Prospects for future electricity production and consumption

FINGRID'S FORECAST Q3/2024

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Finland’s competitiveness as an investment destination for power-intensive industries is crucial for the growth of electricity consumption. **3**

Electrification of district heating production and data center investments are progressing rapidly in Finland at the moment. **5**

01

Background

Energy production and consumption are undergoing a transition from conventional, mainly combustion-based energy to the increasing use of emission-free electricity. The need for clean electricity is forecast to grow rapidly across Europe. Finland's large and competitive renewable electricity production potential provides excellent conditions for success in this transition. Fingrid sees this first-hand: connection enquiries for renewable electricity production have been growing rapidly for several years, and Fingrid is already aware of approximately 400 gigawatts of wind and solar power production projects. Now, enquiries related to new power-intensive industrial projects[1] have also started to grow sharply, exceeding 35 gigawatts. Projects have also progressed to the investment decision and construction phases. For example, the total number of electric boilers used for heat and steam production in district heat production and industry will grow to more than 2 gigawatts in the next few years due to investment decisions already made.

Reliable electricity networks are among the most important national competitiveness factors for industrial projects requiring clean energy. Therefore, long-term main grid planning must also account for the realisation of high electricity consumption and production potentials. The forecasts presented in this document reflect the baseline scenario used in main grid planning, which involves several uncertainties. Uncertainties may affect the implementation schedules of production and consumption projects and, in general, the speed and direction of change. Such uncertainties include energy policy, regulation, permitting, availability and cost of financing, and cost development of electricity and hydrogen production and storage technologies. The impact of various factors on Finland’s position as a place for power-intensive industrial investments and the growth potential and price competitiveness of Finnish wind power relative to European and global competitors is particularly significant, as a considerable part of the projected growth in electricity consumption in Finland relies on refining electricity produced with wind power into export products.

[1] The figure includes electric boilers used in district heat production.

In addition to the scenario used for grid planning, the report outlines an alternative scenario for the increase in electricity consumption. This estimates growth based on investment decisions that Fingrid is aware of and which will raise electricity consumption, as well as connection agreements with customers. The scenario does not consider other projects that will increase the consumption of industrial electricity. This lower scenario does not guide grid planning. However, the scenarios formulate a range that describes the uncertainty inherent in the forecast in relation to projects that where investment decision or connection agreement is yet to be made. The range does not include the normal fluctuations in consumption from year to year due to a year being warmer or colder than average, economic cycles in industries, or temporary changes in electricity prices.

Achieving Finland's climate goals and enabling clean transition investment projects that create economic prosperity in Finland require significant main grid construction and development. Fingrid endeavours to maintain its main grid investment programme and takes measures[2] to improve the connectivity of new projects and the utilisation of the main grid, thereby enabling the development described in the forecast. Maintaining opportunities to develop the main grid in the future is important. Smooth permit processes for transmission line projects and predictable regulation that enables grid investments play a key role in this.

Fingrid presented forecasts and scenarios for the development of electricity consumption and production in a version of this report published in February 2024 and as part of the Main Grid Development Plan and the Network Vision and Electricity System Vision projects. The stakeholder feedback received from these reports has been valuable for developing the main grid.

We welcome free-form feedback on this report by email at strateginen.verkkosuunnittelu@fingrid.fi.

[2] One example is the proposed changes to the structure of the grid service fee. www.fingrid.fi/en/news/news/2024/fingrid-proposes-reforms-to-the-structure-of-grid-service-fees

02

Prospects for future electricity consumption

Figure 1 shows the electricity consumption trend in Finland up to 2035 according to Fingrid's forecast. Electricity consumption is expected to increase in industry, heating and transport. Most of the growth included in the forecast will come from the electrification of industrial processes, data centres and the production of hydrogen and hydrogen derivatives. Connection enquiries for electricity consumption have increased significantly, and if all enquiries were implemented in full, Finland's electricity consumption would rise to approximately 300 terawatt hours. The forecast assumes a more moderate trend in which electricity consumption increases to 126 terawatt hours by 2030 and 160 terawatt hours by 2035. The growth up to approximately 100 terawatt hours is based on investment decisions and connection agreements made for projects that will raise electricity consumption.

Several factors will drive growth in industrial electricity consumption, including data centres, the production of hydrogen and electric fuels, the metal industry, battery manufacturing, and the replacement of combustion fuels with electricity

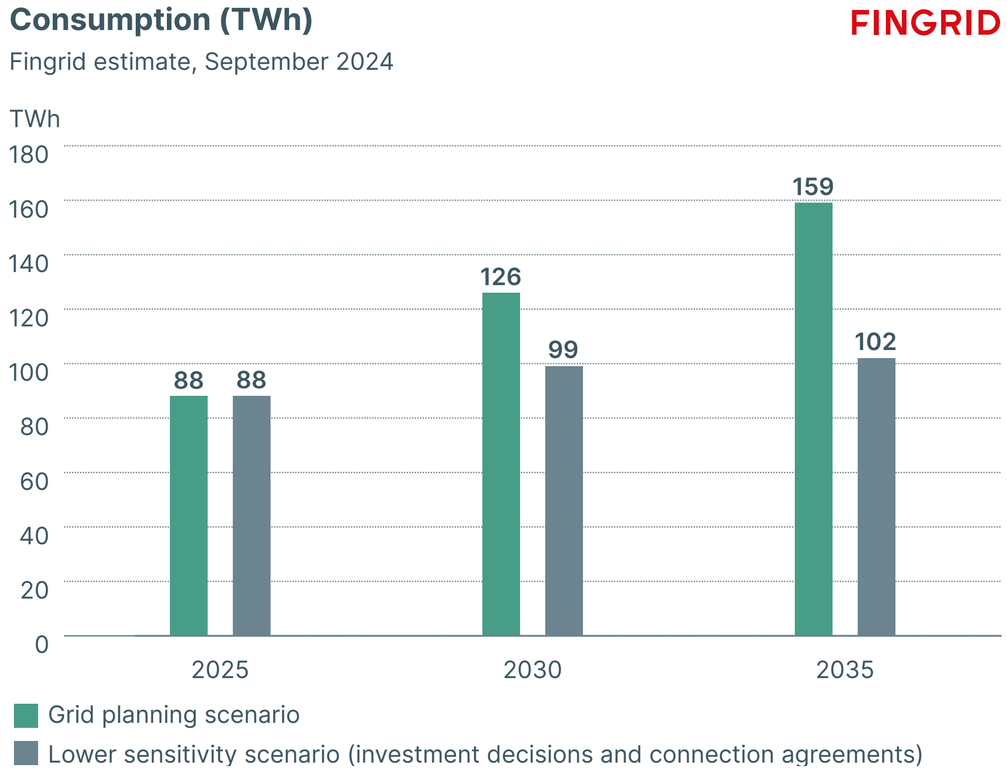

FIGURE 1 Electricity consumption in Finland between 2025 and 2035.

in heat and steam production. In all, the main grid planning process is preparing for industrial electricity consumption to grow by approximately 35 terawatt hours by 2030 and 65 terawatt hours by 2035. This report includes data centres in the industrial consumption figures[3]. The growth in industrial electricity consumption will take place particularly in the second half of the 2020s and beyond.

Industrial electricity consumption is the biggest driver of growth in the forecast. It also involves the greatest uncertainty in terms of the forecast, as the growth rate depends on Finland's competitiveness in projects that require a lot of clean electricity. The competitiveness and growth potential of Finland's wind and solar power compared to European and non-European competitor countries play a key role in this. In addition, Finnish industry must be able to make efficient use of low-cost electricity production that varies according to the weather.

Electricity consumption for space heating is forecast to increase by about eight terawatt hours. This increase is boosted especially by electric district heating, where investment in electric boilers has grown sharply over the past year. As a result of the investment decisions, the electric boiler capacity utilised in district heat production is estimated to grow to approximately two gigawatts by the end of 2026. Along with this, the number of electric boilers is growing in industry. The report presents the consumption of industrial electric boilers in the category Industry and district heat production in the category Space Heating.

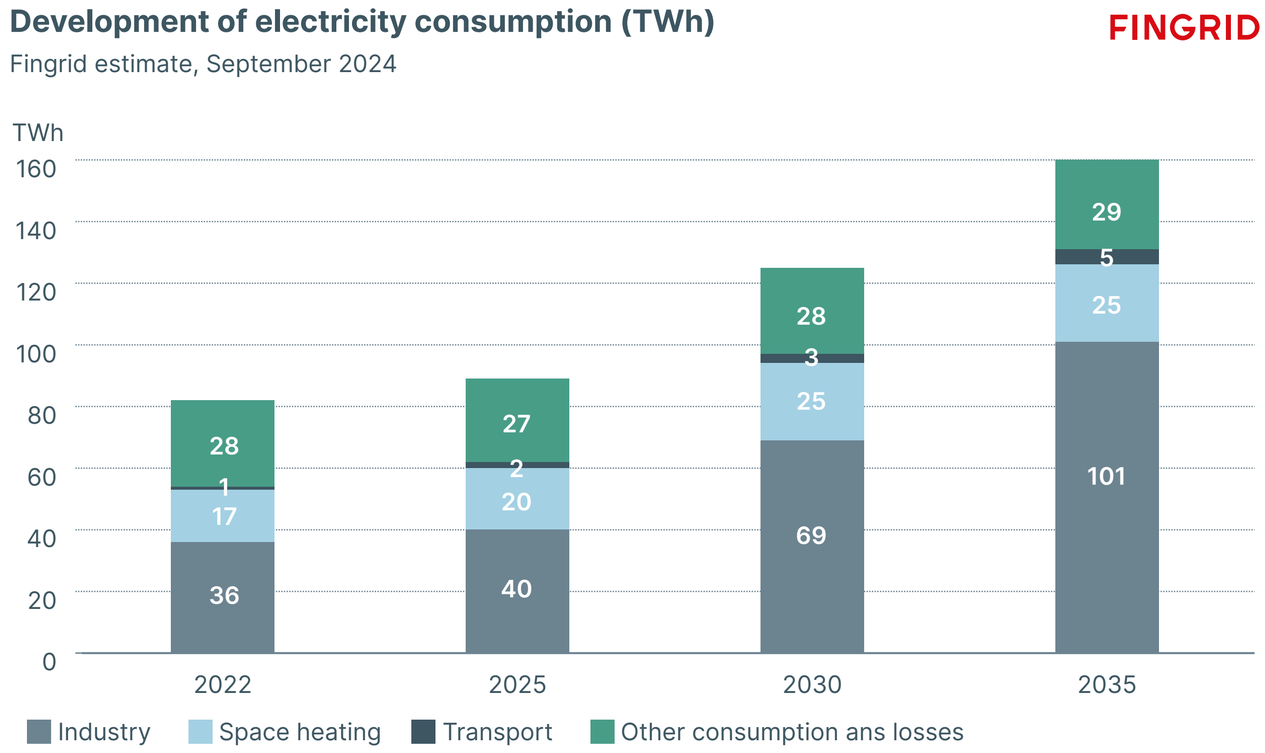

FIGURE 2 Electricity consumption trends in different sectors from 2022 to 2035.

[3] Excluding historical data for 2022, which was reported according to data from Statistics Finland.

According to the forecast, electricity consumption in transport[4] will increase to more than three terawatt hours from the current one terawatt hour. Depending on driving performance and specific consumption, the increase corresponds to the electricity consumption of approximately 800,000–900,000 electric and plug-in hybrid passenger cars in 2030. Despite the forecasted rapid growth in the number of electric cars, the total annual electricity consumption of electric transport is very small compared to industrial electricity consumption. However, charging electric cars has a great impact on the need for electric power, and thus optimising the charging time has significant effects on the electricity system.

Fingrid is preparing for strong consumption growth in the sectors presented above. This report forecasts slightly lower growth in industrial electricity consumption than the forecast published in Q1/2024. This is due to expected delays especially in hydrogen production projects. We expect Finland to remain an attractive place for hydrogen investments, as long as the European hydrogen value chain as a whole leads to investment. The forecast electricity consumption in data centres and electric district heating has risen. For electric transport, the forecasts remain unchanged.

The forecast annual growth in consumption averages 5.9 per cent from 2023 to 2035. Between January and August 2024, consumption increased[5] by 7.2 per cent in Finland. Factors that structurally increase the electricity consumption, such as electric boiler investments, as well as non-recurring factors, such as a colder winter than in the reference season, contributed to growth in the early part of the year. It was noteworthy that growth occurred in the early part of the year despite challenging economic conditions for industries, and industrial electricity consumption decreased by approximately one per cent.

4 Excludes electricity used in the production of electric fuels used in transport. The electricity used to produce Finnish electric fuels is included in the forecast for industrial electricity consumption.

5 Source: Finnish Energy. energia.fi/en/statistics/monthly-electricity-statistics

03

Prospects for future electricity generation

Electricity production in Finland has grown rapidly. From 2012 to 2022, electricity production varied between 65 and 70 terawatt hours. Production was approximately 78 terawatt hours in 2023, and it will be approximately 90 terawatt hours in 2025. Production is forecast to rise to 130 terawatt hours in 2030 and 175 terawatt hours in 2035. Such a large increase in production requires strong growth in domestic consumption to enable market-based production growth. The development of electricity production is shown in Figure 3.

The growth in electricity production is strongest in wind power. Figure 4 shows the growth forecast for wind power until 2035. If realised, the projects under construction and those that have already signed a connection agreement to the main grid will increase wind power capacity to approximately 11 gigawatts by the end of 2027. This corresponds to an annual production of approximately 30–35 terawatt hours, i.e. about a third of Finland's electricity consumption. Wind power production capacity is projected to continue to grow

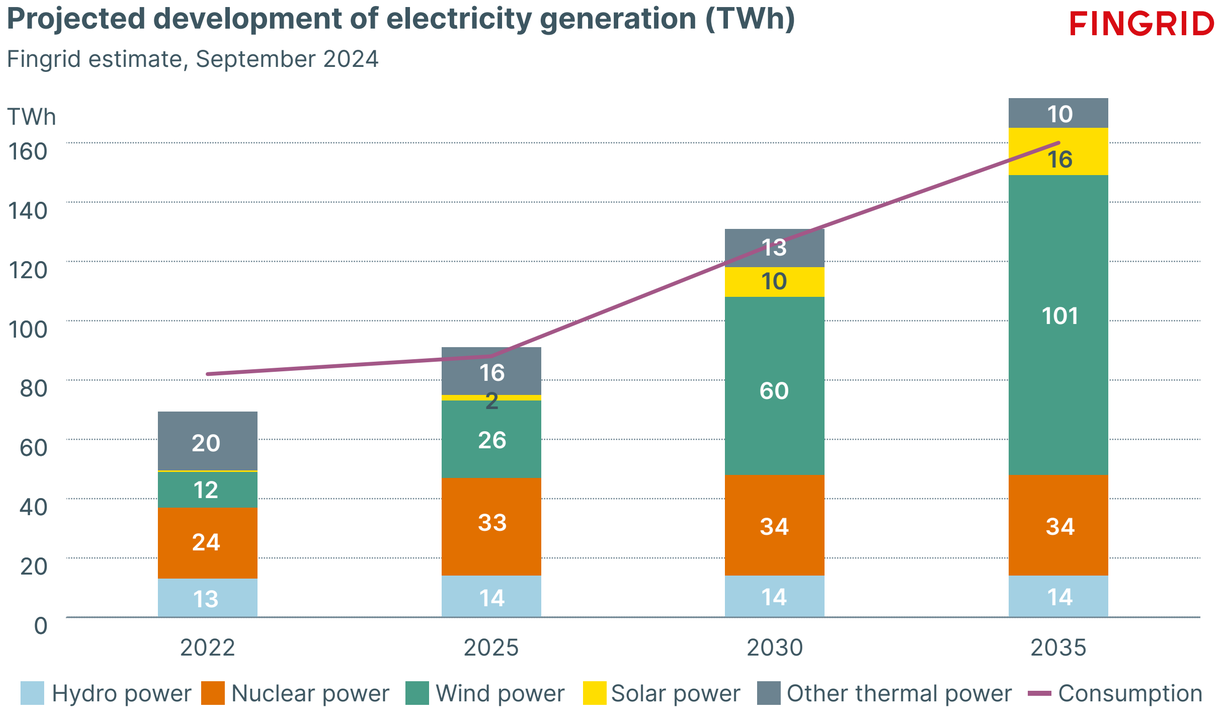

FIGURE 3 Projected development of electricity generation.

as electricity consumption increases. The main grid planning process is preparing for wind power capacity of 19 gigawatts in 2030 and 34 gigawatts in 2035. The corresponding electricity production would be approximately 60 TWh in 2030 and approximately 100 TWh in 2035. Similarly, wind power's share of total production is expected to be approximately 45 per cent in 2030 and 55 per cent in 2035. Wind power is projected to be built onshore until 2030, and the first large offshore wind projects are expected to be completed in the early 2030s.

Solar power production capacity has grown strongly in 2022–2023, mainly due to rooftop solar panels. In early 2024, the solar power capacity was already approximately 1000 megawatts, according to the Energy Authority[6]. From 2024 onwards, solar power production is expected to grow significantly in large ground-mounted solar farms. In the long term, the majority of solar power will be located in such parks. The share of solar power in total electricity production is expected to rise to around 10 per cent in the 2030s. The growth forecast for solar power is shown in Figure 5.

For nuclear power, the forecast takes into account the planned power increases[7]. Net hydro power production[8] is expected to remain at around 14 terawatt hours. The production of thermal power is expected to decline. The production decline caused by the closure of fossil thermal power production is partly offset by the Kemi bioproduct mill power plant (250 MW), which was completed in autumn 2023.

Compared to the forecast published in Q1/2024, the forecast for wind and solar power production has slowed slightly due largely to lower forecasts of electricity consumption. However, the main grid planning process continues to prepare for sharp growth in wind and solar power driven by the forecast increase in demand and Finland's competitive advantages, especially in onshore wind power production. For other forms of production, there are no significant changes in the forecast.

The realisation of the production forecast requires a significant increase in consumption, and correspondingly, the realisation of the consumption forecast requires a sufficient amount of affordable and clean electricity. Most new electricity production is based on weather-dependent production types, especially onshore wind power, where Finland's competitive advantage is strongest due to factors such as our large land area and low population density. However, industrial energy demand has traditionally been stable, and this development will require significant increases in demand-side response, balancing power, and energy storage capacity in Finland. New energy storage capacity can be obtained, for example, from pumped storage power plants, battery power plants, growing electric transport, heat storage, and the storage of hydrogen and synthetic fuels.

6 energiavirasto.fi/en/-/solar-power-production-capacity-rose-to-1-000-megawatts

7 fortum.fi/media/2024/05/fortumin-loviisan-ydinvoimalaitoksen-matalapaineturbiinit-modernisoidaan-ja-sahkotehoa-lisataan-noin-38-mw
tvo.fi/ajankohtaista/tiedotteetporssitiedotteet/2024/olkiluoto1-jaolkiluoto2-laitosyksikoidenkayttoianpidennystajatehonkorotustakoskevayva-ohjelmaonvalmistunut.html

8 Production of hydro power without electricity produced or consumed by pumped storage power plants.

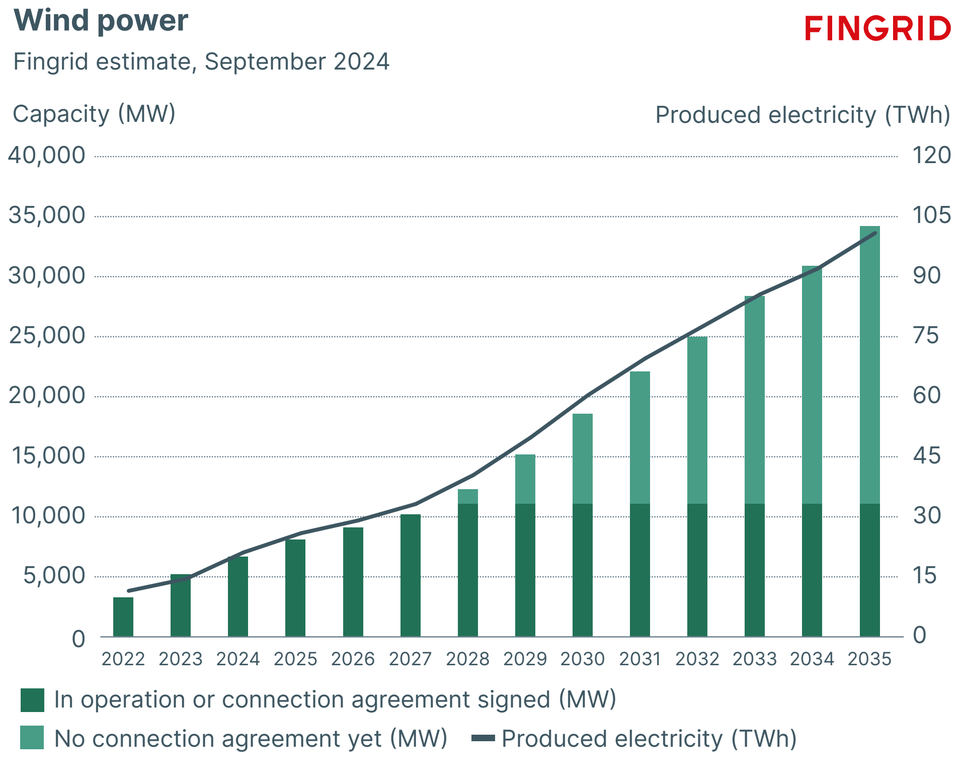

FIGURE 4 Projected development of wind power.

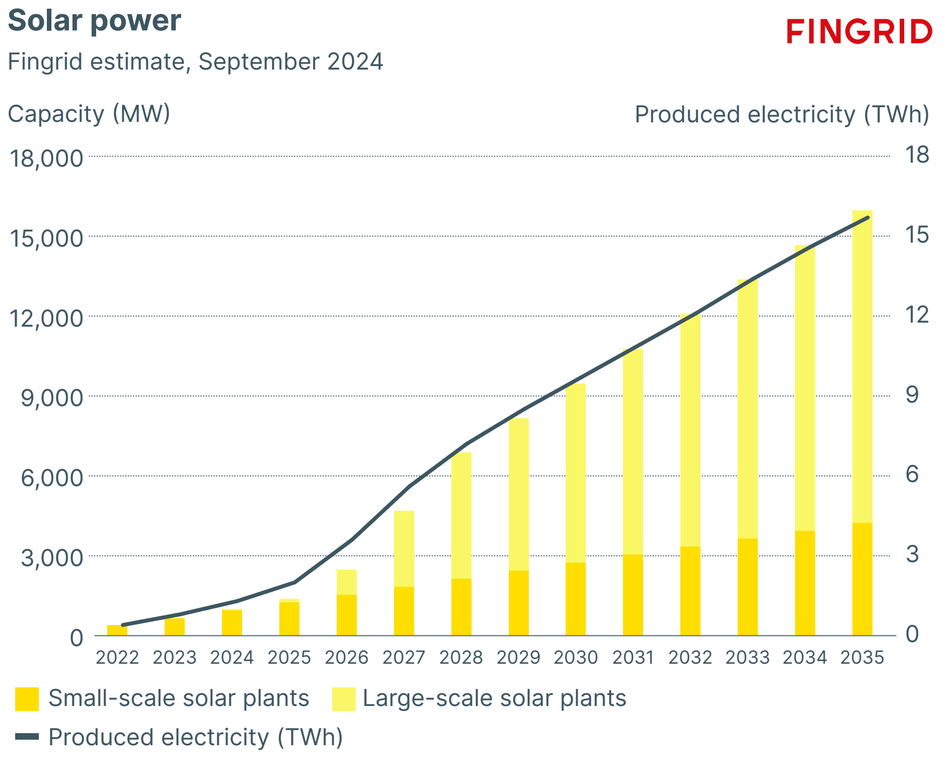

FIGURE 5 Projected development of solar power.

04

Prospects for future electricity imports and exports

Finland almost reached annual self-sufficiency in electricity in 2023: electricity production (78 terawatt hours) and consumption (80 terawatt hours) in Finland during the year were approximately in balance. In 2024, net imports will increase slightly to approximately 4 terawatt hours due to lower-than-expected production availability and a long outage in the EstLink 2 transmission connection, which reduced electricity export opportunities from Finland. In any case, the net import level has changed significantly: between 2012 and 2021, net electricity imports to Finland amounted to 15–20 terawatt hours per year, or 20–25 per cent of consumption. The development forecast for Finland's electricity balance is shown in Figure 6.

Annual electricity production is forecast to exceed consumption in the late 2020s and beyond, when Finland will become a net electricity exporter. On average, exports will account for approximately 5 per cent of Finland’s electricity production, but export and import volumes will fluctuate dramatically depending on the weather. Consequently, Finland is not expected to become a significant net exporter of electricity. Instead, the majority of the growth in electricity production will offset higher electricity consumption in Finland. Instead of exporting electricity, Finland will produce products with higher added value from electricity for the domestic market and export.

Changes in the production and consumption balance of electricity in Finland and its neighbouring areas will change transmissions on cross-border connections between Finland and its neighbouring countries. In recent years, electricity has mainly been imported from Sweden to Finland and exported from Finland to Estonia. Transmission between Finland and Sweden is becoming more balanced. This is due not only to the increasing electricity production in Finland, but also to the considerable increase in electricity consumption in northern Sweden.

Transmission from Finland to Estonia will remain very export-oriented in the next few years. The Baltic Sea region has good electricity production opportunities. If the wind and solar capacities increase as expected, electricity transmission between Finland and Estonia will become more balanced as the review period proceeds. Electricity consumption is not expected to grow significantly in the Baltic countries.

Finland is not expected to become self-sufficient in terms of electrical power within the forecast horizon, which means that Finland will still need imported electricity in low-wind peak consumption situations, for example. The development of power self-sufficiency is affected by the extent to which the fossil capacity being phased out is replaced by, for example, energy storage facilities or new flexible production capacity. In addition, power self-sufficiency is significantly affected by how flexible Finland's future electricity consumption investments will be. On the other hand, even if Finland were self-sufficient in power, there would still be situations where electricity is cheaper in neighbouring countries and importing electricity would be profitable. The export-import balance for an individual year is significantly influenced by the weather conditions (precipitation, wind, sunshine, temperature) in Finland and surrounding areas.

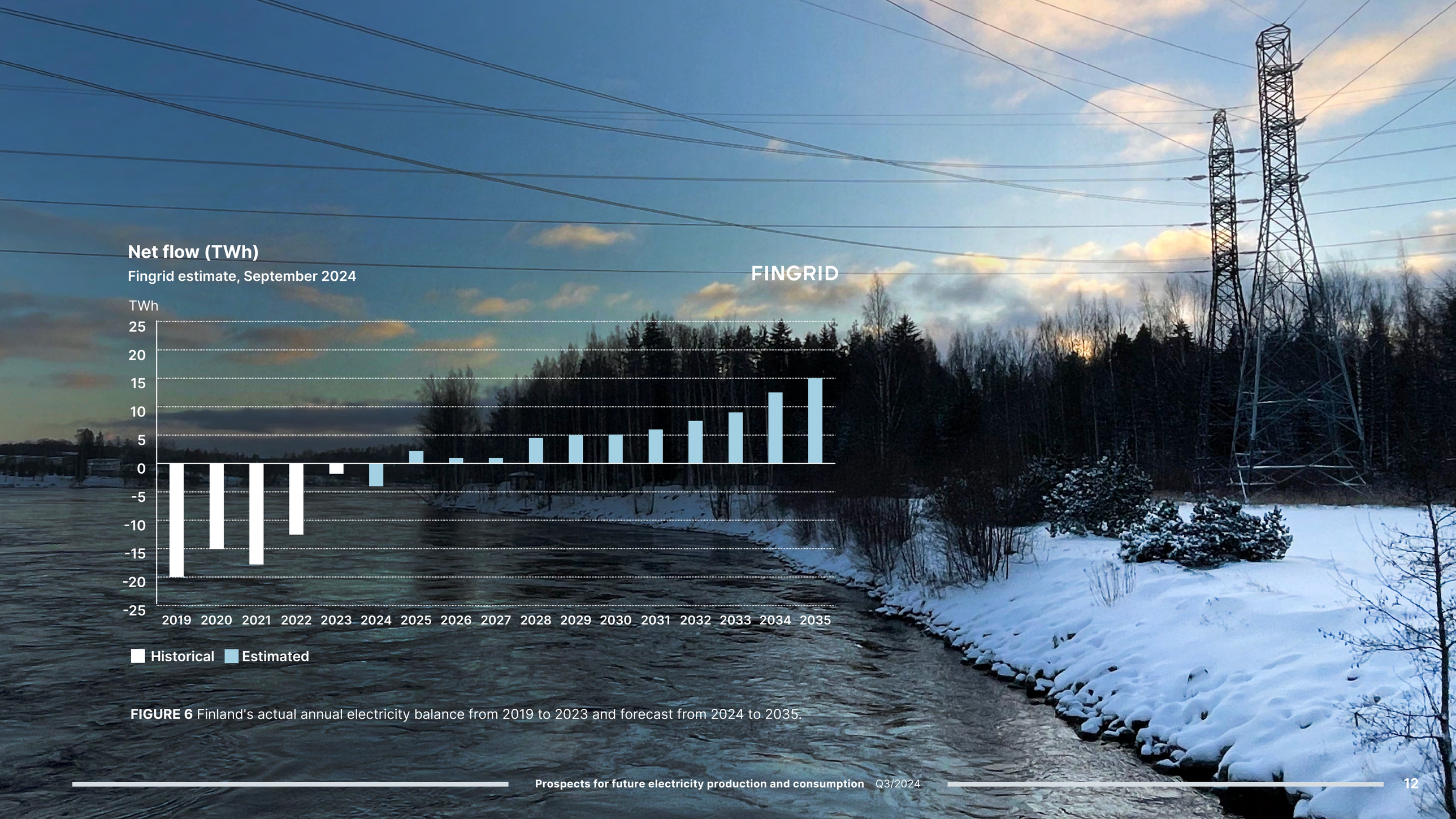

FIGURE 6 Finland's actual annual electricity balance from 2019 to 2023 and forecast from 2024 to 2035.

05

Preparing the forecast

The forecast was prepared as the foundation for Fingrid's main grid planning and is based on production and consumption connection enquiries and the results of electricity market modelling. The forecast takes into account the growing need for clean electricity and products produced from electricity in Europe, as well as Finland's excellent potential to be a competitive producer of these products. The forecast has been created to be challenging in terms of main grid planning and the electricity system, but nevertheless realistic. The forecast guides Fingrid to proactively solve challenges related to the transition of the electricity system and to find solutions with which the company can contribute to enabling investments related to clean electricity located in Finland. The forecast takes into account Fingrid's connection agreements with production, consumption and storage projects, but the projected total growth also includes capacity for which a connection agreement has not yet been made. On the other hand, the forecast omits many projects for which Fingrid has received a connection enquiry.

Electricity market modelling models the operation of the electricity market and the resulting electricity transmission needs on an hourly basis. The modelling takes into account growing electricity consumption and growing electricity production that is becoming increasingly variable according to the weather. In addition to Finland, the entire Baltic Sea region and central and western Europe have been taken into account in electricity market modelling. For other countries, forecasts received from other transmission system operators and scenarios prepared by the European Network of Transmission System Operators for Electricity (ENTSO-E) have been utilised. The modelling assumes that the price formation of the electricity market in Finland will remain unchanged ("energy-only"), supplemented by a capacity mechanism for new flexible capacity investments or investment aid with moderate annual costs (AFRY's estimate: EUR 50 million per year) and thus the impact on the forecast will be limited. If a market-wide capacity mechanism were to be introduced in Finland, its impact on the forecast should be considered separately and higher annual costs would need to be taken into account (Afry's[9] estimate: EUR 500–1,000 million per year).

[9] Afry: Assessment of future capacity solutions to ensure resource adequacy in the Finnish electricity market. www.fingrid.fi/contentassets/847fad4023ae42b2add99fffd0e81bab/fingrid--capacity-markets-high-resoultion_links.pdf

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