



GoA 2.4 –Roadmap for renewable energy transition in BSR municipalities (Version 24.09.2024)

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1 Organization of the Electricity Grid (Transmission Grid) in Finland

Finland's electricity system consists of power plants, the transmission grid, high-voltage distribution networks, distribution networks, and electricity consumers. Finland is part of the Nordic synchronous area along with Sweden, Norway, and eastern Denmark. Finland is also linked to Estonia by direct current connections./1/

Fingrid is responsible for the operation and maintenance of Finnish transmission grid. The transmission grid refers to a high voltage looped main grid connected to large power plants, factories, and distribution networks. Finland's transmission grid includes about 14,500 kilometers of power lines and over 120 substations (as of 2023).

The Nordic system is also linked to the Central European system through direct current connections. The grid serves electricity producers and consumers by enabling trade between them at the national and cross-border level. The vast majority of electricity consumed in Finland is transmitted through the grid.

Fingrid's responsibilities include grid monitoring, operational planning, balancing services, network maintenance, construction, development, and promoting the functioning of electricity markets.

In accordance with the Electricity Market Act, the development plan for the grid is published every two years. The investments in the development plan reflect a sample of Fingrid's investment plan at the time of publication of the development plan. The investment plan is maintained and continuously updated according to the needs of the operating environment. The development plan also presents changes in the operating environment, the principles of grid development, and other factors influencing planning. The transmission grid development plan is based on network plans drawn up according to customer needs, electricity markets, grid condition, and transmission needs. It also takes into account the development plan for the Baltic Sea region and the Europe-wide Ten-Year Network Development Plan (TYNDP).

2 Electricity Distribution Network in Finland

The distribution network is an electricity network with a nominal voltage below 110 kV. The high-voltage distribution network has a nominal voltage of 110 kV. The core network is a nationwide integrated electricity transmission network consisting of power lines, substations and other installations with a nominal voltage of 110 kV or more. The core network includes the interconnectors with a nominal voltage of at least 110 kV under the control of the core network operator. Electricity grids and parts of grids with a nominal voltage of more than 110 kV are defined as the core grid if they are not access lines under the Electricity Market Act.

In 2013, Finland adopted legislation setting target levels for security of electricity supply. According to the law, the electricity distribution network must be designed, built and maintained so that, for example, a storm or snow load does not cause a power outage of more than 6 hours in a zoning area and more than 36 hours in other areas. Exceptions can be made in special circumstances, such as difficult conditions in archipelagos. Distribution companies have until 2036 to develop their networks to meet these requirements.

Distribution network operators must prepare development plans outlining the measures they will take to meet these quality requirements. The plans must be submitted to the Regulatory Information System by the end of June every even-numbered year.

Electricity distribution reliability can be improved in several ways. Overhead lines are vulnerable to natural phenomena and by burying the lines underground, i.e. by cabling, the security of electricity supply can be significantly improved. In addition, the so-called "conductor corridors", i.e. the bare area around the wires, can be widened. Electricity lines can also be moved to places where they can be repaired more quickly, such as along roadsides away from forests.

In urban areas, an effective improvement is to build back-up and ring connections, so that in the event of a fault, an area that would otherwise be without electricity can be supplied via another route. Intelligent components and functionality can also be added to networks, for example to provide the network company with information about a power outage and the exact location of the fault more quickly.

While there are many ways to influence the number and extent of blackouts, it is practically impossible to achieve a completely tame-free electricity supply. Good maintenance and effective fault repair are therefore key to the security of electricity supply. /2/



2.1 Electricity Distribution Network Operators

Finland's largest distribution companies are Caruna Oy, Elenia Verkko Oyj, and Helen Sähköverkko Oy. Together, the fifteen largest electricity distribution network companies in Finland account for about 70% of the distribution networks, electricity users and turnover of the companies. The smallest electricity distribution companies in Finland operate in the territory of a single municipality and serve a few thousand customers. Indeed, most of the almost 80 distribution network companies in Finland are owned by a municipality or a limited liability company with a majority stake in a municipality.

The map below shows the geographic responsibility areas of distribution network operators and closed distribution system operators. These areas are associated with the operators' rights, obligations, and responsibilities. In the electricity network licence, the Energy Agency assigns a responsibility area to the network operator for the distribution network. The network operators' areas of responsibility shall together cover the whole of Finland, excluding the Åland Islands, and shall not overlap. The Energy Agency will also monitor that the changes in the area of responsibility comply with the above requirements. The responsibility area map reflects the latest responsibility area information approved by the Energy Agency./3/



Figure 1: Geographical areas of responsibility of distribution system operators and closed distribution system operators in Finland.

3 Active Stakeholders in Energy Storage Systems

Energy storage stakeholders include people, groups, organisations, companies and communities that are directly or indirectly affected by energy storage activities. In Finland, the active stakeholders in energy storage in the electricity grid include several parties that influence energy production, distribution and consumption. The main stakeholders are:

- Power plants: various electricity generators, such as hydro, wind, solar and fossil fuel, which produce electricity and can benefit from storage.
- Energy storage companies: companies that develop and manage energy storage, such as battery capacity or other storage technologies.

- Grid operators: Operators of the electricity grid, such as Fingrid, who are responsible for balancing the grid and ensuring that generation and consumption are in balance.
- Consumers: industrial and residential consumers who can participate in demand response and storage, for example through smart appliances.
- Legislators and regulators: the role of government and other regulators is to set energy policies that affect energy storage and use.
- Research and development organisations: universities and research institutes that develop new technologies and innovations in energy storage.
- Non-governmental organisations and environmental groups: these actors can influence energy policy and practice, particularly from a sustainability perspective.

The changes caused by energy storage can be estimated. The assessments describe views on the measurable impacts of energy storage on the functioning of the energy system, and the benefits are the value that stakeholders derive from the impacts. The design and implementation of energy storage systems will have a major impact on the benefits that can be achieved, how well the use can be optimised and how real-time monitoring can be achieved.

The indirect benefits and consequences of energy storage activities are generally more difficult to define and measure than the direct benefits. These include environmental benefits such as reduced greenhouse gas emissions and other pollutants, improved energy independence and protection against energy price volatility. The construction and operation of an energy storage facility will also create new job opportunities in the region where it is located./4/

4 Role of Local Authorities in Connecting Energy Storage to the Grid

An electricity producer in Finland is entitled to connect its production facility to the electricity grid when the facility meets the technical requirements for it. The producer is entitled to transfer electricity to the grid when the connection and metering meet the relevant requirements and there is a buyer for the electricity. There is a primary the installation does not cause any disturbance to the network or damage to other network users. (Connection of an electricity generating installation to the distribution network 2016.)

When connecting energy storage and related systems to the grid, the consent of the local distribution system operator, the grid company, is always required.

The network company should be contacted in good time so that any necessary measures can be taken in good time.

The supplier must provide the distribution network company with the necessary information. The Energy Industry Association requires power plants with a capacity of up to 100 kVA to notify at least:

- type, rated power and rated current
- the type of inverter
- protection setting values and operating times
- the implementation of the islanding protection (method and operating time).

(Guide for small electricity producers. 2012.)

When connecting generation to the grid, a generation connection agreement is usually concluded, which applies to the Energy Industry Association's Generation Connection Conditions./5/

5 The Role of Hydrogen and Power-to-X in the Current Energy System

The role of hydrogen in the future energy system has steadily grown in Finland, and hydrogen has become a widely accepted assumption in energy sector scenarios.

The growth potential of the hydrogen industry is based on the fact that hydrogen produced from renewable electricity enables the phasing out of fossil raw materials and fuels in many industrial and transport sectors. This is also the basis for the European Commission's May 2022 REPowerEU plan¹, which aims to reduce imports of Russian fossil energy, significantly increase renewable energy production and accelerate the uptake of renewable hydrogen in the EU. The basic assumption in all scenarios is that Finland will meet its carbon neutrality target and that there will be a strong increase in the production of clean hydrogen in Finland.

In addition to the growth in demand for electricity for hydrogen production and P2X products, demand for other sources of electricity is projected to increase. Demand will increase in transport, heating and existing industry as fossil fuels are replaced by electricity. Moreover, new electricity-intensive industries, such as battery manufacturing and data centers, are anticipated to emerge in Finland. These sectors' electricity use is expected to develop similarly in all scenarios.

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6 Business Models for Energy Storage

Business models for energy storage are evolving rapidly as the use of renewable energy increases and the reliability and flexibility of energy grids is improved. Storage technologies such as batteries, thermal and hydrogen storage offer new business opportunities. Energy storage systems can provide valuable services to balance the power grid and increase flexibility.

6.1 Energy Storage Owned by Energy Companies

Energy companies can own and operate large energy storage systems as part of their energy infrastructure. Energy storage is used to improve grid stability, especially in areas where electricity production is based on variable renewable energy (e.g., solar and wind).

Business model: Energy companies invest in storage systems and benefit from lower operating costs, better grid management, and efficient use of stored energy.

6.2 Energy Storage Integrated into Renewable Energy Projects

Storage systems are integrated directly into renewable energy production facilities such as solar or wind farms. Fluctuations in renewable energy production can be smoothed out by storing energy during high production periods and using it when production decreases. Energy storage systems can store electricity when market prices are low and sell it when prices are higher.

Business model: renewable energy producers invest in storage systems to maximise generation utilisation and revenue optimisation in a volatile market.

6.3 Consumer-Oriented Energy Storage Systems

Households and businesses can install energy storage systems, such as batteries, to ensure energy supply and control costs. Households and businesses can store self-produced renewable energy (e.g., from solar panels) and use it when grid electricity is more expensive. Excess energy can be stored and sold back to the grid, generating additional income. Consumers can use battery storage for backup power during outages, reducing their reliance on the grid.

Business model: consumers invest in their own storage systems and savings are generated by managing their energy consumption and selling surplus electricity back to the grid.



6.4 Hydrogen Storage Business Models

Hydrogen can be used for long-term storage of large amounts of energy, especially for utilizing excess renewable energy. Hydrogen can be used as an energy source in industries, replacing fossil fuels. Excess electricity can be used to produce hydrogen via electrolysis, which can be stored and later used for electricity generation or sold to other markets, such as transport or industry.

Business model: Hydrogen producers can sell stored hydrogen for industrial, transport or energy production. The business model is based on the growth in demand for hydrogen and the development of new uses for hydrogen.

7 Organizing Other Storage (Biomethane, Heat)

7.1 Biomethane

Biomethane (processed biogas) is a renewable gas that can be used similarly to natural gas, for example, for heating, electricity generation, or as a fuel in transportation. Small-scale production at farms and biowaste processing plants: Biomethane is often produced from organic waste or agricultural by-products and can be stored locally in pressure tanks or compressors. This can allow for direct use, for instance, as fuel for agricultural machinery or for electricity and heat production.

Business model: Producers can sell biomethane directly to local users (such as industrial facilities or as fuel for transport) or inject it into the grid.

7.2 Heat Storage

Heat storage is a key component in optimizing energy systems, especially in district heating systems and large industrial processes. Heat storage helps balance energy production and consumption and utilize cheaper or renewable energy.

7.2.1 District Heat Storage

The most common heat storage solutions are large hot water tanks where heat can be stored for



district heating networks. Heat is produced when demand is low and stored for later use, for example, heat generated at night can be used during the day.

Seasonal heat storage can be used to store excess heat produced in summer for winter consumption peaks. This can be achieved through underground water storage or geothermal systems.

Business model: District heating companies can optimize their production by utilizing stored heat and saving on fuel costs. This also reduces the need for expensive energy production investments in winter.

7.2.2 Utilizing Industrial Waste Heat

Industrial heat storage systems: Large industrial facilities can store excess heat generated during processes and use it later for their needs or inject it into the local district heating network. For example, the metal and chemical industries produce significant amounts of waste heat.

Business model: Industrial facilities can save on energy costs by utilizing their waste heat. Additionally, selling waste heat to the district heating network can generate extra income.

7.2.3 Heat Storage in Single-family Houses

Individual households can use heat storage systems, such as water heaters or thermal batteries, to store heat produced by solar panels or heat pumps. This allows for optimizing energy use in single-family homes and properties.

Business model: Households save on energy bills by storing cheap or self-produced energy. Excess heat can also be fed into local networks if such infrastructure is available.

7.3 Summary

Business models for biomethane and heat storage focus on optimizing energy production, cost-effectiveness, and integrating renewable energy into energy systems. Infrastructure such as natural gas grid utilization for biomethane or district heating networks for heat storage is crucial, and local solutions can yield significant savings and additional income. As these technologies develop, business opportunities will diversify, particularly from the perspectives of local communities and industry.



References

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- /2/ [Energiateollisuus](#)
- /3/ [Energiavirasto](#)
- /4/ [Oulun ammattikorkeakoulu](#)
- /5/ Lauri Holopainen, Principles for Connecting Energy Storage to the Grid
- /6/ [Fingrid](#)