

20.09.2024

Carbon driven energy equilibrium at the municipal scale – Energy Equilibrium

Framework conditions for energy infrastructure in Latvia

RTU Institute of Energy Systems and Environment

Address: 12 – K1 Āzenes iela, Riga, Latvia, LV-1048

Phone: +371 67 089 923

dace.lauka@rtu.lv

Interreg
Baltic Sea Region



Co-funded by
the European Union



ENERGY TRANSITION

Energy Equilibrium



Table of contents

1	Assessment of Latvia's electricity generation capacity and consumption ..	3
1.1	Development to date	3
2	Energy Infrastructure	7
2.1	Organisation of Electricity Grid (Transmission Network)	7
2.2	Distribution System Operators (DSOs) in the Electricity Grid.....	8
2.3	Stakeholders Active in Energy Storage (Electricity)	8
2.4	Role of Local Authorities for Energy Storage (Connection to Electricity)	10
2.5	Role of Hydrogen and Power-to-X in Today's Energy (Electricity) System	11
2.6	Business Models for Energy (Electricity) Storage	12
2.7	Organisation of Other Storage.....	12
3	References	14

1 Assessment of Latvia's electricity generation capacity and consumption

1.1 Development to date

Latvia's energy system is made up of various forms of energy production, distribution, and consumption, with a major focus on hydropower and other renewable resources. Latvia produces a large amount of its electricity from renewable energy sources. The three main hydropower facilities on the Daugava River—Plavinas, Kegums, and Riga—account for a substantial amount of the nation's electricity production. The country is renowned for its considerable hydropower capacity. With plans to increase the share of wind and solar energy in the future, Latvia also uses biomass, wind, and solar energy to a lesser extent. Natural gas, which is mostly imported from nearby nations, helps bridge energy shortages, especially when hydropower output is low.

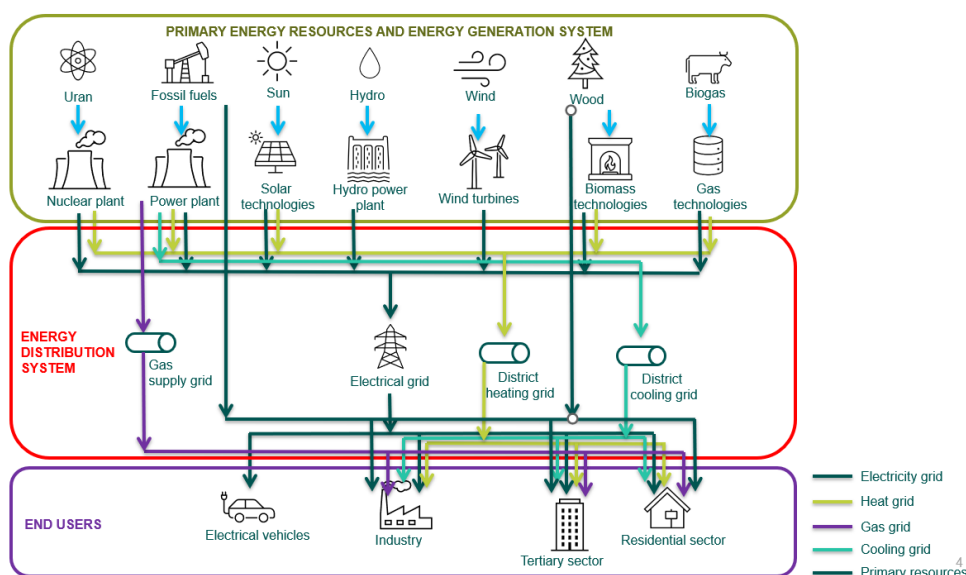


Fig.1. Energy system concept

Latvia has connections to both the wider European energy network and its Baltic neighbours, Estonia and Lithuania, making it possible to import and export electricity. Even though Latvia produces a sizable portion of its electricity domestically from renewable sources, particularly during the winter, it imports electricity to meet demand when local production is insufficient.

In Latvia, district heating systems are the main source of energy for the heating industry, particularly in urban areas where biomass plays a big part. To cut carbon emissions, a large number of district heating systems have shifted from using fossil fuels to biomass. Nonetheless, individual rural homes continue to heat with wood, coal, or imported natural gas.

With the intention of boosting the proportion of renewable energy in its overall energy mix and enhancing energy efficiency, Latvia is dedicated to the energy and climate goals set forth by the European Union. The nation's National Energy and Climate Plan (NECP), which focusses on grid modernisation, energy storage, and wind and solar development, lays out plans to meet higher renewable energy targets by 2030.

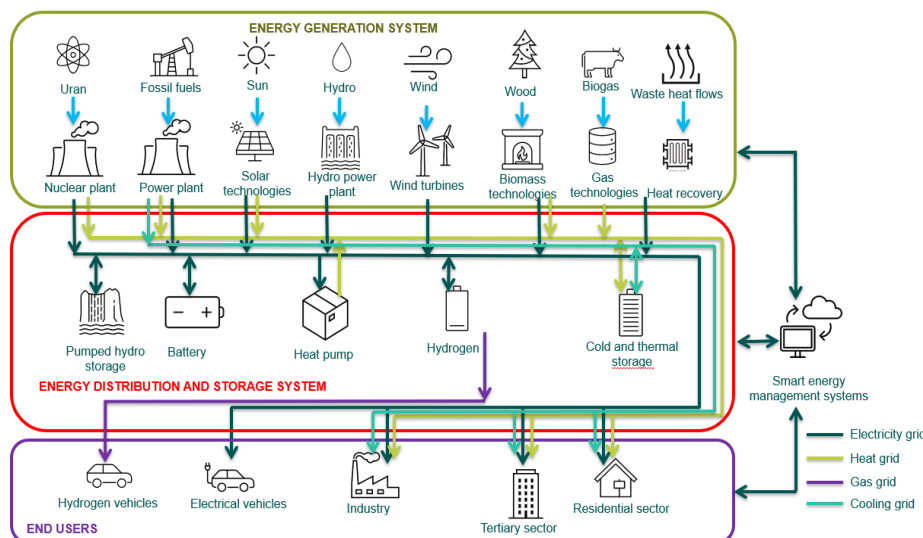


Fig. 2. Smart Energy System

Overall, efforts to strike a balance between energy security, affordability, and sustainability are continuing to move Latvia's energy system towards a more sustainable and renewable-based model.

The electricity generation capacities in Latvia from renewable energy sources are shown in Figure 3. The largest contribution to total electricity generation comes from the three existing Daugava hydro-electric power station cascades, which provide Latvia's base electricity capacity. Until 2021, the wind power generation capacity was only 70 MW, but in 2022 it increased to 136 MW, as a new wind farm was opened. A sharp increase in solar energy capacity was observed in 2022. As the geopolitical situation in Europe worsened, more and more residents began to think about individual energy independence. In addition, the state offered support for the installation of solar panels in households. As a result, Figure 3 shows that the total installed capacity of solar panels increased several times over.

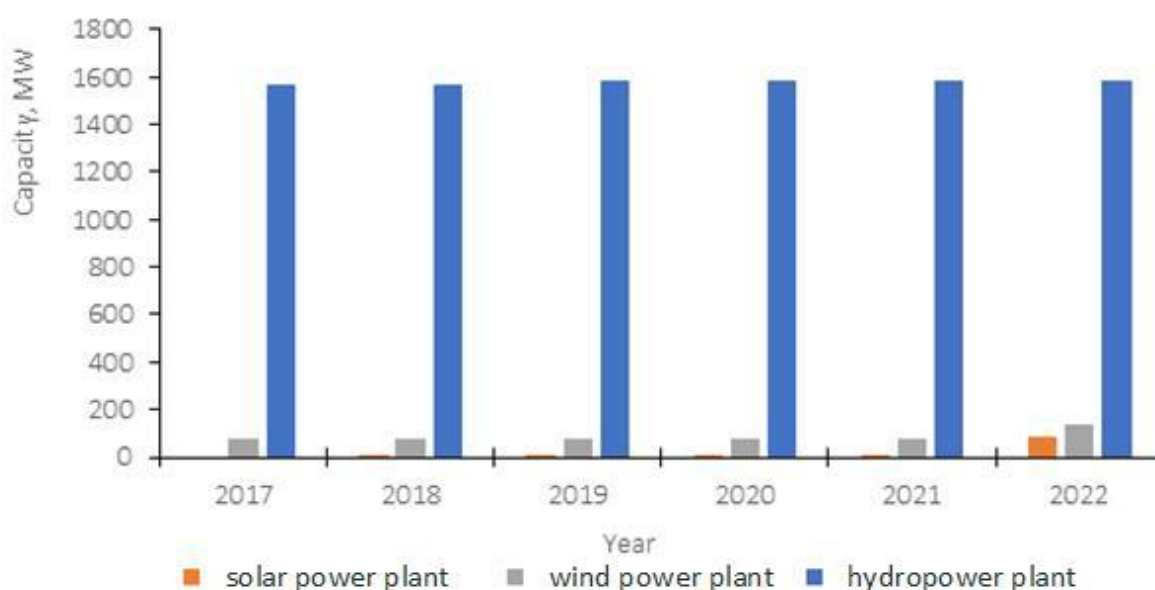


Fig.3. Latvia's renewable energy generation capacities from 2017 to 2022.

The amount of electricity generated from renewable energy sources is highly dependent on the season and weather conditions. Currently, the largest contribution to electricity generation comes from hydroelectric power plants (HPPs). As is known, the operation and output of HPPs depend on the severity of winter and the water inflow from the Daugava River. If there is no water, there is nothing to generate from, which means that in dry summers, the amount of electricity produced in Latvia is several times lower, while during the spring flood period, locally produced electricity fully meets the demand. Potentially, Latvia's electricity output from renewable energy sources could be increased by installing additional generation capacities for wind and solar power, which, as seen in Figure 4., are currently very small.

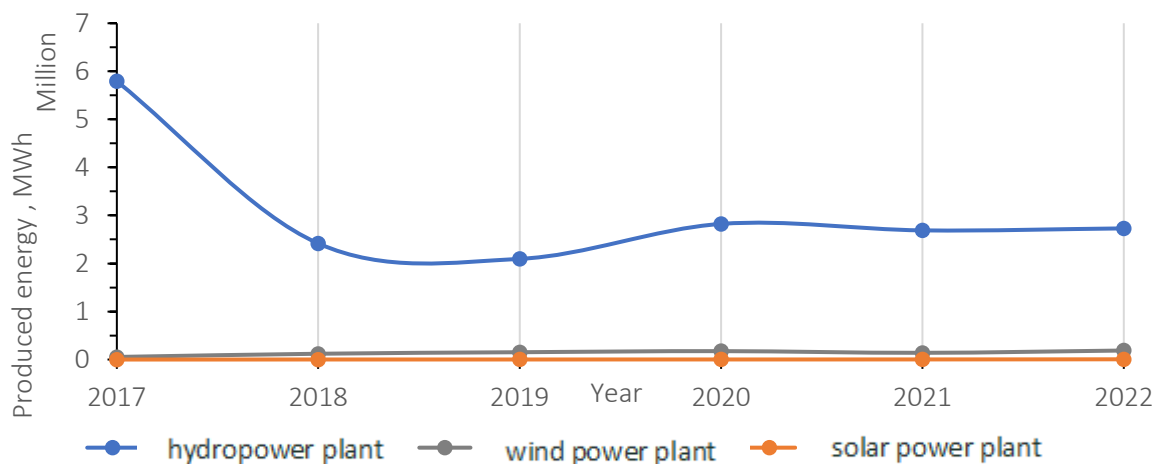


Fig.4. Electricity generated (MWh) by types of renewable energy sources (2017–2022).

Until now, Latvia has relied on electricity generated by hydroelectric power plants (HPPs), and the country's overall policy also included the development of thermal power plants (TPPs), as natural gas was a relatively cheap resource. It should be noted that electricity consumption increases every year, driven by the growing electrification of the world, which necessitates consideration of additional power capacity. In this regard, considering the climate neutrality goals, additional generation capacity can be obtained from renewable energy sources (RES).

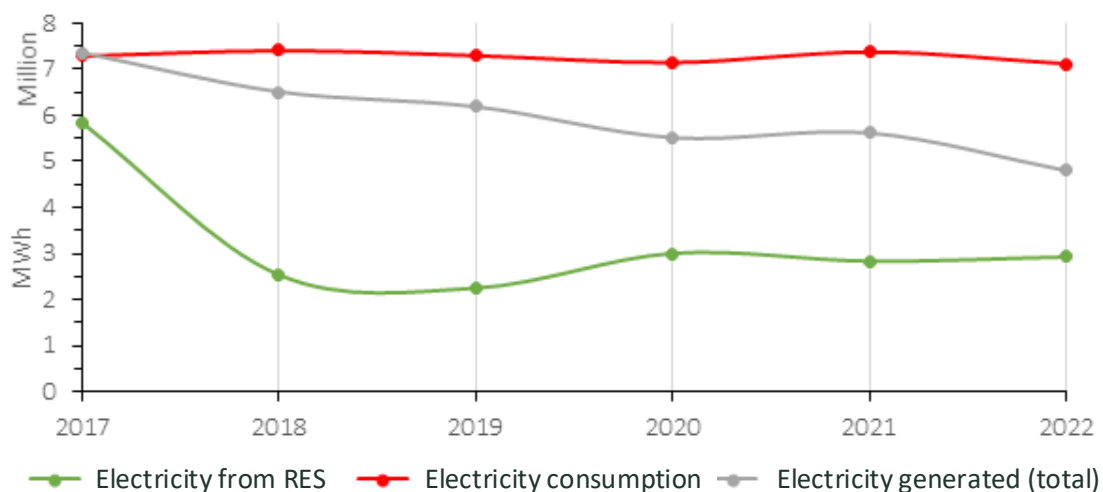


Fig.5. Total electricity generated in Latvia, from renewable energy sources, and total electricity consumption (2017–2022), MWh.

Figure 5. shows Latvia's total electricity consumption (MWh), total electricity produced, and electricity generated from RES (water, solar, wind). The year 2017 was rich in precipitation, which allowed more electricity to be produced from water resources at the Daugava HPPs, as the Daugava's water inflow was sufficient. A portion of the energy was produced by TPPs, even creating electricity surpluses—a positive balance. After 2017, the amount of electricity generated decreased, leading to a need for more imports. The graph in Figure 5 shows that approximately half of the electricity Latvia needs can be provided by RES, with additional volumes generated by TPPs, and the remaining difference imported.

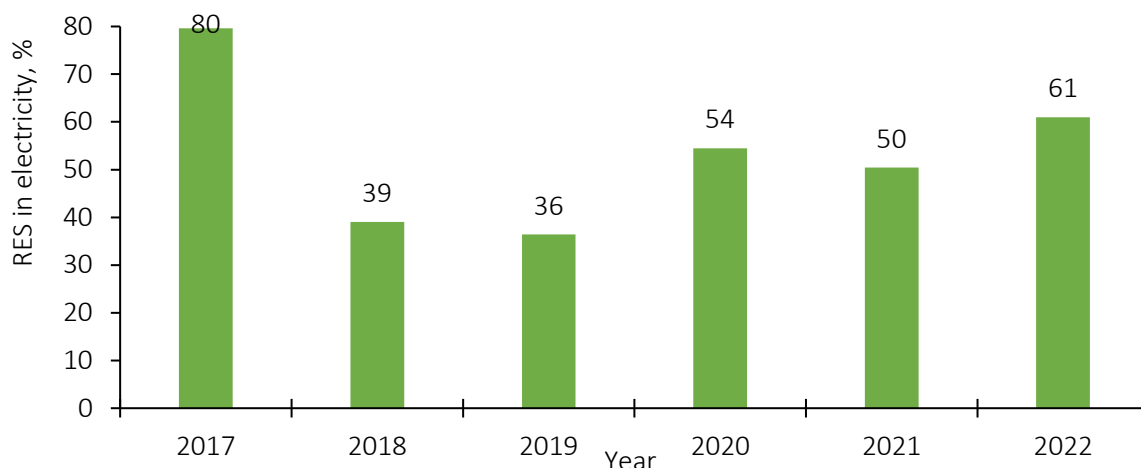


Fig.6. Share of renewable energy sources (RES) (%) in total electricity generation, 2017–2022

On average, depending on the season, which greatly affects electricity generation from renewable energy sources (RES), approximately 40 to 50 % of the total required electricity in Latvia is generated from RES (see Figure 6.).

2 Energy Infrastructure

2.1 Organisation of Electricity Grid (Transmission Network)

Latvia's electricity transmission network is overseen by Augstsprieguma tīkls (AST), which serves as the national electricity transmission system operator (TSO). AST is tasked with managing the high-voltage transmission grid to ensure a stable and secure electricity supply throughout the country. It also manages interconnections with neighbouring countries like Estonia, Lithuania and plays a role in the Baltic grid system.[1], [2]

The main characteristics of the transmission network are the number of step-down substations and high-voltage distribution points in each area, which in turn is determined by the specific electricity demand in that area. The network also includes appropriate transmission lines (330 kV and 110 kV), meeting both reliability and cost-efficiency criteria for electricity supply. Based on these criteria, the transmission network is considered near optimal with potential for further development. Currently, the electricity transmission network consists of 1,346.43 km of 330 kV lines and 3,893.54 km of 110 kV lines, along with 25 transformers at 330 kV and 248 transformers at 110 kV, with a total installed capacity of 9,020.5 MVA. For more efficient operation, the maintenance units are organized geographically: [20]

- 3 substation groups for the operation of 330/110 kV substations and distribution points: Salaspils, Krustpils, Daugavpils, Viskalī (Jelgava), Brocēni, Grobiņa, Valmiera, Gulbene, Rēzekne, Sloka, Ventspils, and in Riga – Right Coast and Left Coast, with one base substation in each group.
- 6 line districts for the operation of 330/110 kV transmission lines: Riga district, Krustpils district, Daugavpils district, Brocēni district, Grobiņa district, and Valmiera district.

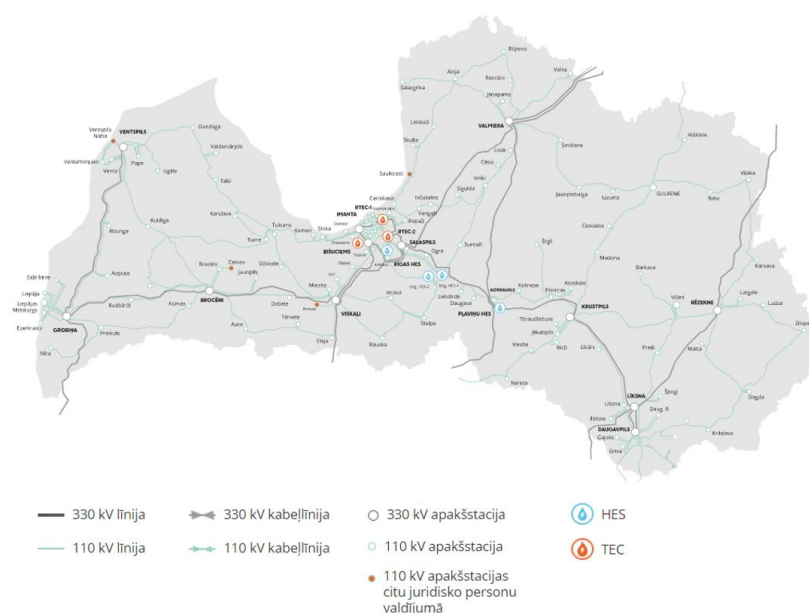


Fig.6. Diagram of Latvia's 330 kV and 110 kV Electrical Networks.

The 330 kV network in Latvia's energy system serves as the central link between the northern and

southern parts of the Baltic states' energy systems. All 330 kV substations, except "Daugavpils," have dual power supply. The 110 kV network follows a loop configuration. Most 110 kV substations are equipped with two transformers and have dual feeding.

To ensure the safe operation of Latvia's power system, the efficient functioning of the electricity market, and to address equipment aging, Latvia's Transmission System Operator (TSO) is reconstructing and modernizing high-voltage substations and electricity distribution points. In line with the energy system development trends in Latvia and neighboring countries, the TSO evaluates and makes decisions regarding the development of Latvia's transmission system interconnections and the need for internal network strengthening and modernization. The electricity transmission network is being developed according to Latvia's Transmission System Development Plan and the European Ten-Year Network Development Plan.

Between 2020 and 2029, the following projects will be implemented to develop the Latvian and Baltic electricity networks [20]:

- Third electricity interconnection between Latvia and Estonia;
- Transmission line connection "Riga TEC-2 – Riga HPP";
- Reconstruction of the existing 330 kV interconnections between Estonia and Latvia;
- Synchronization of the Baltic states with the European electricity grids and desynchronization from the Russian unified energy system.

2.2 Distribution System Operators (DSOs) in the Electricity Grid

In Latvia, the electricity grid is primarily managed by Sadales tīkls, the largest distribution system operator that serves 99% of the country's territory [2]. This company is in charge of the medium- and low-voltage electricity grids, ensuring that electricity is delivered from the high-voltage transmission grid to residential, commercial, and industrial consumers [3].

The transmission system operator Augstsprieguma tīkls is responsible for the development of the transmission network, the reliability of electricity transmission, the stability of the power system and the quality of electricity and ensures it in accordance with technical and economic requirements and modern technologies.

Adequate electricity transmission interconnections are one of the most important preconditions for the optimal functioning of the electricity market. The Latvian electricity market, like the Baltic energy market as a whole, is currently connected to the common European energy market by two sea cables connecting the Estonian and Finnish energy systems, Estlink I with a transmission capacity of 350 MW and Estlink II with a transmission capacity of 650 MW, the Lithuanian-Polish interconnector LitPol Link 1 with a transmission capacity of 500 MW and the Lithuanian-Swedish interconnector "NordBalt" with a transmission capacity of 700 MW. [21]

2.3 Stakeholders Active in Energy Storage (Electricity)

Both public and private energy companies, such as AST and Latvenergo, participate in the sector. Independent renewable energy producers are considering different ways to add energy storage to solar and wind generation.

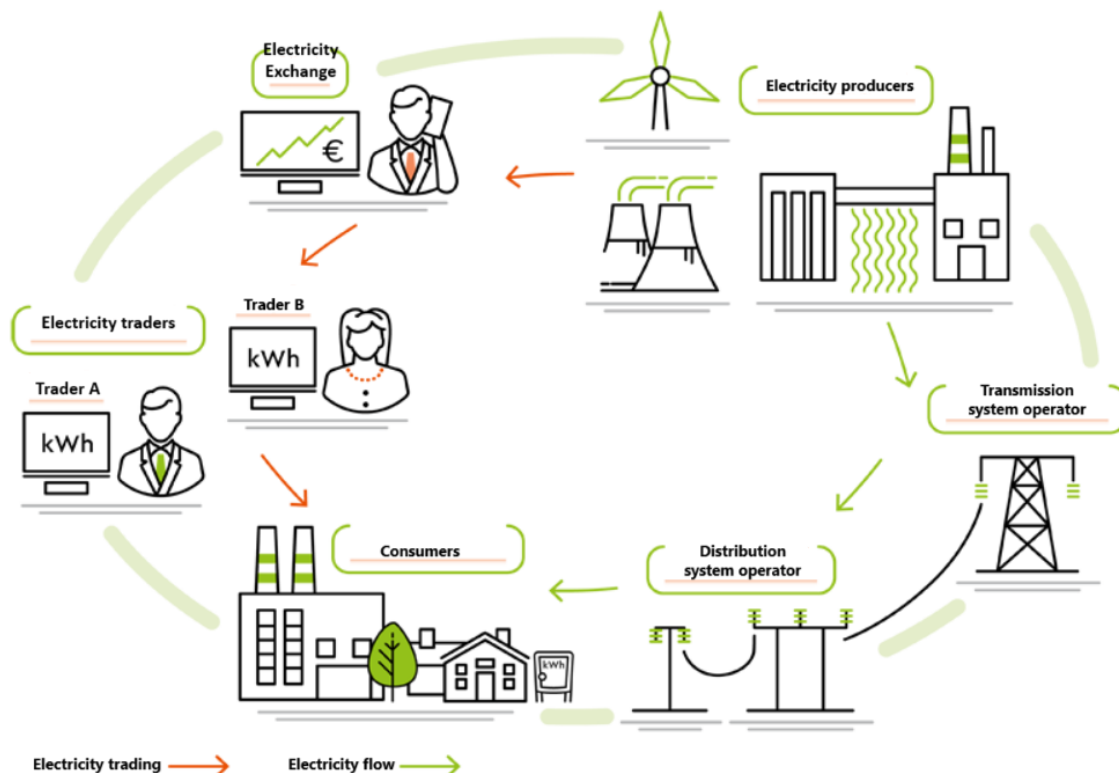


Fig.7. Interaction between electricity producers, traders and consumers

There are several companies in Latvia which sell electricity to market participants. In 2021, five largest electricity traders in the whole retail market by volume were JSC "Latvenergo", JSC "Enefit", JSC "Ignitis Latvija", JSC "Tet" and JSC "AJ Power".

The Latvian transmission system operator, JSC "Augstsprieguma tīkls," has signed agreements with 12 wind and solar power developers to connect renewable energy projects with a total capacity of over 1,100 megawatts (MW) to the transmission network. This exceeds the current installed solar and wind power capacity in Latvia by more than 150%. By the end of the year, it is expected that connection agreements with eight more renewable energy developers, with a combined capacity of 796 MW, will be finalized.

"Currently, the majority of electricity in Latvia is generated by hydroelectric power plants, but there is significant potential for wind and solar energy. The reserved capacity in the transmission network for renewable energy (RES) projects is 6 gigawatts (GW), and more connection agreements are being signed as power stations are being built. We anticipate that by the end of 2025, several solar power plants with a total installed capacity of over 500 MW will be connected." [22]

From the stations that have already signed transmission network connection agreements, 721 MW will be generated by solar power plants, 320 MW by wind power plants, and 60 MW by a hybrid project combining a solar power plant and an energy storage battery system. The largest planned solar power



plant, with a capacity of 199.8 MW, will be built in the South Kurzeme region near Cīrava, while the largest planned wind power plant, with a capacity of 158.8 MW, will be located near Lejasstrazdi in the Dobeles region.

Overall, eight power stations are expected to be connected to the transmission network next year, with the remaining four scheduled for 2026. By the end of 2025, the newly connected solar and wind power stations will have a capacity of 540 MW, with an additional 560 MW expected by 2026. In August, solar power plants generated 66 GWh, or 21% of the total electricity fed into the grid, marking the highest amount of solar energy production in Latvia's history, according to a market review prepared by AST.

Latvian transmission system operator Augstsprieguma tīkls (AST) and German company Rolls-Royce Solutions GmbH (Rolls-Royce) have started cooperation on the construction of Battery Energy Storage Systems (BESS), which are essential for the reliability of the Latvian power system. Rolls-Royce will install the battery system at the AST substations in Rezekne and Tume with a total capacity of 80 MW and a storage capacity of 160 MWh, currently one of the most powerful and largest battery systems in the European Union.[23]

2.4 Role of Local Authorities for Energy Storage (Connection to Electricity)

Local authorities in Latvia are increasingly involved in energy storage, especially in promoting decentralized renewable energy production and integrating storage solutions. Municipalities take charge of the planning and permitting processes for renewable energy and storage initiatives. They collaborate with private companies to set up small-scale energy storage systems within communities, which boosts local energy resilience and efficiency.

Local authorities play an important role in promoting regional development, which is why it is important to raise awareness of energy efficiency and climate change among local authority staff [5].

The strategic documents of the Latvian Association of Local Governments do not set a common target for the construction of electricity storage facilities, but the municipalities are interested in greater energy independence and economic development.

Heat storage

Article 2 of Energy Law provides that local governments, within the framework of their administrative spatial plan, may determine the development of heat supply and issue binding regulations, taking into account the regulations on the protection of the environment and cultural monuments, as well as the possibilities of utilization and cogeneration of local energy resources, and assess the security and long-term marginal costs of heat supply, which means that the application of the concept of heat energy storage highly depends on the local government of the respective area, but there is no precise regulation on heat energy storage. [6]

Regarding land use the regulations on municipal territorial development planning documents stipulate that each municipality develops its own Sustainable Development Strategy and indicates the expected land volumes for the creation and improvement of infrastructure [7].

2.5 Role of Hydrogen and Power-to-X in Today's Energy (Electricity) System

Hydrogen and Power-to-X technologies are still in the early stages within Latvia's energy system, yet they are seen as crucial components for future energy transition strategies. Additionally, Power-to-X, which involves converting electricity into other energy forms like hydrogen or methane, is being investigated to stabilize the grid and improve energy storage capabilities, particularly as the share of renewable energy continues to grow.

Hydrogen

To contribute to achieving climate and energy goals, Latvia is also exploring the potential of hydrogen. In addition to transport, Latvia is also exploring the potential of hydrogen in other sectors, such as electricity generation. As Latvia uses biomass extensively for heat and power generation, biomass-derived hydrogen is another potential way to harness this technology. However, hydrogen can be expensive to produce, store and distribute, especially if it is produced from renewable sources.[8] And still hydrogen is not mentioned in the Energy Law [9].

Concerning the possible utilization of hydrogen technology in Latvia, there have been public statements indicating that Jelgava is considering the production and storage of hydrogen. In May 2023, the Jelgava City Council and "Fortum" entered into a memorandum of intent, initiating collaborative research efforts to assess the technical aspects and economic viability of extracting and utilizing hydrogen. The objective is to enhance the transportation systems of Jelgava municipality companies in the future by incorporating green hydrogen electric buses and hydrogen electric waste removal vehicles, thereby achieving zero-emission operations. [10]

A study was launched in 2022 in collaboration with the Latvian Hydrogen Association to refine hydrogen project concepts and assess key indicators for its utilization in Latvia. The estimate suggests that by 2030, approximately two terawatt hours (TWh) of hydrogen will be consumed, with the figure rising to almost 37 TWh by 2050.[11]

JSC "Latvenergo" is actively working on implementing a pilot project focused on hydrogen and anticipates a growing interest among businesses and collaborative partners in Latvia to procure renewable hydrogen derived from sustainable resources. JSC "Latvenergo's" hydrogen initiative envisions the production of environmentally friendly hydrogen using a polymer electrolyte membrane electrolysis system, with electricity sourced from variable generation, the Daugava hydroelectric power plant, TEC-2 solar panels, or the planned JSC "Latvenergo" wind power plant.[11]

H2Value project is being implemented within the framework of the European Regional Development Fund's Interregional Innovation Investment Instrument (I3) program for the period 2021-2027, under grant agreement No. 101083881. It is a new financial instrument designed to support innovative investments, promote the economy through green technologies, and foster sustainability in the industry and transport sectors.[12]

The establishment of the Latvian Hydrogen Association in 2005 marked a commitment to advancing the adoption of the Hydrogen Economy within Latvia's economic landscape. The association's primary aim was to harness local natural energy resources and utilize hydrogen as a versatile energy carrier. By doing so, it sought to enable the smooth functioning of the energy, transportation, and

industrial sectors in the country while minimizing environmental impact. Additionally, the association sought to promote the adoption of eco-friendly energy consumption and production methods. [13]

In the summer of 2023, the association "Green and Smart Technology Cluster" together with 43 partners from Finland, Estonia, Lithuania, Latvia, Poland, Germany, Denmark, Sweden, France, and Norway will initiate the implementation of a five-year project called "BalticSeaH2" or "Baltic Sea Cross-Border Hydrogen Valley." The project aims to create the first and largest transnational hydrogen ecosystem in the region, transforming the energy circulation economy and promoting a faster transition to renewable energy production, storage, and utilization in Europe. The project is co-funded by the European Union's "Horizon Europe" program. The "Green and Smart Technology Cluster" and The Freeport of Riga represent Latvia in the project. [14]

There is an association called "H2 energokopiena" in Latvia. The main objective of the association is to establish unique public and private sector partnerships in the form of an energy community. The community is engaged in the production and storage of energy from renewable sources (electricity, heat energy, hydrogen, and other types of energy), as well as in trading, sharing, consumption, and accumulation of energy. Additionally, the association provides services such as charging/refueling of zero-emission vehicles, energy efficiency services, or other energy-related services.[15]

2.6 Business Models for Energy (Electricity) Storage

Latvia has recently been actively exploring and developing business models for energy storage, in particular electricity storage, in line with its renewable energy targets and the European energy transition goals. While a number of business models have been established in Latvia, the market is still evolving, and the regulatory framework and investment incentives are still being developed.

2.7 Organisation of Other Storage

There is a growing interest in developing biomethane storage solutions to ensure a reliable supply during peak demand periods. Latvia also has a comprehensive district heating system, especially in urban areas, where thermal storage is crucial for managing heating needs [16].

Biomethane

Over the next three years, Latvia plans to sell biomethane produced locally, and Latvijas Gāze plans to inject it into the national gas network [17].

The European Energy Efficiency Fund (EEEF) is working with Latvian energy company Virsi-A to finance and develop a biomethane plant in Latvia, which is scheduled to start operations at the end of 2025. The plant will use anaerobic digestion to convert agricultural manure into biomethane, which will then be fed into the Latvian national gas grid. The plant aims to produce 60 GWh of biomethane per year, effectively replacing up to 5.6 million cubic metres of natural gas. [18]

On 2 July 2024, the Latvian Cabinet of Ministers approved the REPowerEU Recovery Fund Support Programme, allocating EUR 134.4 million for energy investments to improve Latvia's energy security and stability. An ambitious part of the programme includes the construction of Latvia's first regional biomethane injection point in Džūkste, with a budget of €1.5 million. To support biomethane



production, Conexus Baltic Grid has developed a smart system that allows producers located far from the gas transmission grid to compress biomethane, transport it in mobile containers and inject it into the central grid. [19]

3 References

- [1] "BRIEFLY ABOUT THE GROUP - Latvenergo." Accessed: Sep. 12, 2024. [Online]. Available: <https://latvenergo.lv/en/par-mums/isuma-par-koncernu>
- [2] "Electricity | SPRK." Accessed: Sep. 12, 2024. [Online]. Available: <https://www.sprk.gov.lv/en/content/electricity>
- [3] "Par mums." Accessed: Sep. 12, 2024. [Online]. Available: <https://sadalestikls.lv/lv/kas-mes-esam>
- [4] P. Kurzweil and O. K. Dietlmeier, "Elektrochemische Speicher," Elektrochemische Speicher, 2015, doi: 10.1007/978-3-658-10900-4.
- [5] "Is the key role of local authorities acknowledged?"
- [6] "Enerģētikas likums." Accessed: Sep. 18, 2024. [Online]. Available: <https://likumi.lv/ta/id/49833-energetikas-likums>
- [7] "Noteikumi par pašvaldību teritorijas attīstības plānošanas dokumentiem." Accessed: Sep. 18, 2024. [Online]. Available: <https://likumi.lv/ta/id/269842-noteikumi-par-pasvaldibu-teritorijas-attistibas-planosanas-dokumentiem>
- [8] L. Zemite et al., "A COMPREHENSIVE OVERVIEW OF THE EUROPEAN AND BALTIC LANDSCAPE FOR HYDROGEN APPLICATIONS AND INNOVATIONS," Latvian Journal of Physics and Technical Sciences, vol. 60, no. 3, pp. 33–53, Jun. 2023, doi: 10.2478/lpts-2023-0016.
- [9] "Enerģētikas likums." Accessed: Sep. 18, 2024. [Online]. Available: <https://likumi.lv/ta/id/49833-energetikas-likums>
- [10] "Elektrība bez kaitīgām emisijām. Jelgavā domā par ūdeņraža ražošanu un uzkrāšanu | LA.LV." Accessed: Sep. 18, 2024. [Online]. Available: <https://www.la.lv/zalais-kurss-uz-energijas-uzkrasanu>
- [11] "Arī Latvijā ir iespējas ražot ūdeņradi no atjaunojamajiem resursiem^{[P]_{SEP}}." Accessed: Sep. 18, 2024. [Online]. Available: <https://www.retv.lv/raksts/ari-latvija-ir-iespejas-razot-udenradi-no-atjaunojamajiem-resursiem>
- [12] "Latvijā un Igaunijā pārbaudīs zaļā ūdeņraža potenciālu." Accessed: Sep. 18, 2024. [Online]. Available: <https://uzladets.lv/vidzeme-parbaudis-udenraza-potencialu/>
- [13] "Latvian Hydrogen Association – Hydrogen technologies and research." Accessed: Sep. 18, 2024. [Online]. Available: <https://h2lv.eu/lv/>
- [14] "Zaļo un viedo tehnoloģiju klasteris kopā ar vēl 43 partneriem īsteno projektu 'BalticSeaH2' | Green-Tech Latvia." Accessed: Sep. 18, 2024. [Online]. Available: <https://greentechlatvia.eu/lv/2023/02/istenos-projektu-balticseah2/?cn-reloaded=1>
- [15] L. IT, "H₂ energokopiena, 40008319136 - par uzņēmumu," Lursoft IT, 2024.
- [16] K. Lebedeva, L. Migla, and T. Odineca, "Solar district heating system in Latvia: A case study,"

J King Saud Univ Sci, vol. 35, no. 10, Dec. 2023, doi: 10.1016/j.jksus.2023.102965.

[17] "Energy of the future – biomethane | Latvijas Gāze." Accessed: Sep. 18, 2024. [Online]. Available: <https://lg.lv/en/news/energy-of-the-future-biomethane>

[18] "European Energy Efficiency Fund teams with a Latvian energy company and developers to finance a biomethane production plant in Latvia - European Energy Efficiency Fund eeef." Accessed: Sep. 18, 2024. [Online]. Available: <https://www.eeef.lu/news-detail/european-energy-efficiency-fund-teams-with-a-latvian-energy-company-and-developers-to-finance-a-biomethane-production-plant-in-latvia.html>

[19] "Latvia to invest EUR 134.4 million in energy security and biomethane production | Ministru kabinets." Accessed: Sep. 18, 2024. [Online]. Available: https://www.mk.gov.lv/en/article/latvia-invest-eur-1344-million-energy-security-and-biomethane-production?utm_source=https%3A%2F%2Fwww.google.com%2F

[20] "LATVIJAS NACIONĀLAIS ENERĢĒTIKAS UN KLIMATA PLĀNS 2021. – 2030. GADAM" Accessed: Sep 21, 2024 [Online] NEKP [empl_220120_nekp20301_o.docx \(live.com\)](empl_220120_nekp20301_o.docx (live.com))

[21] "Elektroenerģijas pārvade un sadale | Ekonomikas ministrija (em.gov.lv)" Accessed: Sep 21, 2024 [Online] <https://www.em.gov.lv/lv/elektroenerģijas-parvade-un-sadale>

[22] "12 lieljaudas atjaunīgo elektrostaciju būvniecība" Accessed: Sep 21, 2024 [Online] [Šogad plānots uzsākt 12 lieljaudas atjaunīgo elektrostaciju būvniecību :: Dienas Bizness \(db.lv\)](#)

[23] "Energosistēmas drošumam Latvijā tiksuzstādītas Eiropā jaudīgākās elektroenerģijuuzkrājošas bateriju sistēmas" Accessed: Sep 21, 2024 [Online] <https://www.ast.lv/lv/events/energosisistemas-drosumam-latvija-tiks-uzstaditas-eiropa-jaudigakas-elektroenerģiju-uzkrajosas>