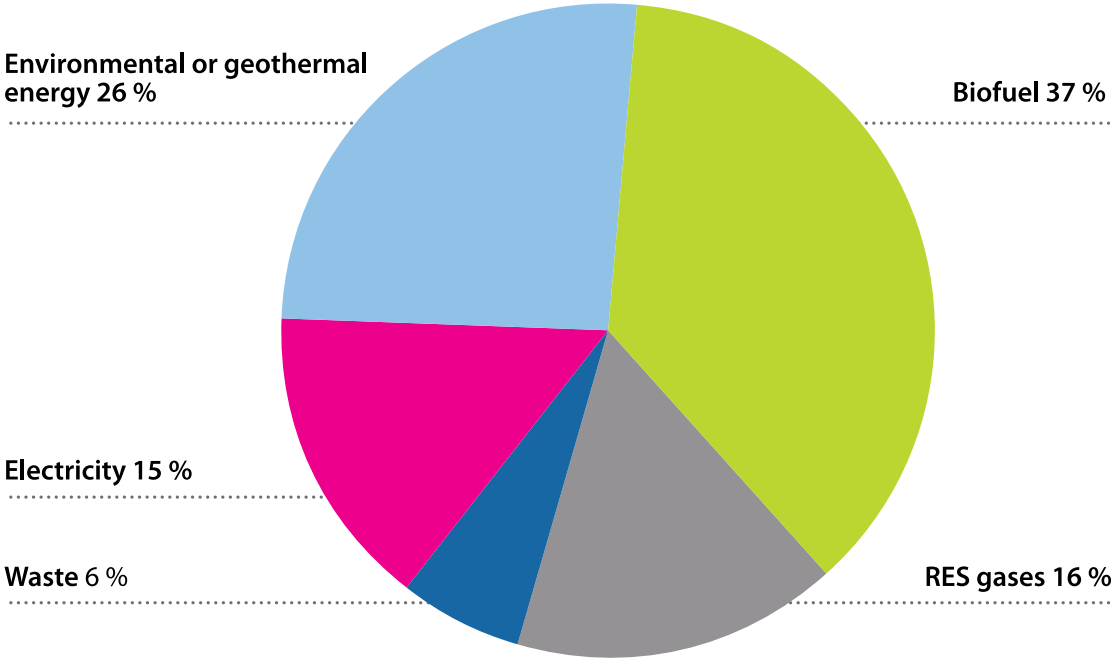


155. The main problem in the area of individual heating and cooling consumers remains the dependence on fossil fuels and inefficient heat production equipment. In 2020, individual heating and cooling consumers used about 7.8 TWh of fossil fuels (including natural gas, coal, peat, etc.). Fossil fuels and inefficient heat production equipment generate 399 million euros per year in social and economic damage to Lithuania due to air pollution and do not ensure complete energy independence.

156. The share of RES in the area of individual heating and cooling consumers in 2020 was about 49.3 percent. The best indicator was in the household sector – about 69 percent, but in the service and industrial sectors, these indicators were significantly lower – about 43.5 percent and 25.7 percent, respectively. By 2030, the goal is for the share of RES in the area of individual heating and cooling consumers to be at least 75 percent of final energy consumption, by 2040 – at least 85 percent, and by 2050 – at least 100 percent.

157. By 2050, the aim is for individual heating and cooling consumers to use climate-neutral energy sources. It is also intended that individual heating and cooling should be as efficient as possible, meeting consumer needs at the lowest cost and having the least negative impact on the environment. Considering the factors influencing heat energy demand by 2050, the pace of building renovation, the pace of new building construction, the pace of old building demolition, climate change, and the increase and development of industrial efficiency, it is forecasted that final energy consumption for individual heat production will consistently decrease due to electrification, and by 2050, final energy consumption in this sector will amount to no more than 10.4 TWh.

Figure 8. *Heat production in 2050 by individual heat-supply consumers by energy source.*



158. Decentralized cooling final energy consumption in the total final energy consumption balance in 2020 was 0.4 percent, or 0.24 TWh. According to 2020 data, decentralized cooling final energy consumption accounted for 100 percent of the total cooling final energy consumption balance. The installation of cooling energy from centralized cooling production sources for final consumers in Lithuania is currently economically unfeasible.

159. To improve the well-being of the population, the installation of heat pumps for cooling in buildings will be encouraged. It is planned that by 2030, about 15 MW of heat pump capacity will be installed, and by 2050 – about 50 MW of heat pump capacity will be installed to produce cooling energy.

Consumption of District Heating

160. District heating (DH) is one of the main methods of heat supply in Lithuanian cities, providing reliable heat energy supply to more than 700,000 consumers. This number has consistently grown and increased by a total of 10 percent. It is planned that with the ongoing energy changes in Lithuania, DH systems will be maintained and expanded, encouraging their transition to renewable energy sources (RES), the development of new heat production methods (heat pumps, electric boilers, etc.), the use of waste heat, and the development of seasonal heat storage solutions. It is planned that the DH sector will also start providing centralized cooling supply services, especially in the major cities of Lithuania.

161. The total maximum capacity demand of Lithuanian DH systems reaches up to 3,200 MW, therefore, most cities have extensively developed large-capacity DH systems, which can be used in the future to balance surplus electricity from RES. The cross-sectoral use of DH systems will contribute to the implementation of climate change management goals, reduce carbon dioxide emissions, and ensure lower energy prices for consumers.

162. The DH sector aims to transition to climate-neutral heat production methods and create a favorable environment for investments in technologies that promote energy efficiency and the implementation of new RES technologies. When choosing a heating method, priority is given to DH as the greenest, most efficient, and reliable method of heat supply in Lithuanian cities. In cities, district heat supplies about 80 percent of heat consumers continuously, with the goal that by 2050, heat will be produced only from RES.

163. The development of DH in the EU is recognized as a key solution in reducing the heat sector's dependence on fossil fuels, as it enables the expansion of RES, as well as the use of surplus and waste heat, contributing to the stability of energy systems and reducing carbon dioxide emissions.

164. The main directions for implementing the transformation of the DH sector:

164.1. Diversification of climate-neutral energy resources used for heat production (solar energy, waste heat, other RES-based technologies, implementation of heat storage);

164.2. Partial electrification of DH systems using ambient energy, electricity, waste, and surplus heat (cooling);

164.3. Creation of short-term and long-term energy storage capacities;

164.4. Bio-cogeneration and the use of sustainable local biofuels;

164.5. Participation of heat suppliers (producers) in providing flexibility and balancing services to the electricity system;

164.6. Transformation of DH systems, adapting them to operate in low-temperature mode (fourth-generation DH systems);

164.7. Use of waste heat generated in hydrogen production and other industrial processes in DH systems;

164.8. Implementation of carbon dioxide capture and storage technologies in heat production facilities;

164.9. Digitalization of DH systems and implementation of smart energy grid management solutions; 164.10. Increasing the resilience of DH systems to external (climate and hybrid) threats;

164.11. Expansion of DH in cities, densely populated areas, replacing polluting individual heating;

164.12. Implementation of measures to improve heat efficiency, including modernization and maintenance efficiency of multi-apartment building systems and heat points.

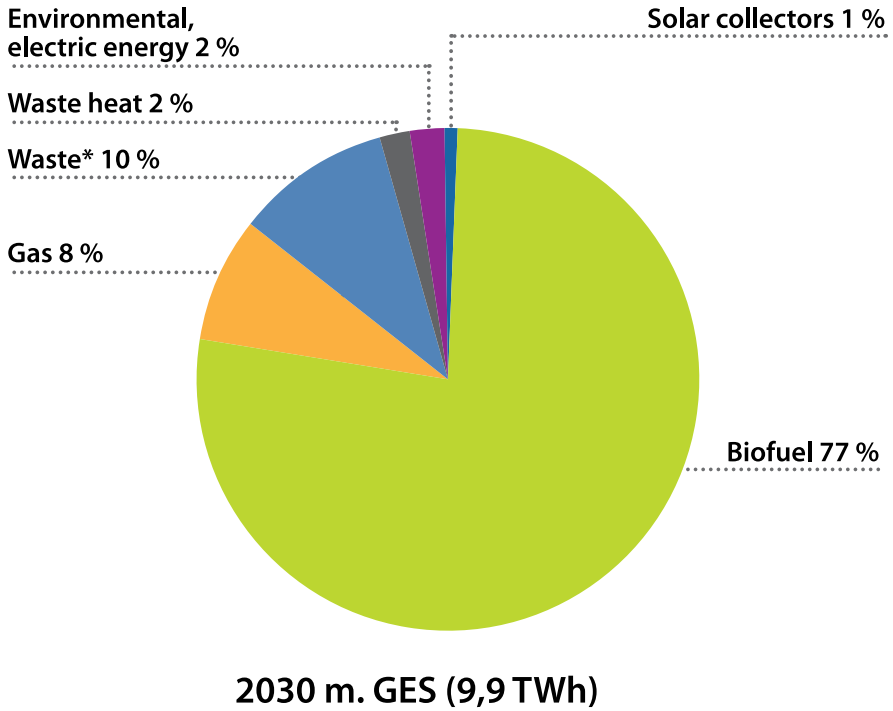
165. The important conditions for implementing the transformation of the DH sector: 165.1. Creation of a favorable investment environment and financial measures for investments in the renovation of DH infrastructure; 165.2. Cross-sectoral integration of energy sectors, efficiently using the existing infrastructure; 165.3. Possible consolidation of heat supply companies, facilitated by greater concentration of financial and human resources.

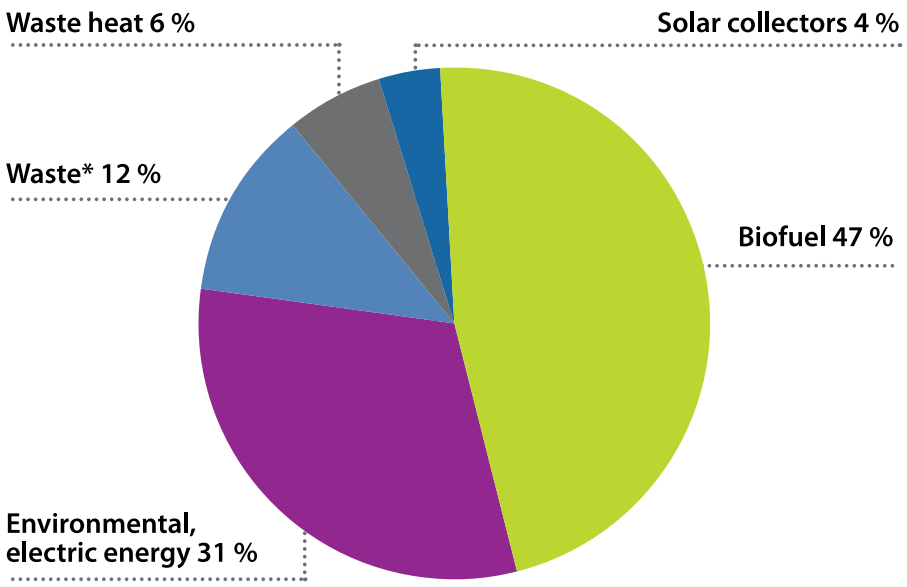
166. In implementing the decarbonization of the heat sector within the district heating (DH) sector, the following targets are aimed for: 166.1. DH final energy consumption: 9.9 TWh in 2030, 9.0 TWh in 2050; 166.2. Share of RES in DH: 90 percent in 2030, 100 percent in 2050.

167. It is estimated that biofuel production sources (both cogeneration and water heating boilers burning biofuels made from forest residues) will account for about 50 percent of the fuel structure used for heat production in 2050.

168. The installation of new production capacities is planned in DH systems, where a significant share of heat energy is currently produced using natural gas, and the entire heat demand cannot be met using DH electrification and RES-based technologies.

Figure 9. *Forecast of the fuel structure used in the district heating (DH) sector and the final energy (FE) demand for 2030 and 2050.*





2050 m. GES (9,0 TWh)

Note: The share of waste is indicated considering the maximum capacities of the waste incineration plants in Vilnius, Kaunas, and Klaipėda. No additional waste incineration capacities are planned.

Use of Biofuel

169. Biofuel is a strategically important energy resource for providing one of the most critical services – district heat supply to urban residents. It is in the state's interest to ensure a sufficient supply of biofuel, its sustainable use in energy production, low concentration levels in the Lithuanian biofuel market, an optimal balance between local biofuel production and biofuel imports from neighboring EU member states, and increased transparency in the biofuel market. This would provide reliable information on biofuel stocks in the country and more predictable information on biofuel supply.

170. The annual biofuel demand of the DH sector is 6–7 TWh, and according to the State Forestry Service, the actual potential supply of biofuel in Lithuania is 6 million m^3 per year (about 11 TWh), including imported raw materials. The theoretical potential of biofuel raw materials in Lithuania is about 11 million m^3 per year (about 20 TWh).

171. In 2022, 73.1 percent of district heat in Lithuania's DH sector was produced from RES (biomass and the RES portion in municipal waste). According to the 2022 Comprehensive National Heat and Cooling Potential Assessment Study, the annual decentralized household sector demand is about 7.4 TWh, of which 60 percent is biofuel (about 4.5 TWh).

172. In the future, the share of biomass in the fuel structure used by the DH sector is expected to decrease due to the development of other RES-based technologies. It is forecasted that by 2050,

biofuel will account for about 50 percent of the fuel structure used by the DH sector.

173. Households are among the most polluting in terms of air quality – the amount of particulate matter emitted from the use of biofuel is up to 10 times higher than in the DH sector. Heat production by old heat production equipment is inefficient – reaching only 50-60 percent (more than 95 percent in modernized high-capacity DH systems' heat production equipment).

174. The goal is for individual heating consumers to abandon inefficient biofuel use equipment in households, and for the DH sector to aim for all heat energy to be produced from biomass and other RES by 2050. The share of RES should be at least 90 percent by 2030, and 100 percent by 2050.

175. To achieve more efficient use of biofuel in households, it is necessary to:

175.1. Replace inefficient biomass and fossil fuel boilers with more efficient, RES-based heat production technologies or efficient biofuel boilers;

175.2. Implement efficient RES-based heat production technologies;

175.3. Limit the use of solid biofuel for space heating in densely populated areas to reduce damage caused by particulate matter;

175.4. Promote the implementation of RES technologies.

176. Widely used local biomass fuel not only increases energy independence and reduces fossil fuel use but also helps maintain energy price stability, avoids significant energy price spikes, and positively impacts the country's economy. One of the main goals is to increase the supply of sustainably produced local biofuel and ensure that as much local raw material as possible, especially forest residues, can be used for biofuel production.

177. The following principles will be adhered to in developing the sustainable use of biofuel:

177.1. Biofuel suppliers and producers must ensure that the biofuel used in Lithuania meets established sustainability criteria;

177.2. It is essential to ensure that biofuel production follows the cascading principle, using wood biomass for its highest economic and environmental added value according to established priority order – using biomass for biofuel only when it can no longer be used for wood products, reuse, or recycling;

177.3. If economically justified, replace worn-out biofuel boilers with cogeneration units or alternative RES technologies;

177.4. Increase transparency in the biofuel market, allowing for the assessment of biofuel stocks suitable for heat production in Lithuania, enabling more reliable demand and supply forecasting, and avoiding significant biofuel price spikes related to uncertainty over sufficient biofuel supply in the market.

178. In implementing the decarbonization of the heat sector, the following results are aimed for in the biofuel area:

178.1. By 2050, the share of RES in the DH sector – 100 percent (biomass – up to 50 percent), and the share of RES in the decentralized heat energy supply sector – 100 percent (biomass – up to 30 percent);

178.2. The supply of local, sustainability criteria-compliant biofuel meets demand, with fluctuations in imported biofuel quantities not affecting market participants and not creating a biofuel deficit or surplus;

178.3. A consistent reduction in the use of biofuel in the DH sector, replacing it with other RES-based technologies that would cover 30 to 50 percent of the annual DH demand;

178.4. Reduced damage caused by emitted particulate matter and final energy consumption by abandoning inefficient biofuel use in households.

Decarbonization of the Transport Sector

179. In 2022, the energy consumed by the transport sector accounted for 40 percent of the total final energy consumption in the country. Of the energy consumed in the transport sector, 92 percent was consumed by road transport. The share of RES in the energy consumed by the transport sector has steadily increased and accounted for 6.28 percent in 2022, with the majority being liquid biofuels.

180. The goal is for the transport sector to transition to non-polluting modes of transport, efficiently use RES production capacities to ensure the supply of domestically produced electricity to the transport sector. One of the key principles of decarbonizing the transport sector is the effective integration of alternative fuels, ensuring a neutral technological impact of energy combinations. The transport sector should use various types of fuels adapted to different transport categories: light transport, public transport, heavy freight transport, maritime and air transport. All available alternative fuels, including biofuels, advanced biofuels, biomethane, electricity, and non-biological fuels from RES, should be utilized in the energy mix of the transport sector.

181. To achieve the decarbonization of the transport sector, it is important to increase the share of RES in its final energy consumption balance and reduce its GHG emissions, ensuring that the energy required by the transport sector is produced domestically, thereby reducing the sector's dependence on imported fossil fuels.

182. The main indicators for achieving the decarbonization of the transport sector:

182.1. The share of RES in the final energy consumption of the transport sector should be at least 15.8 percent by 2030 and at least 90 percent by 2050;

182.2. The total share of biogas and non-biological liquid and gaseous fuels from RES, compared to the final energy consumption of the transport sector, should be at least 5.5 percent by 2030;

182.3. GHG emissions in the transport sector should be reduced by at least 14 percent by 2030 and by at least 90 percent by 2050 compared to 2005;

182.4. The total number of electric and non-biological fuel vehicles from RES in the country should be at least 15 percent by 2030, and the number of alternative fuel vehicles should be at least 80 percent of the total vehicle fleet by 2050;

182.5. The number of publicly accessible charging points should be at least 6,000 units by 2030.

183. The decarbonization of the transport sector will be promoted in the following directions:

183.1. Consistently expanding the charging and alternative fuel refueling infrastructure, ensuring effective planning principles that would allow for the coordinated implementation of energy and transport investments, including the capacities of state-owned infrastructure companies;

183.2. Developing the electricity grid infrastructure considering the growth rate of electric vehicles and the impact of electricity consumption on the electricity grid infrastructure, ensuring the pre-adaptation of the electricity grid infrastructure to the needs of private and publicly accessible charging infrastructure development;

183.3. Special attention to the charging and refueling infrastructure for heavy road transport, installed near highways and main transport and logistics centers;

183.4. Planning smart charging infrastructure solutions that allow for the flexible charging of electric vehicles and participation in electricity demand aggregation service markets, using the integration solutions of electric vehicle batteries and charging points;

183.5. Integrating electric vehicles into the electricity system and smart city concepts;

183.6. Creating favorable conditions for acquiring electric and non-biological fuel vehicles from RES;

183.7. Enabling residents to charge electric vehicles in residential areas or nearby, as well as at workplaces, companies, institutions, and service centers;

183.8. Increasing consumer awareness of non-polluting vehicles, their economic and environmental benefits;

183.9. Increasing the development of RES electricity production capacities to ensure the energy needs of electric vehicles and non-biological fuels from RES;

183.10. Ensuring the expansion and renewal of the public transport fleet to utilize domestically produced energy resources – electricity, hydrogen, biomethane, and non-biological fuels from RES;

183.11. Ensuring the use of domestically produced energy resources – electricity, non-biological fuels from RES, and biomethane – in heavy transport, shipping, and aviation, considering the maturity of technologies in each sector;

183.12. Reducing the share of fossil fuels in sold fuels by gradually increasing the supply requirements of advanced biofuels and non-biological fuels from RES;

183.13. Monitoring the compliance of biofuels and non-biological fuels from RES with sustainability and GHG emission reduction criteria.

SECTION III
TRANSITION TO AN ELECTRICITY ECONOMY AND DEVELOPMENT OF A HIGH VALUE-ADDED ENERGY INDUSTRY

184. The third strategic goal of Lithuania's energy sector is the transition to an electricity economy and the development of a high value-added energy industry.

185. In the Strategy, the energy industry is understood as the activities of companies operating in the energy sector, which include the production or transportation of one of the types of energy or energy resources – electricity, nuclear energy, heat energy, cooling energy, renewable energy, hydrogen, and its derivatives – as well as the provision of related services and the development and production of energy technologies.

186. Ongoing energy changes are creating new demand for energy products produced using climate-neutral technologies – electricity from RES, hydrogen produced from RES, and captured carbon dioxide, which during the transition period to a climate-neutral economy can be both fossil-based and biogenic. From 2036, fossil-based carbon dioxide, if used for the production of renewable energy products, and from 2041, if carbon dioxide is captured from industrial processes, will no longer be considered a sustainable usage solution. Using these raw materials, it is possible to produce hydrogen derivatives: methanol, ammonia, synthetic methane, aviation kerosene, and other synthetic green fuels. Until now, these products have been produced using fossil fuels, but as the world transitions to climate-neutral alternatives, hydrogen derivatives are becoming a sought-after commodity.

187. Lithuania has the opportunity and conditions to leverage ongoing energy changes and stimulate the creation of a new energy industry. The rapid development of RES production facilities, carbon dioxide capture potential, and developed energy infrastructure create favorable conditions for the development of hydrogen derivative production in Lithuania.

188. The availability and supply of electricity from RES, along with the consistent development of energy infrastructure, also create conditions to attract energy-intensive industries and service providers to Lithuania: manufacturers of electricity storage devices, fuel cells, heat pumps, data centers, wind and solar energy plants, or their components.

189. Attracting producers of hydrogen derivatives, energy-intensive industries, and service providers to Lithuania could significantly contribute to the growth of Lithuania's economic well-being, further stimulate the development of RES production facilities, and ensure the return on investments in

energy infrastructure. The development of a high value-added industry would also ensure that the energy created in Lithuania generates maximum added value for the country's economy, thus prioritizing the export of hydrogen derivatives over electricity, as long as it is economically beneficial for Lithuania.

190. To transition to an electricity economy and promote the development of a high value-added energy industry, the following tasks are planned:

190.1. Creation and consistent development of a carbon dioxide capture and utilization value chain;

190.2. Production of new energy products and their export possibilities – creating favorable conditions and promotion;

190.3. Development of the national industry and attraction of high value-added industries. In expanding or modernizing the local industry, creating favorable conditions to flexibly use electricity, hydrogen, and its derivatives, and ensuring favorable conditions to attract energy-intensive, high value-added, sustainable industries and service providers to Lithuania.

The essential conditions, assumptions, and directions for the tasks implementing the goal of transitioning to an electricity economy and creating a high value-added energy industry are indicated in points 191-214 of the Strategy.

Creation and Consistent Development of the Carbon Dioxide Capture and Utilization Value Chain

191. Based on the data from the 2020 reports submitted by operators participating in the EU Emissions Trading System (ETS), the main pollution sources in Lithuania, emitting the largest amounts of greenhouse gases (GHG) into the atmosphere annually, were the fertilizer production industry (2.5 million tons of CO2 equivalent), the oil refining industry (1.5 million tons of CO2 equivalent), the cement production industry (0.9 million tons of CO2 equivalent, of which 16,000 tons were biogenic carbon dioxide), the DH sector, and manufacturing and industrial enterprises (4.7 million tons of CO2 equivalent, of which 3.4 million tons were biogenic carbon dioxide). The biogenic carbon dioxide emitted by all these sectors amounted to 3.5 million tons, or about 36 percent of the total GHG emissions from companies participating in the EU ETS.

192. It is forecasted that by 2050, the carbon dioxide emissions from the largest companies participating in the ETS could reach 1 million tons of fossil-based carbon dioxide and 0.6 million tons of biogenic carbon dioxide. Installing carbon dioxide capture equipment in these companies would create more favorable economic conditions when the equipment is used simultaneously to capture carbon dioxide of various origins.

193. In addition to the waste incineration sector, large sources of biogenic carbon dioxide in Lithuania

include the biogas production and biofuel combustion sectors. Biogenic carbon dioxide can also be released during ethanol production.

194. Biogas production is rapidly developing in Lithuania. The goal is for biogas production in Lithuania to reach 1.4 TWh by 2030 and 3.4 TWh by 2040. If carbon dioxide capture equipment were installed at all biogas production sites, about 0.19 million tons of biogenic carbon dioxide could be captured from total biogas production by 2030, and about 0.45 million tons per year by 2040.

Table 5. *Carbon Dioxide Capture Potential in Lithuania, million tons per year*

	2030	2040	2050
Forecast of fossil fuel carbon dioxide capture (carbon dioxide source – largest GHG emitting companies participating in the Lithuanian ETS)	0	2.4	1.0
Forecast of biogenic carbon dioxide capture (carbon dioxide source – biomethane production, waste incineration, biofuel production and/or use)	0.2	3.5	2.4 – 3.5

Note. *The biogenic carbon dioxide capture potential in 2050 may decrease if heating networks are electrified and/or heat producers decide to electrify (a 40% reduction limit is indicated).*

195. In biofuel-burning facilities, biogenic carbon dioxide will account for about 2.3 million tons per year in the largest facilities during 2030-2040, and carbon dioxide from waste incineration facilities will account for 1.4 million tons per year, of which about 420,000 tons per year will be biogenic carbon dioxide.

196. It is reasonable to install carbon dioxide capture equipment in companies that, due to their specific production processes, cannot achieve climate neutrality targets and have no other decarbonization options, as well as in the largest biofuel and waste incineration facilities, and in areas where several sources of biogenic carbon dioxide are concentrated, if it is financially viable.

197. If it is not possible to ensure the reduction of carbon dioxide emissions, a climate-neutral economy and zero carbon dioxide emissions on a national scale can be achieved by promoting negative emissions, compensating for emitted GHGs in other ways, and promoting natural absorbers through forestry development or transporting captured biogenic and/or atmospheric carbon dioxide to be stored in geological structures and/or permanently "locked" in chemical compounds, such as in concrete products or other products.

198. If necessary, a carbon dioxide export terminal may be established in Lithuania. This terminal would enable reliable and efficient transportation of carbon dioxide collected in the region to its final storage locations offshore (outside Lithuanian territory).

199. Carbon dioxide will be transported by gas carriers, rail, and pipelines. The specific mode of transportation will depend on the quantity of captured carbon dioxide, distance, and economic and financial feasibility.

200. Biogenic carbon dioxide, derived from renewable sources, will be used to produce higher value-added products as raw materials in various industries, for the production of synthetic green fuels or other chemicals to meet Lithuania's needs and for export to other countries.

201. One of the most promising directions for the use of biogenic carbon dioxide is the production of synthetic green fuels (synthetic methane, methanol, aviation fuel, and synthetic diesel), reducing dependence on fossil fuels. The production of synthetic green fuels could be carried out in areas where there are suitable conditions for biogenic carbon dioxide capture.

202. The goal is that by 2050, companies that, due to their specific production processes, cannot achieve climate neutrality targets and have no other decarbonization options, will have their fossil-based carbon dioxide emissions equal to their captured carbon dioxide quantity. Promoting the development of a circular economy in the country and contributing to Lithuania's economic growth by developing high value-added products, the biogenic carbon dioxide captured during biogas production, biofuel use, or waste incineration would be used to produce innovative products, such as synthetic green fuels, in Lithuania.

203. Directions for promoting carbon dioxide capture:

203.1. Implementation of carbon dioxide capture technologies, prioritizing the capture of biogenic carbon dioxide from biogas production and biofuel and waste incineration facilities capable of capturing the most biogenic carbon dioxide;

203.2. Creation of carbon dioxide transportation infrastructure;

203.3. Creation and expansion of the carbon dioxide utilization market;

203.4. Encouragement of business and investment in carbon dioxide capture;

203.5. Dissemination of information and public awareness about carbon dioxide capture and utilization technologies and their benefits;

203.6. Technological innovations and scientific research aimed at effective and technologically mature carbon dioxide capture technologies;

203.7. Regional cooperation to create efficient carbon dioxide transportation infrastructure;

203.8. Creation of monitoring systems to accurately assess the effectiveness and efficiency of carbon dioxide capture, including data on the origin of carbon dioxide;

203.9. Creation of a regulatory and legal environment for the carbon dioxide capture value chain.

204. Stages of the carbon dioxide capture, transportation, storage, and utilization value chain:

204.1. By 2030, implement the first projects for the capture and utilization of biogenic carbon dioxide for the production of synthetic green fuels, prioritizing the biogas sector;

204.2. By 2040, implement the first projects for carbon dioxide capture in large biofuel and/or waste incineration facilities;

204.3. By 2050, ensure that companies that, due to their specific production processes, cannot

achieve climate neutrality targets and have no other decarbonization options, have their fossil-based carbon dioxide emissions equal to their captured carbon dioxide quantity (become climate-neutral companies);

204.4. Amount of captured biogenic carbon dioxide: 0.2 million tons in 2030 and 3.5 million tons in 2050.

205. To promote the capture of biogenic carbon dioxide from biogas production, biofuel, and waste incineration processes, it is proposed to create support mechanisms for the capture, transportation, and utilization of carbon dioxide for the production of synthetic green fuels. Such support mechanisms should encourage the use of biogenic carbon dioxide in the production of high value-added products – synthetic green fuels and other chemicals.

Production of New Energy Products and Their Export Opportunities

206. From the total amount of biogenic carbon dioxide expected to be captured in Lithuania by 2050, the following quantities of synthetic green fuels could be produced (selectively one of them):

206.1. About 2.5 million tons (14 TWh) of synthetic methanol, which would require about 0.5 million tons of hydrogen, and the electricity needed for hydrogen production and carbon dioxide capture would amount to about 30 TWh;

206.2. About 1.3 million tons (17 TWh) of synthetic methane, which would require about 0.5 million tons of hydrogen, and the electricity needed for hydrogen production and carbon dioxide capture would amount to about 30 TWh;

206.3. About 0.85 million tons (10 TWh) of synthetic aviation fuel and about 1 million tons (13 TWh) of synthetic diesel, which would require about 0.7 million tons of hydrogen, and the electricity needed for hydrogen production and carbon dioxide capture would amount to about 43 TWh.

207. The types of synthetic green fuels mentioned in point 206 of the Strategy would become an important economic and environmental element, aiming to diversify energy sources and reduce dependence on fossil fuels. Currently, it is unclear which types of synthetic green fuels will be most in demand and what specific green fuel needs will develop in the future. The development of green fuels is influenced by various factors: market trends, fuel production costs, the progress of scientific innovations, and competition with other types of alternative fuels.

208. Other hydrogen derivatives, such as ammonia, could also be produced in Lithuania, contributing to both national decarbonization goals and energy product exports.

209. Considering these forecasts, by 2030, Lithuania aims to produce at least 2 TWh of hydrogen derivatives, i.e., synthetic green fuels (which would require about 0.4 million tons of biogenic carbon dioxide), and by 2050 – at least 9 TWh. It is likely that about one-third of them could be used in Lithuania.

Development of the National Industry and Attraction of High Value-Added Industry

210. 210. The opportunities created by energy changes should be maximally utilized to promote the transition of the national industry to climate-neutral energy resources and create conditions for its further development. Favorable opportunities should be created to use RES electricity, hydrogen, and hydrogen derivatives, paying a competitive price for the energy resources produced in Lithuania.

211. 211. Considering the investments needed in infrastructure and equipment for energy changes, Lithuania will aim to create favorable conditions for domestic and foreign investments in the production of various next-generation energy sector equipment and their components, ensuring the establishment of high value-added energy industry enterprises and the economic growth of the country.

212. A favorable legal environment will be created, and investments in the development and production of these next-generation energy technologies will be encouraged:

212.1. Solar energy modules and related technologies;

212.2. Onshore and offshore wind power plants and their components;

212.3. Electricity storage devices and other energy storage facilities;

212.4. Electrolysis devices, hydrogen fuel cells, and other hydrogen production, transmission, and storage technologies;

212.5. Electricity grid technologies;

212.6. Hydrogen derivatives and non-biological fuels from RES;

212.7. Energy efficiency technologies.

213. To ensure the development of the next-generation energy value chain in Lithuania, favorable investment conditions will be created to develop energy-intensive, sustainable industries and services in Lithuania:

213.1. Sustainable biogas and biomethane production;

213.2. Hydrogen, hydrogen derivatives, and non-biological fuels from RES production;

213.3. Data centers;

213.4. The production of steel and its products using electricity and/or green hydrogen and other sustainable energy sources;

213.5. Defense industry.

214. By creating favorable conditions for energy-intensive industrial and service entities to establish and/or expand in Lithuania, equal conditions will be created for attracting foreign industrial and service companies, as well as for the expansion of local industry and services into new areas.

SECTION IV
ACCESSIBILITY OF ENERGY RESOURCES TO CONSUMERS

215. The fourth strategic goal of Lithuania's energy sector is the accessibility of energy resources to consumers.

216. Energy supply is considered one of the essential services that every person has the right to access. Individuals who do not have sufficient financial means to use this service must be provided with support measures. The spikes in energy prices and disruptions in energy supply have prompted EU member states to respond unitedly, better protect the EU wholesale energy market, and combat manipulation by strengthening the transparency of the wholesale energy market, supervision mechanisms, and creating conditions for market reform.

217. The decarbonization of the energy sector and the green transition must be carried out in a socially fair and inclusive manner, giving priority to supporting socially vulnerable households and consumers who will face the greatest difficulties due to this transition.

218. Implementing the goal of accessibility of energy resources to consumers should be based on the following principles:

218.1. Priority must be given to promoting energy efficiency: effective and targeted measures (which address the main causes of energy poverty), related to increasing energy efficiency, building renovation, modification of heating systems (considering the type of buildings), access to energy-efficient appliances and renewable energy, targeted measures to improve energy affordability (such as targeted income support, social tariffs, temporary support for households experiencing energy poverty), and ensuring that these measures do not promote inefficient energy use;

218.2. Implementing smart energy metering systems that allow consumers to receive timely energy consumption data, manage their energy use, and benefit from the advancements in energy technologies and digitization;

218.3. It is important to conduct more active information campaigns related to energy efficiency, targeting households experiencing energy poverty to ensure that these groups receive information and consultations tailored specifically for them, utilizing all available consultation networks and one-stop centers.

219. The accessibility of energy resources to consumers will be pursued through the following tasks: 219.1. Promoting the development of prosumers and active consumers; 219.2. Reducing the number of households experiencing energy poverty and promoting the development of community energy; 219.3. Ensuring energy price competitiveness and market competitiveness to protect consumers from energy price spikes and increase overall national resilience; 219.4. Promoting demand-side management in the electricity system flexibility and balancing service markets.

220. The essential conditions, assumptions, and directions for the tasks implementing the goal of accessibility of energy resources to consumers are indicated in points 221–238 of the Strategy.

Development of Prosumers and Active Consumers

221. To encourage the active participation of electricity consumers in the energy market and increase the share of RES in the electricity sector, Lithuania has created and operates a legal framework for prosumers and active consumers.

222. As of January 2024, the number of prosumers and the capacity of their installed power plants continued to grow exponentially. The number of prosumers, compared to 2022, doubled to 92,224, and the installed capacity of their power plants more than doubled to 982.2 MW. Accordingly, 60,297 prosumers produced electricity at the consumption site, and 31,927 prosumers produced electricity in power plants located away from the consumption site. The total number of prosumers reached 5.5 percent compared to the total number of electricity consumers.

223. To ensure sustainable development of prosumers, it is necessary to adhere to the following directions:

223.1. Improve the existing legal framework for prosumers to meet the changing needs and challenges of market participants, while ensuring that conditions for household consumers are not worsened;

223.2. Encourage prosumers to produce as much electricity as they consume, considering their individual needs;

223.3. Promote the autonomy of prosumers (e.g., acquiring equipment that allows the consumer to ensure electricity supply during power grid disruptions);

223.4. Along with the development of prosumers, create conditions for the development of energy storage capacities, which will help reduce energy price fluctuations.

224. The aim is to promote the activities of active consumers in the electricity sector by creating an encouraging regulatory environment, providing financial support for the acquisition of energy storage devices, and creating additional platforms necessary for the activities of active consumers. By creating consumer-to-consumer electricity trading and electricity sharing registration platforms and establishing their operating principles, a more attractive access to standard electricity demand change (regulating load) and electricity system flexibility services and electricity sharing opportunities will be created. Active consumers could easily sell the electricity they produce but do not use and/or share it.

225. The main directions for promoting active consumers:

225.1. Publicize the emergence of new opportunities for active consumers, enabling them to adjust their consumption habits according to electricity market signals and benefit from

lower electricity prices or other financial advantages; ensure comprehensive dissemination of information and personalized consultations about becoming active consumers, opportunities for active consumer participation in the electricity market, including electricity production by various electrical devices, such as plug-in PV technologies connected to general needs or apartment inlets, storage, sale, and participation in providing electricity system flexibility or additional services, including electricity system balancing;

225.2. Establish new regulations that set standard rights and obligations for active consumers and other electricity market participants when sharing surplus electricity, e.g., on peer-to-peer trading platforms. Evaluate the possibility of setting incentive fees and tariffs for the use of electricity grids for active consumers.

226. The goal is to have at least 300,000 prosumers and active consumers (including community energy participants) by 2030.

Development of Community Energy

227. Energy communities (AIEB and PEB, hereafter referred to as energy communities) encourage citizens to be more active in the energy sector and contribute to the transformation of the energy sector. The involvement of residents in creating energy communities also helps to increase public acceptance of RES projects and facilitates the attraction of private investment in the transition to green energy. Energy communities can provide direct benefits to residents by improving their energy efficiency and reducing their electricity bills.

228. Active consumer participation in the energy market, reducing energy poverty, and ensuring that energy changes reach all residents of Lithuania equally are the main focuses of community energy.

229. Efforts will be made to help the public gather into energy communities, strengthen communication about the benefits of energy communities, and establish an attractive regulatory environment and guidelines on how these communities should operate.

230. In developing community energy, social goals will also be pursued, and conditions will be created for the most vulnerable groups of electricity consumers to access green energy.

231. Energy communities will be encouraged, with participants including municipalities and/or institutions or companies, and the main goal of these energy communities will be to reduce energy poverty in their area of operation. The main principle of the operation model of energy communities is that a certain portion of the capacity of a power plant installed or acquired by the energy community must be allocated to individuals experiencing energy poverty, thereby reducing their electricity bills.

232. The operating model of energy communities will help ensure greater local resilience to energy price spikes in the energy market. Residents, farmers, municipalities, and/or small and medium-sized businesses and other legal entities, by gathering together and jointly developing RES capacities,

can share the risks of RES development and take advantage of the opportunity to secure stable electricity prices in the future.

233. In developing energy communities, the following goals will be pursued:

233.1. By providing information about the processes of establishing energy communities and the benefits provided by energy communities, the aim is to encourage the public to contribute to energy independence by creating energy communities. It is planned that by 2030, the energy capacities owned or managed by energy communities on the basis of ownership or other legal grounds will constitute at least 1 percent of all electricity production capacities from RES operating in Lithuania, by 2040 – at least 3 percent, and by 2050 – at least 4 percent. To achieve this goal, it is necessary to improve the regulatory environment, reduce the administrative burden on establishing energy communities, and provide financial support to encourage the creation of these communities;

233.2. Achieving energy independence and reducing energy poverty goals in Lithuania through the development of community energy. By 2030, it is planned to achieve the following energy poverty reduction indicators: the share of households that allocate a significant portion of their income to energy expenses – 10 percent. By 2050, this share should not exceed 5 percent.

Ensuring Energy Resource Accessibility and Market Competitiveness

234. To protect consumers from energy price spikes and increase the overall resilience of the state in this area, a set of actions and support schemes will be created. These will include income support, tax benefits, energy-saving, and storage measures to help consumers and industry more effectively.

235. The accessibility of energy resources and market competitiveness will be ensured in the following directions:

235.1. Implementing structured direct price support schemes based on bilateral transactions concerning energy price differences, to incentivize new investments in electricity generated from non-fossil fuels to achieve the goals of reducing dependence on fossil fuels.

235.2. Ensuring that electricity suppliers implement and maintain adequate insurance strategies to limit the risks posed by wholesale electricity supply changes to the economic viability of their contracts with consumers while maintaining short-term market liquidity and considering potential energy price changes. Energy communities could also use risk insurance products.

235.3. Ensuring that electricity consumers have access to various offers from electricity suppliers and can conclude contracts according to their needs. Electricity suppliers should not unilaterally change the conditions until the end of such contracts. Regulations will be created to ensure that electricity suppliers offer both fixed-term electricity supply contracts

at a fixed price and dynamic electricity price contracts. The fixed-term electricity supply contract at a fixed price should guarantee the same conditions as those at the time of contract conclusion throughout the contract duration.

235.4. Creating a national set of statistical indicators and measures to identify and analyze energy poverty.

Demand Management in the Flexibility and Ancillary Service Markets of the Electricity System

236. The development of RES and increasing electricity consumption raise the need for energy storage, system flexibility, and ancillary services, including balancing services. It is planned that the flexibility sources of the electricity system will reach 8 GW by 2030, 17 GW by 2040, and 24 GW by 2050. Adapting the electricity system to variable and distributed RES generation and growing electricity consumption will play a crucial role in empowering consumers to provide demand response services, including electricity demand aggregation, energy storage, and RES management for flexibility and ancillary services, including balancing services. Digitalization of electricity transmission and distribution network management, metering, and consumption devices, and technological advancements provide opportunities for consumers to contribute to increased flexibility in the electricity system and gain financial benefits from it.

237. In the area of demand management for flexibility and ancillary services, including balancing services, in the electricity system markets, the goal is to create conditions and standardized products (solutions) that allow electricity consumers and other market participants in various energy sectors (natural gas, heating, etc.) to participate more intensively in providing flexibility and ancillary services, including balancing services, managing energy consumption and bills.

238. Ensuring demand management in the flexibility and ancillary services, including balancing services, markets of the electricity system is implemented in the following directions:

238.1. Establishing regulations that allow electricity market participants to provide standardized flexibility products (services) and ancillary services, including balancing services, more intensively.

238.2. Creating a flexibility register based on network codes developed by EU institutions to facilitate the registration and pre-qualification processes of market participants' devices.

238.3. Encouraging the implementation of additional flexibility capacities, incorporating technologies from the natural gas, heating, transportation, and other sectors.

238.4. Assessing the need for flexibility and ancillary services, including balancing services, in the electricity transmission and distribution networks and identifying the most cost-effective measures to meet these needs.

238.5. Initiating and implementing pilot projects for flexibility and ancillary services, including balancing services, and solutions based on scientific research and innovations.

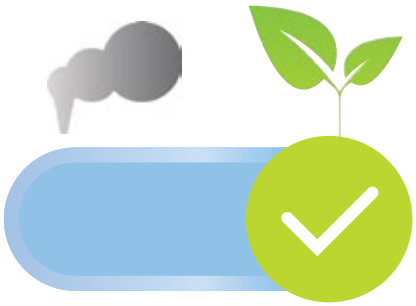
238.6. Establishing regulations that enable consumers to actively provide flexibility and ancillary services, including balancing services, such as demand response and energy storage, to manage their energy consumption and bills and provide more flexibility to the electricity system.

238.7. Encouraging investments in various flexibility measures: energy storage systems, technologies for supplying electricity from electric vehicles to the grid, hydro-pumping systems, as well as energy storage and conversion technologies (e.g., hydrogen and green synthetic fuel or other energy production, storage, and consumption technologies).

238.8. Promoting innovations and changes in different sectors: the integration of electricity and gas sectors (Power-to-Gas), integration of electricity and heating sectors (Power-to-Heat), implementation of smart metering systems, provision of flexibility and ancillary services, including balancing services, empowerment of active consumers, demand aggregators, and different aggregation models.

238.9. Promoting the implementation of various flexibility measures: in the short term, focusing on improving the legal framework for active consumers, energy communities, and aggregators. In the medium and long term, implementing energy storage systems, infrastructure for connecting electric vehicles to the grid, hydro-pumping systems, and energy conversion technologies (e.g., hydrogen and synthetic fuel technologies).

238.10. Applying smart tariffs (hourly billing based on electricity market prices) that encourage consumers to use electricity more smartly according to real-time electricity prices, creating a supply of flexible supply and usage contracts and incentives based on real-time energy prices. Tariffs should encourage distribution network operators to use flexibility services in further developing innovative solutions for optimizing existing electricity networks and purchasing flexibility services.



Chapter VII
ENABLING ENERGY TRANSITIONS

SECTION I
ENERGY EFFICIENCY IMPROVEMENT

239. Improving energy efficiency is one of the most important commitments of the EU and Lithuania. The obligations are set in the ambitious Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast). The directive aims to improve energy efficiency, save energy, reduce energy prices, play a crucial role in reducing GHG emissions, promote electrification, the use of hydrogen, alternative fuels and other technologies necessary for the green transition in buildings, transport and industry sectors. Even with the rapid growth of electricity generation from RES, ensuring energy efficiency can reduce the need for new energy generation capacities and related costs of RES electricity storage, transmission and distribution. Energy efficiency improvement reduces energy costs for consumers, contributes to lower energy bills and increases energy availability. It also promotes innovations and modern solutions that can be economically beneficial in the long term. Improving energy efficiency also makes better use of existing resources and reduces GHG emissions into the atmosphere. This enhances the security and efficiency of the energy system, reduces dependence on fossil fuel imports and energy sources from other countries, thus reducing vulnerability due to geopolitical events and energy price fluctuations.

240. In 2022, Lithuania consumed 73.4 TWh of primary energy and 62.7 TWh of final energy (excluding green hydrogen production and environmental energy). During the 2016-2021 period, primary energy consumption increased by 9.83 percent, final energy consumption by 10.96 percent, while the Gross Domestic Product (GDP) grew significantly more – by 44.39 percent.

241. In Lithuania, about 40 percent of final energy is consumed in the building sector, about 40 percent in the transport sector and about 20 percent in the industry sector. Considering this, these sectors have the greatest potential for improving energy efficiency.

242. Lithuania's energy efficiency targets, excluding green hydrogen production and environmental energy:

242.1. Final energy consumption will not exceed 51 TWh by 2030;

242.2. Final energy consumption will not exceed 46 TWh by 2040;

242.3. Final energy consumption will not exceed 42 TWh by 2050.

243. 243. Considering that the building, transport and industry sectors consume the most final energy in Lithuania and their potential for energy efficiency improvement, the main directions for improving energy efficiency are:

243.1. Promoting the renovation of multi-apartment residential and public buildings, applying the latest and most advanced building renovation methods, constructing new and nearly zero-energy buildings (A+ and higher energy performance classes), installing heat pumps in buildings for heating and cooling, efficient energy management in buildings, which includes building automation, remote control and efficient energy usage monitoring.

243.2. Improving energy efficiency in the industry sector by developing high value-added and energy-efficient industrial sectors, implementing and acquiring the latest and environmentally friendly technologies and equipment, increasing industrial electrification and decarbonization (using hydrogen and its derivatives in industry), promoting energy audits in industrial enterprises and implementing energy consumption monitoring and management systems (artificial intelligence, etc.).

243.3. Promoting the electrification of transport, especially seeking electrification solutions for heavy road and other types of transport, the use of electric vehicles and the expansion of their charging infrastructure, the integration of hydrogen and non-biological fuels from RES, adapting and expanding public and private charging and alternative fuel refueling infrastructure, electrification of railways, implementing sustainable urban mobility plans, renewing the transport fleet through green procurement and ensuring the necessary public procurement objectives in the transport sector, as well as renewing the urban and suburban public transport fleet, promoting the use of RES fuels and electric vehicles (replacing polluting buses with new non-polluting ones powered by electricity, hydrogen and biogas). Hydrogen and non-biological fuels from RES will be mainly used for heavy-duty vehicles, buses, maritime transport and aviation.

SECTION II
PREPARATION OF ENERGY SPECIALISTS FOR ENERGY TRANSITION

244. It is projected that by 2030, there will be a shortage of at least 2,500 employees in state-managed energy companies. The planned offshore wind farms will create around 1,300 new jobs. Considering

the prospects of this activity, the demand for specialists with higher education in energy, electrical, and automation engineering is growing in Lithuania. This growth is primarily driven by the ongoing transformation of the energy sector, including the increasing number of prosumers, synchronization of the energy system with the CEN, development of offshore wind farms in the Baltic Sea, implementation of hydrogen and carbon dioxide capture and storage technologies, and employee turnover due to the aging workforce in the energy sector. Notably, there is a shortage of nuclear energy specialists, driven by both the decommissioning of the Ignalina Nuclear Power Plant (IAE) and the management of radioactive waste, as well as the implementation of new MBR technologies.

245. The integration of specific energy resources (e.g., offshore wind energy, hydrogen, and carbon dioxide technologies) and the development of smart solutions will increase the demand for researchers, IT specialists, and engineers directly contributing to the green transformation of the energy and industrial sectors. The transformation of the energy and industrial sectors will also drive changes in other sectors integral to the production chains of these sectors. Measures focused on the expansion of biofuel in the electricity and heat sectors should increase employment and the need for specialists in agriculture, manufacturing, and service sectors in the long term. For example, the expansion of the biofuel sector primarily increases the demand for technical specialists (engineers, builders, plant operators, etc.) during the creation and operation of cogeneration capacities. This sector's expansion also increases the long-term demand for biofuel raw material specialists (biofuel growers, processors, transporters, etc.).

246. Measures aimed at increasing the potential of wind and solar energy production will not only increase the demand for specialists directly involved in the development of these RES but also contribute to the growing demand for specialists in sectors related to RES development (trade, services, manufacturing). The greatest demand is for IT experts, natural sciences specialists, electrical engineers, installers, and energy system maintenance specialists.

247. As the demand for specialists in the RES sector and related subsectors increases, there may be a skills mismatch in the labor market, which could slow down the economic transition to a less polluting economy. The need for retraining traditional energy sector specialists and preparing new specialists in the education and vocational training system will also increase.

248. The main directions for ensuring the preparation of energy specialists for the energy transition are:

248.1. Increasing the number of applicants to energy study programs. Firstly, it is necessary to assess the content of energy study programs in higher education institutions, the possibilities for participation in the educational process, and to identify the number and types of specialists (competencies) needed for the Lithuanian energy sector. For comprehensive energy competence development, integrated practical training will be conducted in general education schools (grades 4–8), followed by vocational and higher education institutions.

248.2. Improving the quality of energy studies and promoting professions needed in the energy sector. Based on the needs of energy sector companies, energy study programs (or their

modules) should be improved or new ones offered. To ensure the quality of energy studies, it is necessary to assess the transformation of the energy sector due to the use of RES (e.g., offshore wind, hydrogen synthetic gases, and fuels), digital innovations in energy, nuclear energy, and other development trends in Lithuania, energy demand, supply, including network infrastructure development plans, and technology development directions, among others.

249. Increasing the number of energy specialists and promoting the profession will aim for the following targets:

249.1. By 2030, at least 1,900 energy specialists will be trained (cumulative indicator);

249.2. By 2050, 100 percent of energy sector jobs requiring highly qualified specialists in Lithuania will be filled.

SECTION III
CREATION OF RESEARCH AND DEVELOPMENT, INNOVATION, AND ENERGY TECHNOLOGY DEVELOPMENT CENTERS

250. Research and experimental development conducted in Lithuania and the resulting products should be utilized domestically and become part of exports, thereby contributing to the country's economic growth. This requires focusing on priority research directions while ensuring the practical application of research results and existing and improved competencies in Lithuanian companies creating innovative products.

251. To promote research and development in the energy sector and increase business and academic collaboration, new energy technology development centers will be established. These centers will focus on demonstration projects, attracting national energy sector companies.

252. The main methodological axis of the energy technology development centers could be educational factories integrating various renewable energy and energy efficiency technologies, installing various energy sources such as energy storage devices and fuel cells, and implementing comprehensive building energy parameter monitoring and management systems. These centers would simulate real production processes based on educational models with real environments and direct access to production conditions.

253. Considering the specific needs and requirements of Lithuania's energy sector, the impact of future energy changes on the national economy, strategic goals, existing and desired competencies, and the innovations to be developed using energy technology development centers, the following priority research and development directions in energy are highlighted:

253.1. Developing competencies necessary for implementing and using new low GHG and air pollutant emission, climate change-resistant energy production and storage technologies (especially energy storage devices).

253.2. Technologies for energy production from local energy resources and RES.

253.3. Technologies for distributed energy production, smart grids, smart cities, and new prospective energy production and use technologies.

253.4. Development of a new technological generation of district heating and cooling systems using industrial-size heat pumps, waste heat, electrode boilers, and integration into other energy sectors.

253.5. Microreactors (MBR) as a potential additional stable electricity source to balance the Lithuanian energy system based on RES, decommissioning of nuclear energy facilities, and radioactive waste management.

253.6. Carbon dioxide capture, transportation, and utilization (including CO2 from non-fossil sources), especially in alternative fuel, cement, and fertilizer production industries.

253.7. Power-to-gas and gas-to-power technologies to help balance the energy system and facilitate sectoral integration.

253.8. Analysis of the operation of the electricity system and improvement of electricity system management.

253.9. Operation of electricity markets, capacity mechanisms, virtual power plants, demand response (including electric vehicle use), and active consumer involvement in electricity system and market operations.

253.10. Ensuring the reliability and quality of electricity supply, reducing the vulnerability of electricity systems, and optimizing operating modes.

253.11. Energy and cybersecurity, enhancing the reliability and resilience of energy facilities and systems to cyber threats.

254. To use the results of research and development in the energy sector in other areas, promote export growth, create new business types in the country, and develop innovative solutions, the following will be done:

254.1. By 2030, establish at least one energy technology development center in Lithuania.

254.2. Promote investments in the technological development and improvement of solar, wind, other RES, and higher value-added products (hydrogen, synthetic green fuels, synthetic methane, methanol, ammonia, aviation kerosene, and other products), and facilitate the implementation of pilot projects.

254.3. Establish Lithuania as the largest exporter of solar energy technologies and a competence center in the Baltic and Nordic regions.

254.4. Promote the production of energy storage technologies in Lithuania by attracting investments.

254.5. Evaluate opportunities for offshore wind energy technology production by attracting investments in the Klaipėda State Seaport.

254.6. Promote and test digital solutions in the energy sector in Lithuania to optimize the sector and encourage the export of such products.

255. To keep pace with global energy technology trends and the development of the EU energy system, Lithuania must actively contribute to the creation and implementation of the EU's joint research and innovation program „Horizon Europe", the EU Strategic Energy Technology Plan, the International Energy Agency's Technology Collaboration Program, and other international initiatives on energy transformation.

SECTION IV
PUBLIC ENGAGEMENT AND EDUCATION

256. In implementing the critical energy sector changes for Lithuania, transitioning to a climate-neutral economy, strengthening the country's resilience to external threats, developing the existing and attracting new high value-added energy industries, and promoting consumer activity, awareness, and engagement, a crucial success factor is public approval and support.

257. Decisions and choices by the public, based on knowledge and objective information, become responsible and considered. Therefore, it is especially important for state institutions, businesses, and project developers to focus on active and targeted social communication.

258. The following directions to promote public engagement and education are highlighted:

258.1. Proactively provide objective information and knowledge about ongoing energy projects and their benefits to the public, and encourage local community participation and involvement in planned and potential RES projects.

258.2. Strengthen cooperation and information exchange on climate change, renewable energy, and energy transformation issues between national authorities, municipalities, the public sector, businesses, and the public.

258.3. Promote public education projects aimed at familiarizing the public with new technologies and methods in the energy sector, their advantages, disadvantages, and importance, considering climate change.

258.4. Maintain transparency throughout the planning and lifecycle of all renewable energy projects, regularly providing new information, addressing emerging issues, and responding to public feedback.

SECTION VIII
IMPACT OF ENERGY CHANGES ON THE LITHUANIAN ECONOMY

259. Changes in the energy sector, the development of new RES production facilities, the creation of hydrogen and derivative hydrogen product production infrastructure, and the implementation of other goals and objectives outlined in the Strategy will significantly impact the Lithuanian economy and contribute to GDP growth.

260. The impact of energy transformation on employment and GDP changes was assessed in the study "Lithuania's Energy Vision Until 2050" based on the International Monetary Fund's research on the impact of green energy on jobs and other studies. The predicted impact of energy transformation on the Lithuanian economy was evaluated using the methodologies used in these studies, based on Lithuania's strategic energy goals and objectives.

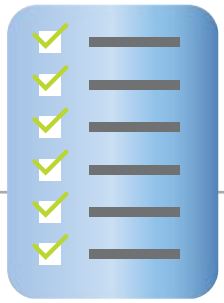
261. Optimistically, the implementation of changes in the energy sector by 2050 could create 140,000 new jobs, including direct (all jobs related to projects: design, production, construction, installation, management, maintenance, and other related work) and indirect (indirect impact on jobs includes all jobs related to the entire supply chain) job impacts. The impact on the Lithuanian economy could reach 6.3 billion euros during this period.

262. Pessimistically, by 2050, 44,000 new jobs could be created, and the impact on the Lithuanian economy would be 2 billion euros during this period, constituting 4 percent of Lithuania's GDP based on 2021 data.

263. Additional benefits are also anticipated due to significantly reduced (if MBR construction is planned, the need for energy resource imports will remain due to uranium imports) or completely

eliminated expenses for imported energy resources. Currently, about 6 billion euros per year is spent on energy resource imports, which could potentially be replaced by income from energy resource exports by 2050.

264. The impact of energy changes on the Lithuanian economy presented in this section is indicative, based on study results, and should not be considered an exact forecast. The presented results are intended for general evaluation and comparison with the planned impact of energy transformation on the economies of other countries. Additional specialized studies on the impact of energy changes on the Lithuanian economy should be conducted in the future.



SECTION IX
IMPLEMENTATION AND ACCOUNTABILITY OF THE STRATEGY

265. The goals and objectives set in the Strategy for the period 2024–2030 will be pursued by implementing the NEKSVP, in compliance with the requirements of the European Parliament and Council Regulation (EU) 2018/1999 of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU, and 2013/30/EU, Council Directive 2009/119/EC, and (EU) 2015/652, and repealing Regulation (EU) No 525/2013, as amended.

266. The implementation of the Strategy is funded by the state budget of the Republic of Lithuania, municipal budgets, the EU, international organizations, the private sector, and other sources. Special attention is given to the following funding sources: the Economic Recovery and Resilience Facility, the European Regional Development Fund, the Modernization Fund, the Cohesion Fund, the Just Transition Fund, the "Horizon Europe" program, the EU Innovation Fund's European Hydrogen Bank auctions, and financing opportunities from the European Investment Bank.

267. The achievement of the goals and objectives set out in the Strategy will be assessed through the monitoring of NEKSVP implementation, conducted in accordance with the provisions of Regulation (EU) 2018/1999, as well as the Strategy's impact indicators presented in Annex 2 of the Strategy. Monitoring is carried out and reports are prepared by the Lithuanian Energy Agency.

268. The Strategy is updated for the first time in 2030 and subsequently at least once every 5 years, taking into account the state's commitments in the field of climate change management, changes in the energy sector, the results of the implementation of existing objectives, and the latest trends in the energy sector.

SCHEME OF THE NATIONAL AGENDA „NATIONAL ENERGY INDEPENDENCE STRATEGY"

NATIONAL AGENDA "NATIONAL ENERGY INDEPENDENCE STRATEGY" IMPACT INDICATORS FOR 2024-2050

No.	Impact Indicators	Initial Value 2022	Target Value 2030	Target Value 2040	Target Value 2050	Data Providing Entity
1.	Energy dependency index, %	73	55	40	30	2022 Lithuanian Energy System Transformation Study; 2030, 2040, 2050 - Public Institution Lithuanian Energy Agency
2.	Energy demand (for energy and non-energy needs), TWh	93	88	81	75	2022 Lithuanian Energy System Transformation Study; 2030, 2040, 2050 - Public Institution Lithuanian Energy Agency
3.	Electricity production, TWh	5.66 (2023)	25	54	74	LITGRID AB
4.	Installed capacity of onshore wind power plants, GW	1.288 (2024)	4.5	6.5	10	LITGRID AB
5.	Installed capacity of offshore wind power plants, GW	0	1.4	2.8	4.5	LITGRID AB
6.	Installed capacity of solar power plants, GW	1.165 (2024)	4.1	7	9	LITGRID AB
7.	Installed capacity of reliably accessible power plants, GW	1	1.5	1.5	2	LITGRID AB

8.	Installed capacity of hydroelectric power plants, GW	0.129 (2024)	0.129	0.129	0.129	LITGRID AB
9.	Installed capacity of pumped storage power plants, GW	0.9 (2024)	1.01	1.01	1.01	LITGRID AB
10.	Installed capacity of electricity storage devices (batteries), GW	0.2 (2023)	1.5	2	4	LITGRID AB
11.	Devices ensuring flexibility of the electricity system (including intersystem electric connections), GW	4.96	9.522	18.225	29.71	LITGRID AB, Public Institution Lithuanian Energy Agency
12.	Total electricity consumption, TWh	11.83 (2023)	24	48	74	LITGRID AB
13.	Installed capacity of hydrogen production (electrolysis), GW	0	1.3	5.5	8.5	Public Institution Lithuanian Energy Agency
14.	Amount of green hydrogen produced, TWh	0	4.3	13.8	24.2	Public Institution Lithuanian Energy Agency
15.	Production volume of derived green hydrogen products, TWh	0	2	5	9	Public Institution Lithuanian Energy Agency
16.	Share of electric transport in the vehicle fleet, %	0.69	15	60	80	State Enterprise "Regitra"
17.	Amount of biogas produced, TWh	0.047 (2023)	1.4	3.4	3.4	AB "Amber Grid"
18.	Amount of collected biogenic carbon dioxide, mln. t	0	0.2	3.5	3.5	Public Institution Lithuanian Energy Agency
19.	Amount of greenhouse gas emissions (in the energy and transport sectors), mln. t	11.7	7.8	3.4	0.1	Environmental Protection Agency
20.	Share of renewable energy sources (RES) compared to total final energy consumption, %	29.62	55	85	95	State Data Agency
21.	Share of RES compared to total final electricity consumption, %	25.50	100	100	100	State Data Agency

22.	Share of RES for heating and cooling compared to final energy consumption, %	57.6	80	90	100	State Data Agency
23.	Share of RES for individual heating and cooling users compared to final energy consumption, %	49.3 (2020)	75	85	100	Studies on heating and cooling demand in Lithuania commissioned by the Ministry of Energy of the Republic of Lithuania
24.	Share of RES in the district heating sector compared to final energy consumption, %	73.1	90	97	100	State Data Agency
25.	Share of RES in the transport sector compared to final energy consumption, %	6.28	15.8	75	90	State Data Agency
26.	Number of electricity users generating energy from RES and active electricity users, units	103,219 (2024)	300,000	-	-	AB "Energijos Skirstymo Operatorius"
27.	Renewable energy communities and citizen energy communities	0	1	3	4	AB "Energijos Skirstymo Operatorius"
28.	Share of households spending a large part of their income on energy, %	19.1 (2021)	10	5	3	State Data Agency
29.	Final energy consumption without green hydrogen production and environmental energy, TWh	62.7	51	46	42	State Data Agency

Lietuvos energetikos vizija 2050 m.
Savo poreikiams energiją pasigaminanti ir ją eksportuojanti valstybė, sukūrusi neutralaus poveikio klimatui ir aukštą pridėtinę vertę kuriančią energetikos pramonę

1. STRATEGINIS TIKSLAS Užtikrinti saugų ir patikimą energijos tiekimą visiems vartotojams	2. STRATEGINIS TIKSLAS 100 proc. neutralaus poveikio klimatui energijos Lietuvai ir regionui	3. STRATEGINIS TIKSLAS Perėjimas prie elektros ekonomikos ir aukštą pridėtinę vertę kuriančios energetikos pramonės vystymas	4. STRATEGINIS TIKSLAS Energijos išteklių prieinamumas vartotojams
Lietuvos energetikos strateginiai tikslai siekiami įgyvendinant šiuos uždavinius:			
1.1. Elektros energetikos sistemos sinchronizavimas su kontinentinės Europos elektros tinklais	2.1. Jūrinio vėjo elektrinių plėtra ir energetinio centro sukūrimas	3.1. Anglies dioksido surinkimo ir panaudojimo vertės grandinės sukūrimas bei vystymas	4.1. Gaminančių ir aktyviųjų vartotojų plėtros skatinimas
1.2. Elektros energetikos sistemos pajėgumų ir lankstumo užtikrinimas	2.2. AEI plėtros sausumos teritorijoje užtikrinimas	3.2. Palankių sąlygų sudarymas naujų energijos produktų gamybai ir eksportui	4.2. Bendruomeninės energetikos vystymas ir energijos nepriteklių patiriančių namų ūkių skaičiaus mažinimas
1.3. Elektros energijos perdavimo ir skirstymo infrastruktūros vystymas	2.3. Galimos branduolinės energetikos (saugių MBR) panaudojimo galimybių įvertinimas	3.3. Nacionalinės pramonės plėtros skatinimas ir aukštą pridėtinę vertę kuriančios pramonės pritraukimas	4.3. Energijos kainų ir rinkos konkurencingumo užtikrinimas
1.4. Gamtinių ir kitų dujų, naftos ir naftos produktų tiekimo užtikrinimas pereinamuoju į neutralaus poveikio klimatui ekonomiką laikotarpiu	2.4. Vandenilio energetikos ir išvestinių jo produktų vystymas		4.4. Paklausos valdymas elektros energetikos sistemos lankstumo ir papildomų paslaugų rinkose
1.5. Pasirengimas krizėms ir atsparios Lietuvos energetikos sektoriaus infrastruktūros užtikrinimas	2.5. Šilumos energijos sektoriaus priklausomybės nuo iškastinio kuro mažinimo ir vėsumos sektoriaus plėtros užtikrinimas		
	2.6. Transporto sektoriaus perėjimas prie netaršių, neutralaus poveikio klimatui transporto rūšių ir kuro		

Energetikos pokyčių įgalinimas

- Energijos vartojimo efektyvumo didinimas
- Energetikos specialistų pasirengimas energetikos transformacijai
- Moksliniai tyrimai ir eksperimentinė plėtra, inovacijos ir energetikos technologijų vystymo centrų sukūrimas
- Visuomenės įtraukimas ir švietimas

Strategijos įgyvendinimas

Nacionalinis energetikos ir klimato srities veiksmų planas (NEKSVP) 2021-2030 m.	Nacionalinis energetikos ir klimato srities veiksmų planas (NEKSVP) 2031-2040 m.	Nacionalinis energetikos ir klimato srities veiksmų planas (NEKSVP) 2041-2050 m.

MINISTRY OF ENERGY
OF THE REPUBLIC OF LITHUANIA