Elenia Verkko Oyj's electricity distribution network development plan

2014–2036

ELENIA

Contents

Introduction

Reliable electricity distribution is a basic prerequisite for the electrification required by the clean transition and for the security of supply of society

As part of responsible, cost-efficient and long-term electricity network development, we have updated our electricity distribution network development plan that encompasses the period until 2036. The update takes into account the requirements of the regulation issued by Energy Authority in December 2023 concerning the content of the electricity distribution network development plan and the consultation of customers and distribution system operators.

We cost-efficiently improve the security of electricity distribution to our customers

According to the Electricity Market Act, after 2036, there shall not be power outages of over 6 hours in zoned areas or power outages of over 36 hours in other areas as a result of storms or snow loads. A clear majority of power outages experienced by customers are due to trees falling on medium-voltage overhead lines. Higher temperatures and increase in annual rainfalls caused by climate change will reduce the thickness of soil frost and increase heavy snowfall. As a result, the risks and effects of storms and snow loads on electricity distribution will increase even if the weather events themselves do not intensify.

As part of the 2022 network development plan, Elenia organised a public hearing for its customers and stakeholders on the network development plan for the first time. One of the findings of the hearing was that 85% of our customers think that 12 hours is the maximum acceptable outage length, which is significantly shorter than the 36-hour limit set in the Electricity Market Act for 2036. Considering the electrification of society and the already existing expectations of customers, the quality of electricity distribution must be significantly improved to a level exceeding the minimum quality requirement of the Electricity Market Act.

The quality requirements of the Electricity Market Act, the increasing dependence of society's functions on electricity and the growing demands of our customers for undisturbed electricity distribution guide us to favour underground cabling in the modernisation of the ageing electricity network. The weatherproof electricity network is protected from the effects of extreme weather events and thus the customer effects of major power disruptions are reduced even further.

The underground cable network is a more affordable alternative in terms of overall lifecycle costs than overhead lines when cost comparisons take into account network construction costs, maintenance, fault repair and regulatory outage costs. Elenia's electricity network is mainly located in very forested areas, which makes the effects of tree-clearance activities and forest management in areas adjacent to the electricity network rather short-lived. In addition, the underground cable network has many advantages when it comes to safety and environmental aspects.

The construction of the underground cable network also enables the cost-efficient joint construction of the fibre optic network and the other infrastructure network in connection with the renewal of the electricity distribution network. Elenia is one of the industry's forerunners in joint construction and we believe that there will continue to be a need for joint construction with the electrification and digitalisation of society and remote work.

In line with our development plan, we are building battery storage islands in sparsely populated rural areas that are susceptible to faults and where the upgrading of the electricity network is not yet scheduled. In addition, in areas awaiting electricity network upgrading, the security of electricity supply is ensured through targeted maintenance and effective fault repair and operations in response to major power disruptions.

Continued on the next page »

We make the clean transition possible with investments and flexibilities

In our development plan, we take into account the impacts of the clean transition of society on our electricity network. The clean transition requires the electrification of energy use and increasing electricity production from renewable energy sources, which will increase the capacity needs of the electricity network. Elenia enables the sufficient capacity of its network cost-efficiently through investments and the use of demand response. Using renewable clean energy to the fullest extent is also a step towards a self-sufficient energy policy.

The production of renewable wind and solar power is increasing quickly. More than 1,300 MW of wind power capacity is already connected to Elenia's network, or almost one-fifth of the total wind power capacity in Finland. We have more than 17,000 small-scale production sites in our network, meaning that approximately four per cent of our customers have small-scale renewable production. In the two years since the previous development plan update, approximately 600 MW of new wind power capacity and approximately 10,000 small-scale production plants have joined our network.

The use of electricity will increase as fossil energy sources are abandoned. Plug-in hybrid cars and electric cars are becoming more common, as are solar power plants in homes and other properties. The replacement of fossil heating solutions and the electrification of industrial processes require electricity. Diverse storage and battery solutions will become more common and have impacts on our network. At the same time, energy communities that use shared production and storage resources will join our network.

The amount of solar and wind power supplied to the network is influenced by changes in weather. The need to balance production and consumption is growing as production becomes increasingly weatherdependent. The market needs functionality that enables demand response as part of the smart grid. Enabling the green transition requires Elenia to not only make network investments but also develop digital solutions and facilitate and use demand response. A good example of this is our meter reform. We are currently replacing our electricity meters with next-generation smart electricity meters that enable our customers' demand response consumption solutions and full use of renewable energy.

We secure critical infrastructure and security of supply for society

Electricity distribution is an important part of critical infrastructure, which must ensure the undisturbed functioning of society in all circumstances and at all times. Without electricity, a modern society and its services do not function. It must be possible to repair disturbances in electricity distribution and the supply of electricity to our customers must continue in any situation. Human and equipment resources and network construction materials must be available also in exceptional circumstances to secure electricity distribution.

We prepare for various threats and ensure the continuity of our operations together with our partners in accordance with our up-to-date preparedness and contingency plan and our playbook for major power disruptions. We are ready and prepared round the clock every day of the year. We work in close cooperation with authorities and other parties in the sector as part of the Finnish security of supply community. We take the tenser security situation in Europe into account, especially in terms of material availability and cyber threats.

Continued on the next page »

Our climate targets are ambitious

In 2021, Elenia made a commitment to join the Science Based Targets initiative. The most significant target is Net Zero, meaning net zero greenhouse gas emissions, by 2050. Elenia's own ambitious target is to be carbon-neutral in direct (Scope 1) and indirect (Scope 2) emissions by 2035.

These ambitious targets will require systematic climate action from us and our partners. Committing to climate targets will affect our operations in the long term. Planning this comes naturally for Elenia as we make our investments for decades ahead, serving our customers and society.

Regulatory methods have a negative effect on our ability to invest

The Energy Authority supervises Finnish distribution system operators and their pricing policies with control periods. The regulation is based on four-year regulatory periods.

On 29 December 2023, distribution system operators received a new regulatory decision on regulatory methods valid for two consecutive regulatory periods, i.e. the sixth regulatory period 2024–2027 and the seventh regulatory period 2028–2031. There are numerous changes in the new regulatory methods compared to the previously applied methods. The key change to the previous methods is freezing of the asset base to 2022 construction costs, as a result of which the value of the asset base no longer corresponds to the fair market value. From our point of view, this is a remarkable negative change and, in our opinion, violates the basic regulatory principles in terms of reliability and predictability.

The new methods weaken the investment capacity of distribution system operators, which will slow down the investments required for the clean transition, as well as the development of the security of supply of the networks and the security of electricity supply. In practice, this means that Elenia has had to cut its investments for the next few years by a quarter compared to the development plan submitted to the Energy Authority in June 2022. At the same time, the need for investments is higher than at any time in Elenia's history due to ongoing security of supply investments to be made by 2036, as well as network expansion and reinforcement investments required by the clean transition.

We will continue to work responsibly while listening to our customers

We hope that this development plan will contribute to providing certainty about Elenia's commitment to developing its electricity distribution network to meet the needs of customers, stakeholders and society in a cost-efficient and responsible manner in spite of the weakening of our ability to invest.

By building a smart, weatherproof electricity network, we ensure smooth everyday life for our customers and security of supply for society and contribute to the realisation of the clean transition in Finland.

Jorma Myllymäki
CEO

Elenia Verkko Oyj

Revenue
316,4 M€

Personnel
75

Market share
12 %

Customers
440 000

Electricity network
76 600 km

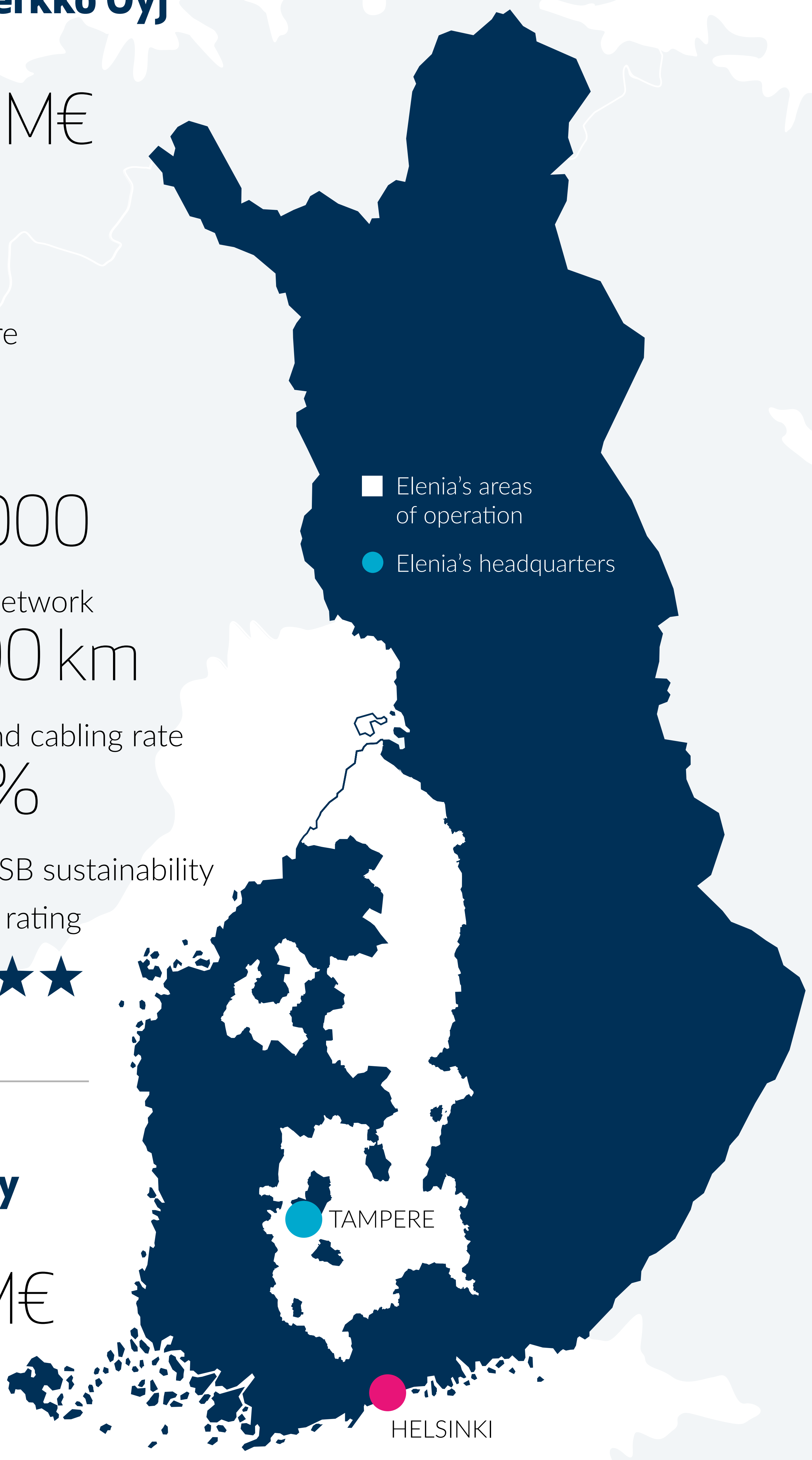
Underground cabling rate
63,5 %

Global GRESB sustainability assessment rating
★★★★★

Elenia Oy

Revenue
10,5 M€

Personnel
229



General

The development plan of the electricity distribution network describes Elenia's strategic choices and future development measures to serve the needs of the electrifying society. Our goal is to responsibly develop a smart and extreme weather event-proof electricity network that facilitates the connection of new fossil-free energy production and consumption, as well as secure electricity for our customers. We have improved the security of electricity supply in our electricity network on a long-term basis since 2009 by upgrading the network to make it weatherproof. The development plan describes the measures with which there will be no power outages of over 6 hours in zoned areas nor power outages of over 36 hours in sparsely populated rural areas as a result of storms and snow loads in 2036. However, we are aware that a 36-hour power outage does not meet the needs of the renewing society. In connection with the 2022 development plan consultation, customers in sparsely populated rural areas in particular considered the 36-hour requirement insufficient and the 2036 deadline too distant. In order to guide and develop its own operations, Elenia has already, since 2009, voluntarily paid compensation for each outage of more than six hours, regardless of whether the customer who experienced the outage lives in an urban or sparsely populated rural area. Together with our contractor partners, we are developing ways to cost-efficiently shorten the outage times experienced by customers further.

Thanks to our long-term investment programme, since 2023, 82 per cent of our customers have been within the service of electricity distribution that meets the security of electricity supply requirements of the Electricity Market Act; the share of customers within the scope of the quality requirements is 88 per cent in zoned areas and 73 per cent in sparsely populated rural areas. The renewal of the electricity network started in areas in which there are a high number of customers and services that are critical to society and in the vicinity of which the substations are typically located. The focus of network renewal has now shifted from zoned areas to sparsely populated rural areas as the sending ends of substation feeders, including densely populated areas, have been made weatherproof. Significant investments are still required to meet the quality requirements in sparsely populated rural areas. In addition to security of electricity supply investments, the enabling of the clean transition and in particular new production connected to the high-voltage network will require significant investments in Elenia's electricity network.

Elenia's electricity distribution network development plan for 2014–2036 has been prepared in accordance with the structure of the regulation on electricity distribution network development plans (record number 3167/000002/2023) issued by the Energy Authority on 2 November 2023. The development plan sets out Elenia's strategic choices as well as actions to enable changes in the energy system brought along by the energy transition and clean transition, such as the integration of carbon-free energy production and consumption in the electricity system at different voltage levels. The development plan also sets out actions to systematically and cost-efficiently improve the reliability and security of electricity supply of the electricity distribution network. With the actions defined in the development plan, we can ensure that Elenia's distribution network fulfils the requirements set out in sections 51 and 110 of the Electricity Market Act, in accordance with our criteria. Elenia has been implementing the network development plan in its operations already since 2012 and the basic principles and strategy of the plan have not essentially changed.

In accordance with the guidelines, the development plan is divided into seven separate appendices, which present Elenia's responses and their justifications for each of the points in the appendices of the regulation. The background materials describe, among other things, Elenia's operating principles and ongoing electricity network development projects. The documents that are appended as background materials to the development plan form a part of Elenia's certified asset management system.

Sustainability and quality management systems

Sustainability is an integral part of Elenia's day-to-day operations. In recent years, we have taken significant steps in developing the sustainability of our operations. Elenia's first sustainability report was published in spring 2019 and the sustainability programme was launched in autumn 2019. The sustainability programme and the set targets guide our work systematically and purposefully. Our latest sustainability report can be found on our website.

Our operations are based on certified quality management systems. In 2014, our asset management system was certified in accordance with ISO 55001:2014. Elenia has a certified environmental management system (ISO 14001:2015), an occupational health and safety system (ISO 45001:2018, previously OHSAS 18001:2007) and an information security management system (ISO/IEC 27001:2013), which was certified in March 2020.

In 2018, we started the TEKO – Safely Back Home programme in which Elenia employees and contractor partners jointly committed to developing occupational safety so that everyone can return home healthy at the end of the day. Our goal is to make Elenia one of the world's safest places to work, so as a natural continuation, we have launched the TUISKU safety development project that takes safety practices, operating culture and common safety thinking even further based on the identified targets for development. In 2023, for example, best practices for field work were launched and a safety academy for Elenia employees and contractor partners was launched. In practical work, we conduct monthly monitoring and reporting of safety, environmental and information security incidents, proactive safety and environmental actions as well as the realisation of recycling.

The policies that guide our operations have been published on Elenia's website and can also be found in Appendices 1–5. The background materials also include more information about Elenia's existing and certified quality management systems.

Elenia's strategic forecast of changes in the operating environment

1. Elenia's key indicators and forecasts for the future

This section presents the forecast for the development of the key indicators of the electricity network business over the next ten years. The forecast used is the forecast of rapid transition selected as the outcome result of scenario work. The forecast is presented in Table 1.

Table 1: Forecast for the development of the key indicators of the electricity network business over the next ten years

	Current state 31.12.2023	Forecast 31.12.2033
Energy transmitted in the network area, MWh		
1) Energy transmitted to network service customers	5,789,601	7,902,000
2) Energy received from network service customers	2,928,679	12,170,000
Number of places of use	440,025	450,000
Distributed generation		
1) Nominal power, kW		
1.1) Connected to the high-voltage network	1,246,000	3,986,000
1.2) Connected to the medium-voltage network	150,800	642,000
1.3) Connected to the low-voltage network	130,851	401,000
2) Number of production sites		
2.1) Connected to the high-voltage network	26	75
2.2) Connected to the medium-voltage network	89	526
2.3) Connected to the low-voltage network	16,026	43,053
Number of connections used in public charging of electric vehicles	266	602

2. Demographic development, electrification and renewable electricity production forecasts

During 2023, we carried out new scenario work in cooperation with Vanguard Consulting Oy. This was necessary because the forecast made in 2021 could not take the changed global situation into account. After the war of aggression launched by Russia and the resulting energy crisis, many EU Member States have significantly reduced the use of fossil fuels, invested in self-sufficiency and accelerated the transition to cleaner energy.

Several scenarios were produced to describe how demographic, housing and heating method changes, the electrification of mobility, carbon neutralisation and decentralisation of energy production and the electrification of industry will affect the amount of distributed electrical energy and power needs in Elenia's network area.

The key figure forecasts are based on Finland's national development forecasts, **which have been scaled to match Elenia's network area.** These forecasts serve as the basis for all of our development work:

- Finland's official municipality-specific population projections (Statistics Finland)

Building stock and heating method breakdown

- Long-term renovation strategy 2020–2050 (Ministry of the Environment)

Property and heating method forecast

- Carbon neutral Finland 2035 – measures and impacts of the climate and energy policies (HIISI)

Carbon neutralisation and breakdown of electricity production

- Impact of carbon neutrality target to the power system (Publications of the Government´s analysis, assessment and research activities)
- Fingrid, Network vision

Home and fast charging and heavy charging of electric vehicles

- Impact assessment in National Transport System Plan Environmental report (Ministry of Transport and Communications)
- Annual Climate report (Ministry of the Environment)
- Roadmap to fossil-free transport (Ministry of Transport and Communications)
- Status report on e-mobility Q1/2023 (Technology Industries of Finland)
- Report on charging infrastructure for heavy goods vehicles Identified needs (Ministry of Transport and Communications)
- Programme to improve the distribution infrastructure for new fuels in road transport in Finland by 2035 (Ministry of Transport and Communications)

Electrification of industrial processes

- Technology industry low carbon roadmap 2035 (Technology Industries of Finland)
- Impact of carbon neutrality target to the power system (Publications of the Government's analysis, assessment and research activities)

In addition to national forecasts, Elenia's own studies, actual volumes, growth forecasts and expert opinions were used as background information.

In addition, we cooperate closely especially with the transmission system operator Fingrid and wind power operators. Our development plan is aligned with Fingrid's updated Q1/2024 forecast "Prospects for future electricity production and consumption".

Four scenarios were produced as the outcome of the work, on the basis of which forecasts were created and impacts were analysed:

1) **Slow transition**
- Slower transition than national forecasts.

2) **Normal transition**
- Wind and solar production will grow, and industry and transport will electrify in accordance with national projections.

3) **Rapid transition**
- Wind and solar production will grow, and industry and transport will electrify at a rapid rate based on national forecasts and Elenia's own studies and actual volumes. The migration of customers to exchange electricity will continue according to the current trend.

4) **Faster transition than national forecasts**
- Clean transition faster than national projections. The main emphasis is in large production and consumption projects according to Fingrid's Q1/2024 projection.

On the basis of this extensive scenario work, historical data and recent findings, Elenia has decided to use the rapid transition scenario in its network development plan. The scenario work is presented in more detail in Appendix 18.

Main findings from the rapid transition projection

The population will decrease in Elenia's network area, which may increase network operating costs per customer, especially in sparsely populated rural areas. However, the decrease in population is not directly proportional to the development of the number of customers in the electricity network.

Electricity consumption will increase significantly in Elenia's network area in the rapid transition scenario, especially due to the electrification of industry and transport. Between 2022 and 2023, we have sold a record-high number of industrial-scale electricity connections. The numbers of connection inquiries and sold connections are also many times higher than in previous years.

The increase in electricity consumption will enable Elenia both to increase current distribution volumes and to acquire new customers through electric vehicle charging stations or industrial connections, for example. The energy crisis that began in late 2021 has affected customers' consumption behaviour and the increasing use of exchange electricity. The change in customers' consumption behaviour, as customers direct their consumption to the same low-cost exchange electricity hours, has begun to cause challenges to network capacity.

Production will continue to increase significantly due to the increase in solar power and wind power; for example, about 300 MW of new wind power production was connected to Elenia's network in 2023. Since 2022, a significant number of new electricity storage connections have also been sold to Elenia's network, and their number is expected to continue to grow.

Increasing consumption and production will require significant investments in Elenia's network. With the proliferation of home charging of electric vehicles and loads controlled based on the exchange price, low-voltage networks will require new feeders and feedersplits, new secondarysubstations and increasing transformer capacity. Connecting new large production projects requires additional capacity to the high-voltage distribution network. The increase in both consumption and production capacity requires new substations in Elenia's network area, as well as increasing or duplicating the existing transformer capacity.

Elenia's view for energy transmitted in the network area

According to the rapid growth scenario, the gross consumption of electricity in Elenia's network area will increase by approximately 35 per cent in ten

years. Electricity consumption will increase, in particular, by the electrification of energy-intensive industries, transport and heating. The processes that are electrified to reduce emissions from industry will increase electricity consumption most, according to estimates especially in chemical and food industries. Small industry is estimated to offer less potential as process electrification has already taken place there. In addition, more electricity will be consumed in the heating of homes when other fuels are replaced by heat pumps. Consumption is curbed by declining demographic trends, improved energy efficiency and volatile market prices of electrical energy.

Wind power capacity is expected to triple and solar power generation to increase at least fourfold over the next ten years. Additional wind power capacity is expected especially in North Ostrobothnia and Central Finland but also increasingly often in other network areas. Our website features a map showing all completed wind farms connected to Elenia's network as well as wind farms under construction. The increase of solar power generation is expected to be divided in Elenia's network area in proportion to the current production capacity.

Population and places of use

It is estimated that the total population in Elenia's network area will decrease by approximately 4 per cent over the next ten years. The decrease is particularly strong in Elenia's northern areas, while population is expected to increase in the municipalities surrounding Tampere and Seinäjoki.

The connections to be dismantled are individual houses in sparsely populated rural areas and the new connections are often in terraced houses or blocks of flats in growth centres where the electricity connection consists of several places of electricity use. E-mobility and especially public charging stations will also increase the number of connections or, alternatively, existing connection capacity.

During the COVID-19 pandemic, we have witnessed the revival of rural areas as increasing new leisure-related places of use and the re-activation of passive places of use. This is believed to have impacts on leisure housing and multilocality. The number of inhabitants and places of use are not decreasing at the same rate in different regions. A study by the Lappeenranta University of Technology[1] indicates that if the place of electricity use is located near a body of water, it is more likely to remain in use. Elenia's own findings support the findings of this study.

Population decline in Elenia's network area does not directly mean that the number of customers, i.e. the number of places of use, would decrease. According to our estimate, there will be no major changes in the number of Elenia's places of use over the next ten years.

Electrification of transport

In July 2021, the European Commission published the Fit for 55 package of proposals for climate change legislation to help the EU achieve a 55-percent reduction in net emissions by 2030. The package contains 13 legislative proposals. The Alternative Fuels Infrastructure Regulation, aiming at the reduction of emissions from transport, provides distribution system operators with a framework for the development of the future electricity network.

The Regulation contains requirements for different charging speeds and vehicle types, specified by road type. The Regulation discusses the TEN-T core network, which in Finland means 1,100 kilometres of road: roads 4 and 5 from Helsinki to Jyväskylä and via Oulu to Tornio and the West-East road connection from Naantali to Vaalimaa. More than 200 kilometres of road 4, belonging to the TEN-T core network, is located in Elenia's network area. Practically all Finnish roads with numbers consisting of one or two digits belong to the TEN-T comprehensive network. Hundreds of kilometres of roads belonging to the comprehensive network are located in Elenia's network area.

[1] *Lassila, Jukka et. al. Joustava ja toimintavarma sähköverkko – Asiakaskatoriski ja käyttöpaikkakohtainen toimitusvarmuus.* Available here

Home and away charging

By 2035, the target for electric vehicles in traffic in Finland is more than one million fully electric cars and more than 350,000 plug-in hybrids, which corresponds to about one-half of Finnish cars. We estimate that about 14 per cent of these cars will be connected to Elenia's network area with steadily accelerating growth.

Elenia has made a calculator for customers to check how much available capacity the connection has for electric vehicle charging devices. Dynamic load management devices are also commonly used to make more efficient use of customers' connection capacity.

The increasing use of home and away charging is challenging the capacity of the distribution network due to the increased use of exchange electricity, as consumption is allocated to the same low-cost hours.

Slow charging

For every fully electric vehicle registered, a total power output of at least 1 kW must be provided through publicly accessible charging stations. For hybrid vehicles registered, this requirement is 0.66 kW. This requirement will be reviewed annually starting from the entry into force of the Regulation. In Finland, there is no need to make separate investments with regard to the slow charging requirements as we already have a lot of parking spaces with power for car heating.

Fast charging

Along the TEN-T core network, there must be public charging pools for passenger cars with a maximum distance of 60 km between them. By the end of 2025, each charging pool must offer a power output of at least 300 kW and include at least one charging station with an individual power output of at least 150 kW. By 2030, each charging pool must offer a power output of at least 600 kW and include at least two charging stations with an individual power output of at least 150 kW.

The TEN-T comprehensive network must have public charging pools at the same intervals as the core network. The power outputs of charging pools and individual charging stations are also subject to equivalent requirements, but the schedule is set 5 years later than in the core network area.

Considering the current situation, the requirements seem to be very appropriate and the market is naturally guiding the development in this direction. The power required for charging passenger cars is not a major challenge for Elenia's network. However, it must be taken into account in the electricity network development plan.

Along the TEN-T core network, there must be public charging pools for heavy-duty vehicles with a maximum distance of 60 km between them. By the end of 2025, each charging pool must offer a power output of at least 1,400 kW and include at least one charging station with an individual power output of at least 350 kW. By the end of 2030, each charging pool must offer a power output of at least 3,500 kW and include at least two charging stations with an individual power output of at least 350 kW. In the TEN-T comprehensive network, the requirements for public charging pools are equivalent but the schedule is set 5 years later than in the core network area. In addition, charging requirements are proposed for the parking and rest areas and urban nodes for heavy-duty vehicles. The proposed power output requirements are 100–150 kW for one charging point and 100-1,200 kW as the total power output but the proposals do not include a guideline for the distance between charging facilities.

At the moment, the proposal for heavy-duty vehicles seems ambitious in the Finnish operating environment as the electrification of heavy traffic has not started in the same way as for passenger cars. Electrification has started from the short-distance fleet such as urban bus transport and delivery trucks. This is still a long way from the electrification of the long-distance fleet, which requires efficient charging pools and the electrification of rest areas. As the electrification of heavy traffic becomes more widespread, it will require significant network development as the distribution of several megawatts over the medium-voltage network is not a sensible option or even possible over long distances.

3. Impact of weather events and changing climate on Elenia's electricity network

Elenia's electricity network is geographically very extensive, spanning approximately 600 km in the north–south direction and 200 km in the west–east direction in eight provinces from Hailuoto to Karkkila. The network area is mainly forested and lake regions of Finland. The geographical location, altitude differences, the abundance of forests and lakes and the short distance to sea areas expose the electricity network to various strong weather events. On the basis of history and statistics, it can be said that Elenia's electricity network is geographically located in the area that is the most susceptible to major power disruptions in Finland.

Elenia has compiled detailed documentation about the impacts of major weather events on its operations. During the last five years (2019–2023), our electricity network has been subject to 16 major power disruptions and numerous minor disturbances due to low-pressure storms, thunderstorms and snow loads. Contingency planning has been initiated a total of 42 times during the above-mentioned period. Major power distribution disruptions have occurred at a steady rate each year and this can be expected to continue. Extreme weather events are causing power outages, which may last for several days, to customers in Elenia's electricity network. In 2023, for example, there were several storms where the long duration of the storm required postponing the restoration of power and the start of fault repair by a maximum of more than 12 hours due to conditions that compromise occupational safety.

According to the Finnish Meteorological Institute's estimate, the intensity and number of storms, as such, will not increase but their impacts will become more significant, especially when it comes to soil frost and rainfall. The ground will be more wet due to higher rainfall and higher temperatures during the winter months, which prevents the formation of soil frost. Due to these factors, roots do not provide trees with as good protection against falling due to wind as before. Rainfall will increase also in the winter period and will be more intense both locally and temporally, resulting in higher occurrence of heavy snow loads. The above conclusions are also supported by the Finnish Climate Change Panel's report 2/2021, "Ilmastonmuutokseen sopeutumisen ohjauskeinot, kustannukset ja alueelliset ulottuvuudet"[2] (Steering measures, costs and regional dimensions of climate change adaptation). According to the report, there will be a clear decrease in the amount of soil frost throughout Elenia's network area, with the exception of North Ostrobothnia, and an increase in rainfall in the entire network area, also in the winter, which increases the risk of snow loads.

Based on regional risk assessments prepared in 2023,[3] storms, floods, forest fires and other extreme weather events are seen as potential risks in Elenia's network area. Because the overwhelming majority of power outages experienced by customers are caused by weather events and natural phenomena, it is expected that there will be more disturbances in the overhead line network due to climate change. In addition, the costs caused by faults in the electricity network and major power disruptions are significant, as contingency planning, electricians and special equipment are needed regardless of the season or the time of day.

---

[2] *Gregow, H; Mäkelä, A et. al. Suomen Ilmastopaneeli raportti 2/2021)* Available here

[3] *Regional risk assessments* Available here

4. Development of the operating environment over the next 10 years

This section presents other operating environment changes over the next ten years, as identified by Elenia.

Customers' zero-emission expectations

Customers are increasingly aware of the impacts of climate change and biodiversity loss and are more actively following the sustainability targets and actions of energy industry operators. Sustainability issues must be taken into account in operations and decision-making.

We have set the targets for reducing the greenhouse gas emissions of our own operations in accordance with the Paris Climate Agreement, and the international Science Based Targets initiative has validated Elenia's climate commitment. According to the validated target, Elenia will reduce its greenhouse gas emissions by 42 per cent by 2030, including Elenia's own emissions and emissions arising from purchased energy. The target that we have set for ourselves is even more ambitious in this respect: Reducing the emissions of our own operations by 75 per cent, using 2020 as the baseline, by 2030.

In addition, Elenia is committed to setting Net Zero targets that cover not only the emissions from Elenia's own operations but also the emissions generated by the entire value chain. The Net Zero targets must be met by 2050 and in practice this means a reduction of approximately 90 per cent in emissions for the company's entire value chain. For Elenia, this means that climate targets will not only be pursued in the company's own operations but also incorporated into procurement decisions. Low-emission requirements apply to the purchasing of energy to cover network losses as well as to the contracting and maintenance purchases of network construction. The purchase of materials for the electricity network, in particular the underground cable

supply chain, also plays a significant role. By committing to climate action, we respond to the increasing expectations of customers and society with regard to combatting climate change, and we want to lead the way for the whole industry.

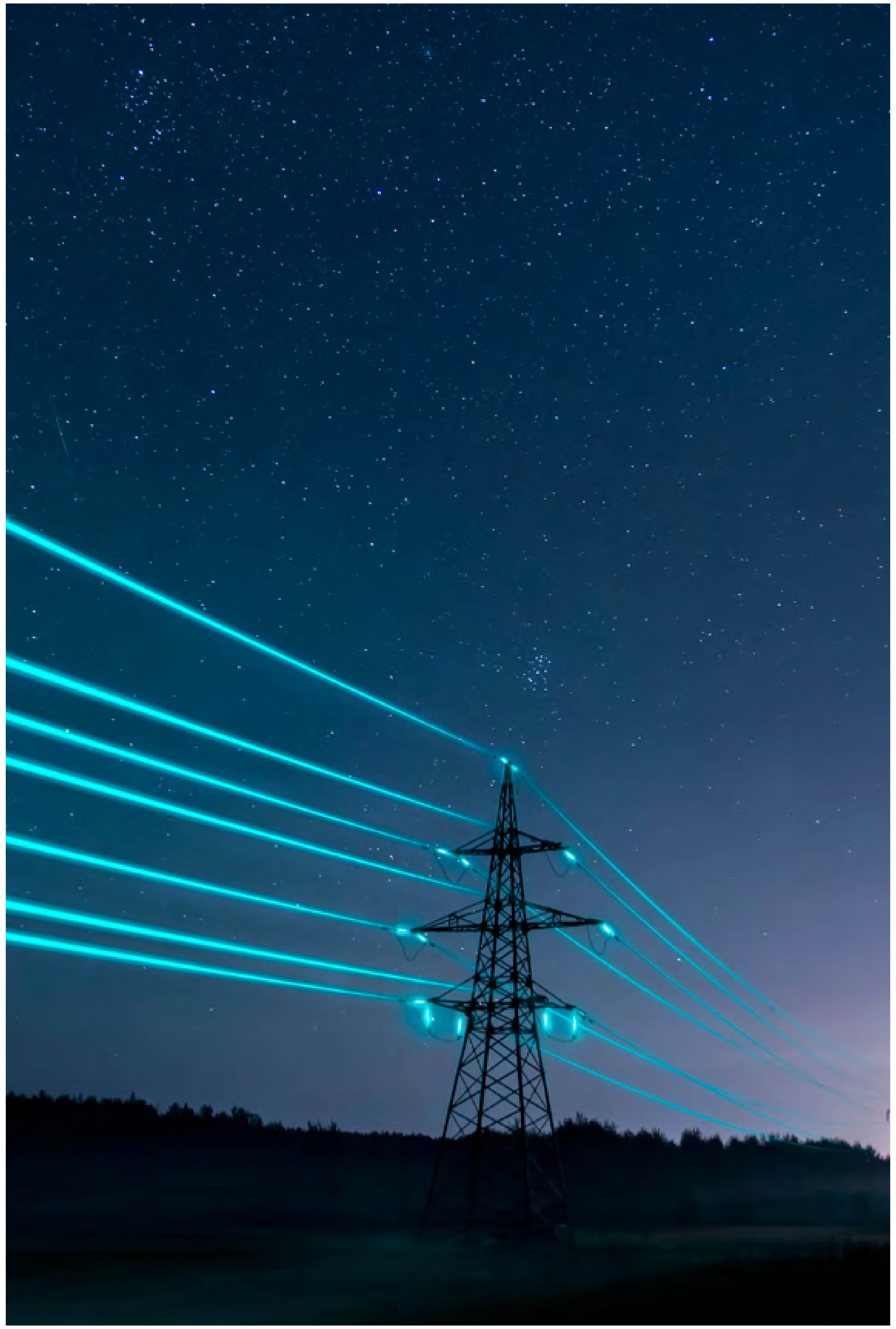
We have published the carbon footprint of Elenia's electricity network services in our sustainability report. Our customers can directly calculate the carbon footprint of their network service use by multiplying their own consumption by this amount of carbon figure. Industrial customers in particular calculate and report information forward through their own channels, so the information can now be found publicly. Reducing the emissions of our electricity network services naturally reduces the carbon footprint of each of our customers.

Partnerships and competence needs

Elenia's operations and service production are based on versatile partner networks. As a network builder, Elenia Group purchases network construction and maintenance services from the open market. The Group companies do not have their own installation operations or ownership stakes in the service market. In cooperation with our partners, we have created a solid foundation for well-functioning services. Our model has proven to be effective in customer projects, investment projects, network maintenance and exceptional situations caused by power outages.

Maintaining the functionality and competence of the partner network is of paramount importance from the point of view of security of supply, which is described in more detail above. As power outages caused by storms and snow loads cannot be completely eliminated, we are constantly developing efficient fault repair operating models with our partners to ensure security of electricity supply. The operating models are finetuned to be as effective as possible and they can be used in day-to-day operations in the event of extreme weather phenomenon/condition but they also guarantee our ability to respond to other crises. Competence associated with making repairs to the overhead line network will be a challenge for the entire industry as investments are justifiably focused on the underground cable network while overhead line experts retire. Future investment conditions should be favourable to make it possible for network construction companies to use apprenticeships, among other things, as a way to ensure the continuity of competence.

The role of digital systems is growing and, as a result, new skills are required from network technicians. An increasing amount of real-time information is produced on network development and maintenance, enabling better service to network users. Customer expectations regarding service provided to them will increase in the future, which will require better customer service skills from network technicians, too.



Security of supply and contingency planning

According to both national and regional risk assessments, energy supply disruptions are identified as key risks to society's ability to function and overall security. Electricity distribution plays an important security of supply role in today's society and enables the functionality of infrastructure that is critical for society, such as telecommunications and water supply. With long-term investments in the electricity network, we can significantly improve the day-to-day security of electricity supply visible to customers, but also the backup connections and distribution capacity required due to exceptional disturbances. Investments enable us to maintain the structure that consists of fault repair expertise, the spare part supply chain, the equipment needed for rebuilding and efficient operating models. This structure serves the tasks required by normal conditions as well as emergencies.

Contingency and preparedness plans are Elenia's key tools when it comes to ensuring the security of supply and being prepared. These plans have been used both in major electricity distribution disruptions, the COVID-19 pandemic, Russia's war of aggression as well as the elevated risk of electricity shortages. The plans will be updated the next time by June 2025 and submitted to the Energy Authority for evaluation.

Our short-term goals for increasing the security of supply and preparedness capability are especially related to improving the cyber security of our systems and the physical security of our electrical equipment. In addition to these measures, our goal is to practise a wide range of risk and threat scenarios both independently and with stakeholders.

Elenia continuously cooperates extensively in terms of security of supply, both regionally and nationally. We work in numerous working groups in the sector, participate in various contingency planning and preparedness exercises, and familiarise our stakeholders with matters related to the security of electricity supply and preparing for power outages. Elenia has a steering group that coordinates contingency planning and security of supply issues and meets regularly.

Cyber security requirements

Cyber security requirements have increased strongly in recent years and are perceived to continue to grow. EU-level regulation, such as the NIS2 directive and the NCCS network code, tighten up the requirements of the sector and also impose financial sanctions in order to guide operations. At the same time, the geopolitical situation continues to be challenging and the technological race between cyber threats and protection against them is accelerating. For example, the use of artificial intelligence increases the number of cyber attacks and requires additional investments, for example, in identifying phishing messages and training the organisation.

From the point of view of digital systems, cyber security requirements are complex. As requirements change and cyber security solutions evolve, the pressure to shorten the lifecycle of systems is high. Continuous monitoring of the cyber security situation, especially cyber security reviews and audits related to changes in systems and software, identifying and monitoring threats, as well as the often large-scale implementation of security updates, increasingly require both human and financial input.

Since 2020, our operations at the company level have been guided by a certified ISO/IEC 27001 information security management system. Cyber security-related risk assessment, the implementation of management methods and the continuous development of operations are part of day-to-day life. National cooperation, information exchange and contingency planning exercises with both the authorities and other parties in critical infrastructure are active and are perceived to continue to be active in the future.

5. Amendments to the 2022 development plan

Elenia submitted the previous electricity network development plan in 2022. Already at that time, the effects and, to some extent, the challenges of the clean transition were visible, but the change has been significantly faster in the last two years than estimated in the previous development plan. Underlying megatrends are the transition from fossil energy produced by combustion to renewable energy in accordance with climate targets and, on the other hand, the challenges brought about by the new energy system. New connections to Elenia's distribution network have been sold for renewable energy production plants, energy storage facilities operating in the frequency control market, as well as charging stations for electric cars and electric district heating boilers that represent new types of electricity consumption. On the other hand, as a result of Russia's war of aggression and the 2022 energy crisis, many consumers who previously preferred fixed-price contracts switched to exchange-based electricity contracts of their own accord, or in the absence of alternatives. At the same time, a significant increase was seen in the number of fully electric cars, and record-high electricity prices inspired private customers to invest in solar panels at an accelerating pace. From a network company's point of view, these new consumption and production units pose a challenge, as the statutory connection obligation guarantees that everyone can connect to the network, but from the distribution system operator's point of view, they almost always require changes, new components and construction. While the consumption of private customers was previously randomly spread over different hours of the day, now consumption increasingly takes place during the lowest-priced hours of exchange electricity. Simultaneous charging of electric cars and other high-power consumption has already caused bottlenecks in some transformer areas. At the same time, interest in connecting new industrial-scale consumption and production to the high-voltage distribution network and medium-voltage network has increased significantly compared to the situation two years ago. In Elenia's view, the change towards a carbon-neutral energy system that has now begun will only accelerate in the coming years and decades.

In accordance with the development plan submitted to the Energy Authority in June 2022, Elenia's investment plan for 2022–2036 was in total 2 billion Euros . This consisted above all of investments in security of supply, safety and new electricity connections, as the estimate included investments in the clean transition only to a moderate extent. In practice, these have included known wind power projects over the next few years, small-scale solar power projects and new smart meters. Elenia has worked persistently for the security of supply of customers and therefore the investment need for security of supply, security and new electricity connections in accordance with the 2024 development plan has remained proportionally at the same level. In contrast, the investment need for the clean transition has increased significantly, amounting to well over EUR 500 million in 2024–2036. Therefore, the total investment need in Elenia's electricity network in 2024–2036 is approximately EUR 2.4 billion.

Starting point for the electricity distribution network development plan

Defining the electricity distribution network development zones

We have divided Elenia's electricity network into seven development zones, each of which is a separate entity in the development plan. In the division of the development zones, attention has been paid to the operational quality requirements in accordance with section 51 of the Electricity Market Act, the topology of the existing network and the target-state network as well as geographical characteristics. The development plan's cost comparisons and selected actions, together with their schedules, are presented separately for each development zone. Each part of the network belongs to a single development zone.

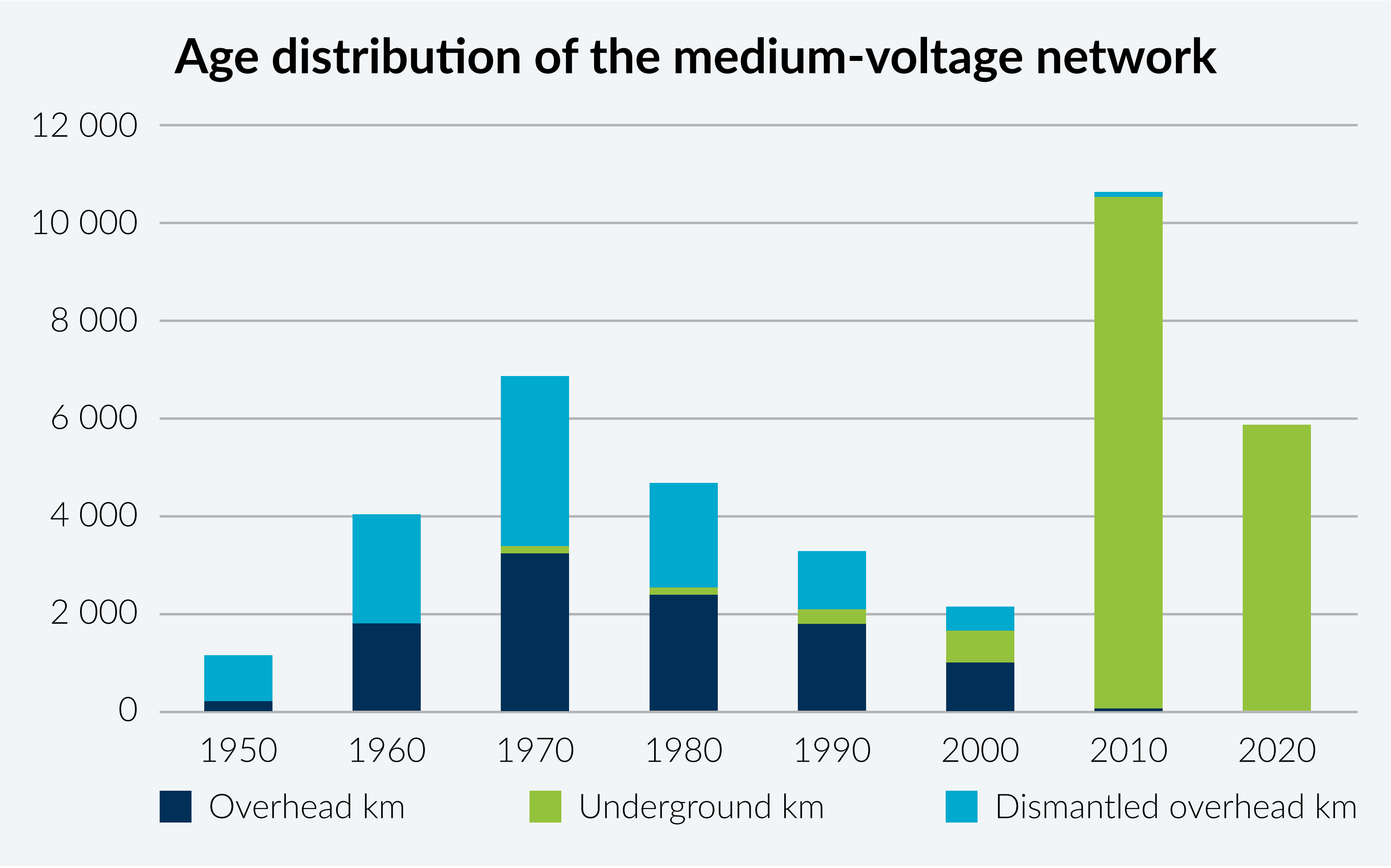


Figure 1: Age distribution of the medium-voltage network by decade

The age and condition of Elenia's electricity network varies a great deal, and the network is spread over a very large geographical area and is subject to different conditions. The age distribution of the medium-voltage network is shown in Figure 1, indicating that there are still a lot of ageing overhead medium-voltage network left. Since 2010, we have been upgrading significant amounts of aging overhead line network. The age distribution of the overhead lines dismantled in connection with the upgrading is also shown in the figure.

Due to the extent of our network area, we have considered it appropriate to divide our network into several parts so that each development zone becomes a manageable entity and that cost comparisons and actions can be justified with sufficient precision.

Our seven distribution network development zones are:

1. Urban areas
2. Densely populated areas
3. Trunk line connections between densely populated areas
4. Trunk line connections in sparsely populated rural areas
5. Spur line (furthest parts of the network) in sparsely populated rural areas
6. Overhead line network to be maintained in sparsely populated rural areas
7. Demand response solutions for the security of supply

As the high-voltage distribution network extends into nearly all of these development zones, it is treated as an entity separate from the development zones.

Modern information systems, automation and smart metering devices play an important role in the monitoring, maintenance and development of Elenia's electricity network and in the management of fault situations. The strategic development of this whole is a prerequisite for efficient and timely action now as well as along with the changes in the electrification of society described in section 1. The development plan describes actions that encompass the entire network area regarding information systems, automation and smart metering devices, and it is not meaningful to divide these actions by development zone.

Description of the development zones

Information systems, automation and smart metering devices

Achieving the security of supply targets does not only require traditional network investments, but also efficient use of the electricity network and fault management. In Elenia's electricity network, efficiency has been increased especially through the use of automation devices, smart metering devices and information systems. At the beginning of 2024, Elenia's network already features almost 11,000 remote-controlled switchgear devices and more than 4,000 fault indication devices. In addition, we have made long-term investments in advanced substation protection device technology. These technologies, combined with partially autonomous information systems that efficiently combine data, create a comprehensive overview of the situation and guarantee the efficiency of our operations. In practice, in the event of a fault in the electricity network, this enables the restoration of electricity supply to over 80 per cent of the affected customers on average in less than 15 minutes with the aid of remote-controlled switchgear and electricity network stand-by supply connections. Together with our contractor partners and information system suppliers, we have also actively developed information systems that make field work more fluent, with the aim of speeding up and enhancing final fault repair and power recovery for customers affected by outages. We continue to increase the automation of our electricity network as part of the electricity network investments, taking into account the requirements and characteristics of the different development zones.

Smart metering devices have been part of Elenia's operations for more than a decade. Their features have been used not only to meter customers' consumption of electrical energy but, in particular, also to manage electricity network faults and support investment planning. The installation project of the new generation of metering devices, which began in 2021, is now reaching the home stretch, as one-half of Elenia's customers had already received a new electricity meter in 2023. These metering devices enable many new energy management features that are offered directly to the customer. For example, the customer can schedule the load control relay in the meter to turn on the water heater or other device of their choice at the lowest-priced exchange electricity hours of the day or monitor their electricity consumption in almost real time. Next-generation smart electricity meters and the services they make possible are a significant leap in the energy transition.

According to clean transition forecasts, renewable energy production will increase at all voltage levels. The increase in weather-dependent production and, on the other hand, fluctuations in consumption make the operation of the electricity network increasingly challenging. On the other hand, an increasing volume of real-time data is available from the network, which can be used in network monitoring and preventive maintenance, and the resulting data can even be used to identify incipient power grid faults. However, the management of the new kind of electricity system required systems to help people. Elenia is actively developing operational systems to respond to these challenges.

High-voltage distribution network

Elenia's 110-kilovolt high-voltage distribution network is scattered throughout Elenia's network area and does not constitute a coherent entity. Elenia also has numerous power line connections directly to the network of the transmission system operator Fingrid. Our website features a map where you can see Elenia's high voltage distribution network and the wind power generation connected to it.

Technical characteristics of the high-voltage distribution network

The majority of Elenia's high-voltage distribution network is located in sparsely populated rural areas and consists of overhead lines. The network has a partly looped structure but is used as a radial network. The operational reliability of branch lines in the high-voltage distribution network is secured with medium-voltage stand-by supply connections. Previously, network capacity was determined on the basis of the use of electricity in sparsely populated rural areas and thus it does not, as such, allow large-scale wind power generation, for example, to be connected to it. From the perspective of the high-voltage distribution network, electricity consumption needs have traditionally been very stable and power levels moderate.

The fact that the network is located in sparsely populated rural areas makes it possible to build the high-voltage distribution network mainly as overhead lines. In urban and densely populated areas, the high-voltage distribution network is also built with underground cabling, on a case-by-case basis.

Impacts of operating environment changes on the high-voltage distribution network

Changes in the operating environment of the high-voltage distribution network are contemplated in close cooperation with the transmission system operator Fingrid, other high-voltage distribution network operators and customers.. The increasing volume of renewable energy production will require investments in the high-voltage distribution network, including parts of the network, where there would not have been otherwise a need for investments in such a fast schedule or on such a large scale. Energy-intensive industry is expected to be located in industrial areas near growth centres, which will require an increase in the capacity and security of electricity supply in the high-voltage distribution network in these areas. In addition, the requirements for heavy traffic charging infrastructure laid down in the European Union's Fit for 55 climate legislation proposal will put pressure on the high-voltage distribution network and the capacity of main transformers will need to be increased in some substations.

1. Urban areas

Urban areas consist of the zoned central areas of larger cities, which are either clear grid-plan areas or otherwise very densely built urban environments. At the moment, such areas in Elenia's network area are the grid-plan areas of Hämeenlinna and Heinola city centres. According to section 51 of the Electricity Market Act, after 2036, the maximum allowed power outage in this development zone is 6 hours.

Technical characteristics of the development zone and the use of electricity

In urban areas, the electricity network is densely built and distances are short. The area's electricity network has been built as an underground cable network already decades ago, and consequently, some of the structures have already exceeded their useful life. Because the area is densely built, many secondary substations have been and will continue to be placed inside properties as indoor secondary substations. Due to alterations and changes made over the years, the age structure of the electricity network is very varied.

The electricity network of the development zone is looped and at least two alternative feed directions are built for all secondary substations. In maintenance and fault situations, this allows electricity distribution from an alternative direction. The low-voltage network is also extensively built with underground cabling as a ring network to support the replacement of a single distribution transformer in maintenance and fault situations.

In urban areas, the energy and power intensity is high. Buildings are usually heated by means other than electricity.

Environmental factors in the development zone

Urban areas are characterised by a very dense building stock and public areas are almost entirely paved or asphalted, with large numbers of people moving around. There is also plenty of other underground infrastructure in the area. For these reasons, it is not possible to carry out major construction projects; instead, infrastructure is built and upgraded a little at a time in order to minimise the inconvenience caused. In construction projects, it is important to replace the entire infrastructure of the project area as joint construction in order to minimise the inconvenience in a single area during the project. The upgrading of indoor secondary substations is primarily carried out in cooperation when the buildings are renovated.

The zoning of the areas sets strict requirements for how the electricity network can be built and what kind of structures are allowed: cables must be underground and secondary substations must mainly be placed inside properties as indoor secondary substations. Due to the building density and lack of space in public areas, cables are often placed in the street area and even in street structures, in which case the cables must be protected by placing them in pipes or canals. Another consequence of the building density is that in connection with earthworks in the development zone, it is not possible to deposit removed soil on the site; instead, it must be transported away from the site and then back again.

Impacts of operating environment changes on the development zone

The car fleet and heating in the development zone will be electrified, which will pose a challenge to the current connection capacity of housing companies and electricity network of the property, which is owned by the customer. The municipalities surrounding the growth centres in Elenia's network area, especially in Pirkanmaa, are becoming more densely built and, therefore, it can be expected that these areas will meet the definition of an urban area in the future.

Solar power generation in urban areas is expected to increase. It is likely that electricity is consumed near small-scale production, which means that energy distribution distances are short and technical challenges do not emerge in the distribution network.

2. Densely populated areas

All zoned areas outside urban areas, apart from areas zoned with detailed shore plans, are considered densely populated areas. The areas are clear-cut and manageable but their size and shape vary highly/widely . At the smallest, the areas consists of only a few real estate properties or even just one but, at the largest, they cover an area of several square kilometres or form ribbon-like areas extending over several kilometres. Typically, the areas are also developing intensively. Land use develops within the areas and they also usually expand through the implementation of new zoning. According to section 51 of the Electricity Market Act, after 2036, the maximum allowed power outage in this development zone is 6 hours.

Technical characteristics of the development zone and the use of electricity

The electricity networks of densely populated areas have been built over time, using different principles and structures and in many places as a mixed network. The overhead lines of the mixed networks have mainly been replaced with underground cables, at least for the medium-voltage network, over the last ten years.

Kiosk-style secondary substations are commonly used in densely populated areas. Especially in the old network, there are also individual indoor secondary substations which are replaced, as far as possible, with kiosk-style secondary substations.

The medium-voltage network in densely populated areas has been built with underground cabling starting from the feeding substation and as a ring network. The low-voltage network has been built with underground cabling, partially as a ring network, and the connectivity of reserve capacity has been taken into account in the low-voltage network structures. A single transformer area can be replaced with a combination of stand-by supply connections and reserve capacity in potential maintenance and fault situations.

The energy and power intensity of the areas varies but is rather high, especially in industrial areas.

Environmental factors in the development zone

The areas have a fairly dense building stock but, as a rule, secondary substations can be built as kiosk-style secondary substations. The cables and equipment are mainly placed on the edge of the street area or in the strip between the street and the pedestrian and cycle route, for example, but in some places, cables also have to be placed in street areas and structures, which requires that the cables must be protected by placing them in pipes.

The zoning of the areas sets strict requirements for how the electricity network can be built and what kind of structures are allowed: cables must be underground and secondary substations must be kiosk-style secondary substations. Typically, zoning also sets requirements for the permitted locations of aboveground structures and the appearance of structures.

Impacts of operating environment changes on the development zone

In the old network, typical for these areas, electric heating is common. In addition, various heat pump solutions are becoming more common in areas with old heating networks as well as in new areas that are being built. In industrial areas, the use of electricity is expected to increase along with the electrification of industrial processes.

Small-scale production, in particular solar power, will increase significantly and electric cars will become more common, especially in zoned areas surrounding major growth centres. Increasing solar power generation will not pose extensive problems in densely populated areas as it is likely that electricity is consumed near small-scale production, which means that energy distribution distances are short and technical challenges do not emerge in the distribution network. The electricity consumption of properties has been determined on the basis of winter months and peak demand will probably not exceed this.

3. Trunk line connections between densely populated areas

The trunk line connections built between substations ensure the undisturbed electricity distribution to densely populated areas if the substation feeder or the transmission line feeding it is down due to maintenance or a fault. Substations are mainly located in the immediate vicinity of densely populated areas but some of them are also placed outside densely populated areas in order to ensure capacity and develop network management and security of electricity supply. This development zone is located in sparsely populated rural areas and, according to section 51 of the Electricity Market Act, after 2036, the maximum allowed power outage in this development zone is 36 hours. In addition, this development zone plays a significant role in ensuring the 6-hour security of electricity supply in densely populated areas.

Technical characteristics of the development zone and the use of electricity

Elenia's substations are mainly equipped with one main transformer and one main busbar. Consequently, in the event of downtime due to maintenance or a fault, the substation's stand-by supply is arranged from other surrounding substations over solid trunk line connections. The medium-voltage network in the development zone has previously consisted almost completely of overhead lines and it still partly is. The upgrading method used in the development zone is underground cabling.

The capacity under the normal switching situation in the development zone does not differ significantly from other sparsely populated rural areas but power transmitted in stand-by supply situations can be several times higher than under normal circumstances. As a result, the capacity of the network has been determined to be higher in other sparsely populated rural areas.

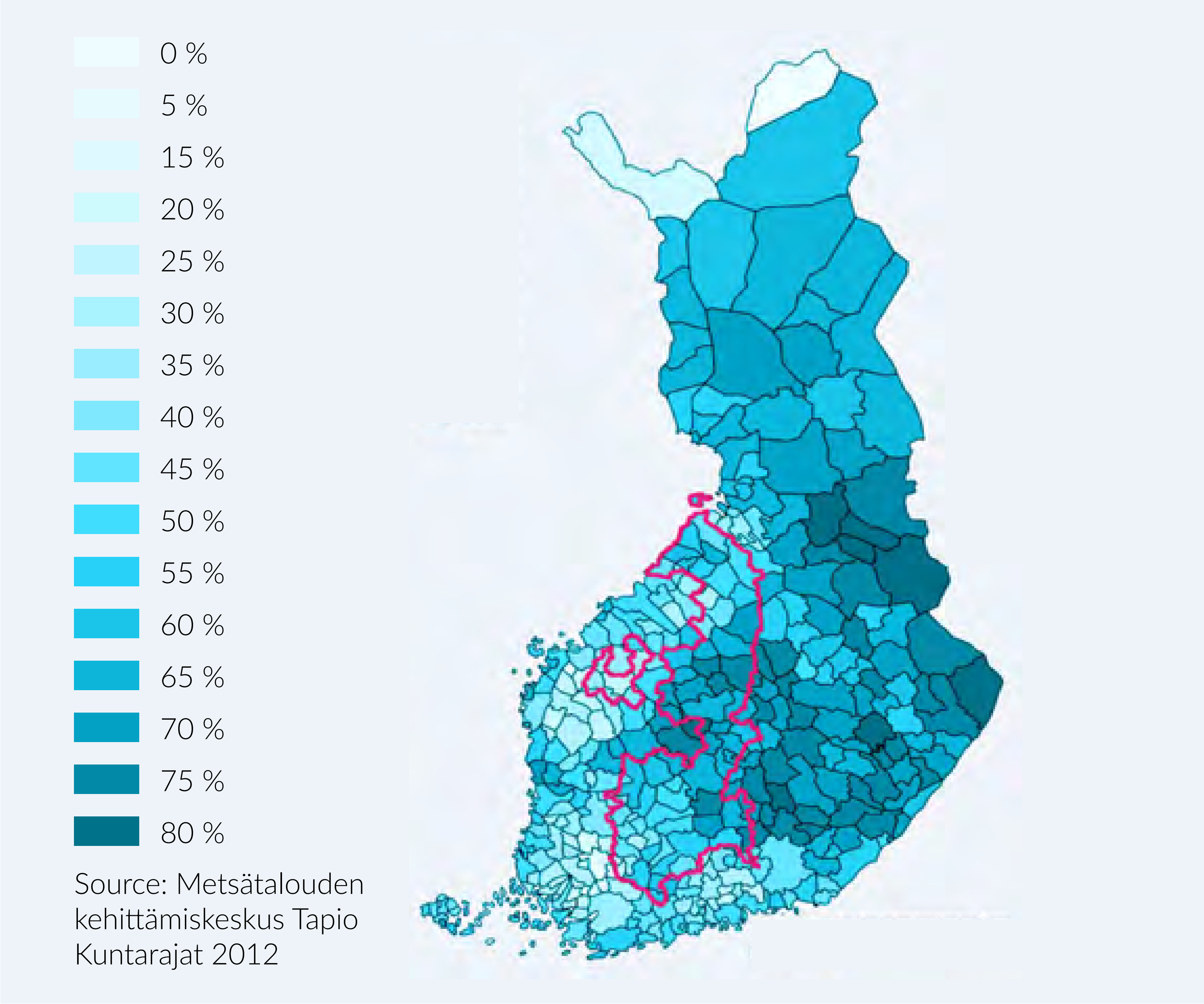


Figure 2: Forest coverage percentages in Elenia's network area

The energy and power intensity of the development zone varies a great deal depending on population density and the environment. Consumption comes mainly from detached houses and agriculture and, to a small extent, from small industry. As a rule, there are no large concentrations of power consumption; instead, consumption is largely distributed along the network in a ribbon-like manner.

Environmental factors in the development zone

The environment and soil vary significantly in different parts of the development zone. The main principle is that the lines and equipment are placed along roads and on the edges of fields or plots. In determining the location of the network, attention must always be paid to soil conditions that are favourable for installation. Rocky terrain can be circumvented in places, provided that the electrotechnical preconditions are taken into account.

Figure 2 shows Finland's forest coverage percentages, with Elenia's network area highlighted. It can be seen that Elenia's network area is mainly located in very forested areas.

Impacts of operating environment changes on the development zone

Due to the forest coverage in the development zone and climate change described in Annex 1, it is justified to expect that impacts on the overhead line distribution network will be stronger. Taking into account the role of the development zone, it can be noted that the overhead line network does not meet the requirements set regarding security of electricity supply.

In the development zone, the impacts of the electrification of industrial processes, heating and transport can be seen as the expectation of more secure electricity distribution as well as higher power levels, especially in maintenance and fault situations. Electric vehicle charging pools usually require a medium-voltage network and a secondary substation near them. In order to assess the impact of these factors, Elenia has modelled and calculated the impact of e-mobility on the electricity network as part of extensive scenario work.

4. Trunk line connections in sparsely populated rural areas

The key trunk line connections in sparsely populated rural areas normally feed a relatively high level of power and thus serve a significant number of customers.

Technical characteristics of the development zone and the use of electricity

The network of the development zone is extensively looped, so that in case of failure of a single line section, it is possible to restore the electricity distribution to customers outside the fault area by means of operation measures. The network of the development zone differs from trunk line connections between densely populated areas in that it does not function as key substitute links between densely populated areas or substations.

Previously, the network of the development zone was built as an overhead line network. The network has been systematically upgraded since 2013, from substations onwards. The network of the development zone mainly feeds power the spur line (the furthest parts of the network) in sparsely populated rural areas, the overhead line network to be maintained and the "demand response solutions for the security of supply" development zone.

The development zone contains, for example, village concentrations typical of sparsely populated rural areas. The energy and power intensity varies depending on population density and the environment. Typically, there are no large concentrations of power consumption; instead, consumption is distributed along the network in a ribbon-like manner. Electricity consumption comes mainly from detached houses and agriculture and, to a certain extent, small industry.

Environmental factors in the development zone

The environment and other environmental factors are equivalent to those of trunk line connections between densely populated areas.

Impacts of operating environment changes on the development zone

In the development zone, the impacts of the electrification of heating and transport can be seen as increasing power and the electricity users' expectation of better security of electricity supply. Locally important small-scale production facilities, particularly in agriculture, place increasing demands on the capacity of the network.

Figure 3: Places of use on the shores and islands of Päijänne

5. Spur line in sparsely populated rural areas

The development zone consists of the spur line (the furthest parts) of the cable feeder network and the branch networks connected to other development zones.

Technical characteristics of the development zone and the use of electricity

To begin with, the network of the development zone was built as an overhead line network. The age structure of the network is very varied. The network of the development zone has been upgraded on the basis of its age and condition over the years, in connection with projects in other development zones.

The network of the development zone has a looped structure in some places but it is also typical to have only one feed direction without the possibility of backup supply.

There is a wide range of places of use and varying electricity needs in the development zone. The development zone contains a lot of detached houses and agriculture. In addition, the development zone also contains a significant amount of leisure housing.

Environmental factors in the development zone

The environment and soil of the development zone are partially equivalent to those of trunk line connections between densely populated areas and in sparsely populated rural areas as well as those of the overhead line network to be maintained in sparsely populated rural areas.

In addition to the above, there are lakes and islands in the development zone, which are challenging in terms of fault susceptibility and fault repairs. The second largest lake in Finland, Päijänne, is largely located in the development zone. Figure 3 highlights the places of use on the shores and islands of Päijänne: more than four hundred places of use in nearly one hundred separate island locations.

Impacts of operating environment changes on the development zone

The impacts of the operating environment change forecast are different in different parts of the development zone. On one hand, the impacts of the electrification of heating and transport can be seen in the development zone as increasing power and the expectation of better security of electricity supply. Locally important small-scale production facilities, particularly in agriculture, also place increasing demands on the capacity of the network. On the other hand, there are areas in the development zone where the use of electricity remains unchanged or even decreases slightly. Places of use near a body of water typically remain in use and even more of them are built.

6. Overhead line network to be maintained in sparsely populated rural areas

We have identified sections of our network that are justified to be remained as overhead lines until the end of their life cycle from the point of view of the age and condition of the network and the development of electricity use.

Technical characteristics of the development zone and the use of electricity

The characteristics of the development zone are mainly equivalent to those of the spur line in sparsely populated rural areas. The most significant difference is the structure and lifecycle phase of the network of the development zone. The network in the development zone is an overhead line network, with more than 10 years of its technical useful life still remaining. Consequently, the development zone is subject to less upgrading pressure than other development zones and, on the other hand, it is justified to carry out more far-reaching and comprehensive maintenance management actions for the network of the development zone than for an electricity network that is at the end of its lifecycle. The electricity consumption, environmental factors and operating environment changes of the development zone are equivalent to those of the spur line in sparsely populated rural areas.

7. Demand response solutions for the security of supply

With regard to the electricity network of the development zone, it is justified to consider improving security of electricity supply and capacity management through non-conventional network technologies. In practice, the currently used solution is a battery pack connected to the distribution network.

Technical characteristics of the development zone and the use of electricity

Potential locations for batteries include the branch lines of the medium-voltage network in sparsely populated rural areas, which are located relatively far from a substation and for which a ring connection cannot be built easily because they are located next to a body of water or the border of the distribution district. In this case, the battery pack makes it possible to improve the security of electricity supply in these network sections more quickly than with conventional technologies. The network in the development zone has more than 10 years of its useful life remaining and, consequently, there is no need to upgrade the network due to age and condition and upgrading can be postponed to a later date.

The use of electricity in the development zone is similar or slightly above average than the use of electricity in sparsely populated rural area. The environmental factors and operating environment changes of the development zone are similar to those of the spur line in sparsely populated rural areas and the overhead line network to be maintained in sparsely populated rural areas.

1. Basic information about the development zones

This section presents the basic information about the development zones and the figures describing the network at the end of 2023.

Table 2 shows the average age and the average technical useful life of the network in the development zones. The determination of these figures took into account the ages and estimated technical useful lives of the medium-voltage and low-voltage lines, secondary substations, switchgear and link boxes in the development zones.

According to the quality requirements laid down in the Electricity Market Act, after 2036, there shall not be power outages of over 6 hours in zoned areas or power outages of over 36 hours in sparsely populated rural areas. If the place of electricity use is located on an island without a bridge or another similar fixed connection to the mainland or a regular ferry connection, the network operator can define a different target level based on local conditions. In Elenia's network area, there is one such island: Hailuoto. For Hailuoto, the targeted period of 36 hours starts from the time when the island can be reached by ferry.

Table 2: Average age and average technical useful life of the network in the development zone, years

	Urban areas	Densely populated areas	Trunk line connections between densely populated areas	Trunk line connections in sparsely populated rural areas	Spur line (furthest parts of the network) in sparsely populated rural areas	Overhead line network to be maintained in sparsely populated rural areas	Demand response solutions for the security of supply
Overhead line network							
Average age	-	31.2	33.8	34.4	36.8	30.3	32.6
Average technical useful life	-	43.4	45.0	45.0	44.9	45.6	45.3
Underground cable network							
Average age	32.6	16.2	7.2	7.4	7.2	15.4	11.5
Average technical useful life	47.1	46.2	46.3	46.4	47.1	47.0	46.9

	Urban areas	Densely populated areas	Trunk line connections between densely populated areas	Trunk line connections in sparsely populated rural areas	Spur line (furthest parts of the network) in sparsely populated rural areas	Overhead line network to be maintained in sparsely populated rural areas	Demand response solutions for the security of supply	Total
Table 3: Development zone network length at different voltage levels and the extent of the network that meets the operational quality requirements of the electricity distribution network, kilometres								
MV network total	25	4,633	6,713	3,260	11,098	2,465	118	28,311
MV network that meets the quality requirements	25	4,329	4,758	2,105	6,660	10	24	17,911
LV network total	88	12,868	9,373	4,542	15,535	3,896	198	46,500
LV network that meets the quality requirements	88	12,104	6,596	2,958	8,283	967	51	31,047
Table 4: Total number of connections in the development zones								
Zoned area	702	111,147	333	151	178	0	0	112,511
Outside the zoned area	0	14,002	48,139	22,493	72,070	19,236	1,037	176,977
Local conditions	0	82	0	265	159	457	0	963
Table 5: Total number of places of use in the development zones								
Zoned area	10,554	246,831	382	184	184	0	0	258,135
Outside the zoned area	0	15,683	49 381	23,026	72,965	18,701	1,040	180,796
Local conditions	0	148	0	278	208	460	0	1,094
Table 6: Places of use within the scope of the quality requirements of electricity distribution operations, number								
Zoned area	10,416	217,239	271	153	37	0	0	228,116
Outside the zoned area	0	15,490	40,744	18,108	48,264	9 828	113	132,547
Local conditions	0	127	0	104	0	0	0	231
Table 7: Amount of underground cable in the development zones, kilometres								
MV underground cable	25	4,314	4,689	2,066	6,629	0	24	17,747
LV underground cable	88	12,104	6,596	2,958	8,283	967	51	31,047
Table 8: Overhead lines in the forest in different development zones, kilometres								
MV overhead line in the forest	0	106	712	453	1,932	797	32	4,032
LV overhead line in the forest	0	148	699	418	2,136	851	39	4,291
Table 9: Overhead lines by the road at the edge of the forest in different development zones, kilometres								
MV overhead line by the road	0	121	586	371	1,211	1,197	38	3,383
LV overhead line by the road	0	337	1,208	692	3,145	1,611	84	7,077
Table 10: Overhead lines that meet the operational quality requirements of the electricity distribution network, kilometres								
MV the overhead line meets the quality requirements	0	15	68	40	31	10	0	164
LV the overhead line meets the quality requirements	0	0	0	0	0	0	0	0

MV = Medium-voltage, LV = Low-voltage

Development strategy for the network located in the development zone

1. What are the planning criteria considered to meet the operational quality requirements?

In Elenia's network area, there are only substations within the 6-hour and 36-hour quality requirements. The local conditions criteria is not used.

a. 6-hour quality requirement

The 6-hour quality requirement includes secondary substations that supply electricity connections located inside the zoned area, even if the secondary substation supplying the electricity connections is located outside the zoned area. According to Elenia's definition, the 6-hour quality requirement is fulfilled at the cable network secondary substations that have a uniform underground cabled connection to the primary substation bus bar. In the same 20kV feeder, overhead line sections are allowed if they can be separated from the cable network by manual or remote control disconnectors. The 6-hour quality requirement is also considered to be fulfilled at the cable network secondary substations that are supplied from the overhead line network in normal connection, but the substation has a backup connection via the underground cable network. The low-voltage network can be comprised of overhead line.

b. 36-hour quality requirement

Secondary substations that do not supply connections located in zoned areas are included in the 36-hour quality requirement. According to Elenia's definition, the 36-hour quality requirement is met at secondary substations that have an underground cable connection to the primary substation's bus bar and the supply route includes a maximum of 5 km of overhead line. The overhead line can also be longer if it is considered weatherproof, that is, genuinely clear of trees. An overhead line marked as weatherproof is considered equivalent to an underground cable in terms of the security of supply. The 36-hour quality requirement is also considered to be met at the secondary substations that are supplied through the overhead line network in normal connection, but the secondary substation has a backup connection that is cabled and includes a maximum of 5 km of overhead line. The low-voltage network can be comprised of overhead line.

2. Taking special characteristics into account in network design

This section describes how special characteristics, such as joint construction, connections to the networks of other network operators, demand response services and places of use that are critical for the functioning of society have been taken into account in network design and in the selection of development actions.

Connections to the networks of other network operators

Elenia's distribution network connects to Fingrid's main grid at 105 connection points. Some of the connections are in areas controlled by the transmission system operator at the TSO's substation, to which Elenia connects with its own transmission line of the high-voltage distribution network. These connections typically serve a large number of customers through

several of Elenia's substations. In addition, Elenia has so-called power line connections directly to the main grid, in which typically only one of Elenia's substations connects to the main grid. Apart from direct main grid connections, Elenia has 24 connection points to the networks of other high-voltage distribution network operators.

In the medium-voltage network, Elenia has approximately 100 stand-by supply connections with other network companies. The majority of these are medium-voltage network connections. The connections are subject to agreements on distribution capacity, practical arrangements when capacity is needed, and costs. Most of the stand-by supply connections are in the overhead line network, and their capacity typically does not allow feeding power into a very large network section. The connections are mainly used in connection with maintenance downtime. During major power disruptions, the situation is often challenging as because when a local stand-by supply connection is needed, the neighbouring network operator usually has electricity distribution challenges in the same area. The boundary disconnectors for stand-by supply connections are typically controlled locally. Maintaining the capacity and regulatory compliance of stand-by supply connections requires a significant amount of cooperation between companies. For the reasons mentioned above, the network is primarily developed so that sufficient stand-by supply connections are formed within the network operator's own network.

In the high-voltage distribution network, stand-by supply points are continuously maintained and developed, and they form an integral part of the development actions of the high-voltage distribution network. An information exchange system between the network companies is also available in the high-voltage distribution network, enabling real-time, comprehensive monitoring of the connection status in the event that stand-by supply is used.

Promoting joint construction

Elenia has made determined efforts to promote joint construction. Our goal is to combine the infrastructure construction projects of Elenia, cities, towns, municipalities and other operators. We have cooperated systematically and regularly with the municipalities, telecommunications companies and other significant stakeholders in our operating area. The future projects of Elenia's investment programme have been presented to other infrastructure operators in separate meetings well before their launch. The investment programme projects are selected and scheduled in a manner that ensures that Elenia can participate in the projects of the stakeholders in the area and that other infrastructure operators can participate in Elenia's projects.

In 2016–2018, approximately 20 per cent of the cable route built by Elenia entailed joint construction activities. In 2019–2020, the share of the jointly constructed route increased up to 25 per cent. However, the end of the public broadband project support programme significantly reduced the amount of joint construction in 2021, when the share of joint constructed routes decreased to 12 per cent. Between 2022 and 2023, we have had to significantly reduce our investment programme and have not been able to join all potential joint construction projects. The share of joint construction has been approximately 10%. In the coming years, joint construction is expected to increase as several different operators are about to launch numerous fibre optic network projects. Nevertheless, significant changes in the business environment pose challenges to the future of joint construction from the point of view of distribution system operators' investment capability, and it is not possible to join all potential projects. The share of joint construction is estimated to remain at approximately 10%.

We provide information about our projects in the map service on Elenia's website. In addition to the map service, Elenia has bilateral system solutions with different infrastructure operators to support the smooth exchange of project information. The projects have been entered into the Finnish Transport and Communications Agency's common Verkkotietopiste online information service, as required by the Act on Joint Operation and Joint Construction, ever since the system was introduced. Cabling project areas suitable for joint construction are entered into the Verkkotietopiste service through a dedicated interface. A computer-generated summary map of preliminary excavation routes is entered into the service, in order to make the area details as specific as possible. Projects are automatically entered into the Verkkotietopiste service on a daily basis, provided that they meet certain criteria regarding phases and project type. After their entry in the Verkkotietopiste service, the projects will be searchable by other operators, who can contact Elenia with regard to joint project construction. Projects that are not suitable for joint construction, such as the construction of connections, are not entered into the Verkkotietopiste service, as their turnaround time is typically short and their potential for joint construction is low.

Elenia is a party to an inter-customer agreement on the joint construction of electricity, telecommunications or other infrastructure networks. The agreement defines the customers' common principles applicable to the implementation of construction projects in joint construction projects and on construction sites, as well as the rights, obligations and responsibilities of the different parties to the agreement. The cost allocation criteria are based on the cost allocation recommendation published by Finnish Energy and FiCom or they agreed on a case-by-case basis, depending on the project procurement method, so that joint construction benefits all parties.

Elenia aims at smooth permit practices and the conclusion of land use agreements. We have actively participated in developing, with various stakeholders, practices to facilitate the placement of electrical equipment and cables and to streamline permit processes.

Demand response services

Elenia has identified demand response services as one opportunity to improve security of electricity supply. In the context of security of electricity supply, demand response refers to a situation in which, in the event of a maintenance or fault in the electricity network, electricity distribution can be continued with the aid of battery packs serving as electricity storage units and customers' demand response, for example. This has been taken into account as part of Elenia's network development strategy by identifying the currently potential network sections as a separate development zone in the "Demand response solutions for the security of supply" zone. A more detailed description of the development zone can be found in section 2.

In addition to the demand response for the security of supply, the demand response service can be used to obtain demand and capacity flexibility. Demand response can be used to control the customer's electricity use, for example, when there is a threat of electricity shortage, and capacity flexibility can be used to solve short-term bottlenecks in the distribution network.

Elenia has developed free time or spot price control for its next-generation electricity meters. This provides Elenia's online service customers with opportunities for demand response. Elenia's goal for the next few years is to offer such demand response to electricity market operators, and the first project has already begun. After demand response has become more common, it will be possible to use demand response to manage bottlenecks in the electricity network. Elenia considers that such possibilities will grow significantly towards the end of the decade.

Elenia started planning the piloting of battery packs in 2018 and they have been in use since 2020. In the ongoing innovation partnership procurement process, our goal is to implement electricity storage in the "demand response for the security of supply" development zone in the coming years. Elenia has an ongoing innovation project that aims to commercialise a battery equipment solution. Its purpose is to develop, in cooperation with the equipment supplier, a solution that will serve as network companies' demand response for the security of supply in zone 7. The project will be completed in 2024.

In the INTERRFACE project, which is implemented with Horizon 2020 funding from the European Commission, we have developed information sharing between network companies, the transmission system operator Fingrid and various market operators to support the development of the demand response market of the future. The project entailed a demonstration piloting the demand response platform developed in the project and the exchange of messages between different operators.

Places of use that are critical for the functioning of society

Following Russia's war of aggression, the energy crisis and electricity shortages, the importance of places of electricity use that are critical to the functioning of society and overall safety has risen even higher. Needs for and awareness of reliable electricity supply have increased, and so have contacts received by Elenia. Thousands of critical locations have been identified in Elenia's electricity network, a significant part of which meet the criteria set out in section 2 of Government Decree 981/2022. In addition to customer notifications, Elenia surveys customers' critical places of use in several ways. A customer criticality assessment is conducted in connection with the acquisition of a new connection, in continuous cooperation with customers that use a lot of electricity and using various security of supply channels. In addition to the classification of the Government Decree, Elenia uses the industry's general guidelines, the 2021 report of the National Emergency Supply Agency and its own criticality classification to classify customers as comprehensively as possible from the point of view of the overall functioning of society. Information about critical places of use is maintained in operational systems to a limited extent, where they are available when the system or operations managers prioritise the fault repair order. In addition, information about the critical places of use is also available to experts designing the network. Places of use that are critical for the functioning of society are taken into account in targeting network development actions, determining project scope and designing the network topology and structure on the basis of the criticality of the places in question.

Energy efficiency measures, in particular as an alternative to expanding distribution capacity

In 2018, Elenia commissioned[4] a master's thesis that explored the energy efficiency measures of a distribution system operator. The possibilities to make a difference can be roughly divided into two categories: the company's own electrical losses caused by the distribution network and customers' energy consumption. From the point of view of the network company, the latter can largely be influenced by communication only, but as the 2022 energy crisis showed, customers' energy consumption can be influenced to some extent. However, the change in customers' consumption behaviour achieved in this way cannot be accurately predicted locally, so energy efficiency communications alone cannot guarantee sufficient distribution capacity. On the other hand, network losses can be reduced by replacing components so that the electrical losses of the new components are lower than those of the original ones. Without component replacements, a network company can reduce electrical losses by optimising the network switching state. According to the calculations of the master's thesis, the optimisation of the 110kV network switching situation could, in one case, save 13.5 MWh of energy per year, which roughly corresponds to the annual consumption of one electrically heated detached house. However, the impact of losses in the distribution network on the current-carrying capacity of the network is so marginal in relation to other limiting factors, such as voltage drop or short circuit-current, that the losses do not primarily limit the connection of new loads or production. Thus, energy efficiency measures alone cannot replace conventional network investments.

[4] *Koskela-Koivisto, Jaakko: Energiatehokkuustoiminnan arvioinnin kehittäminen jakeluverkkoyhtiössä. 2018.* Available here

3. Calculation of network lifecycle costs in development zones

The next section presents the life cycle cost calculations of the network of different development zones with different network technologies. In the calculations, the direct labour and materials costs arising from network design and construction are included in investments at the value of money in the commissioning year. The fact that the network is longer when underground cabling technology is used instead of overhead line solutions is taken into account in investment costs.

Costs arising from operations include the direct costs of regular network inspections, maintenance management metering, maintenance and repair work based on the results of inspections and metering and fault repairs.

Harm caused due to outages (regulatory outage costs) is a way that is used in the regulatory methods of electricity distribution to describe, in monetary terms, the harm caused by outages in electricity distribution on the basis of undistributed electrical energy and interrupted electric power. In the example calculations, harm caused due to outages is based the average power in the example projects and its predicted change as well as the unit prices for interruptions defined by the Energy Authority applied in the regulatory methods of electricity distribution that entered into force on 1 January 2024. The unit prices are presented at the value of money of 2023 and adjusted to the level of 2023 according to the consumer price index.

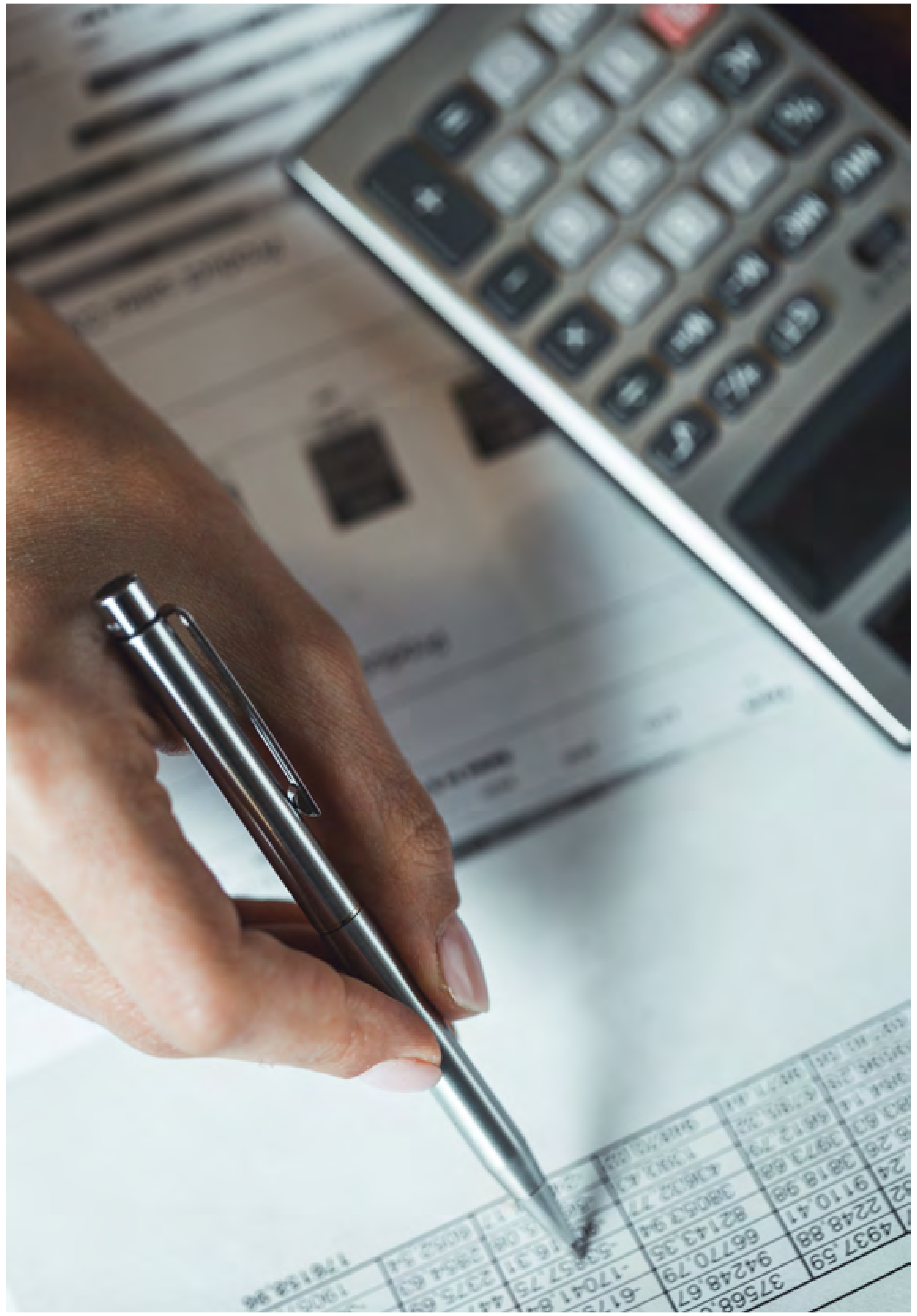
The lifecycle cost calculations do not take into account potential joint construction with other network construction operators as significant changes in the business environment pose challenges to the future of joint construction from the point of view of distribution system operators. In addition, possibilities of joint construction vary considerably from year to year and from region to region, depending on, among other things, the support programmes targeted at other networks.

Elenia is actively following how advanced network solutions, such as electricity storage units and DC technology, are used as part of network development. Elenia participated in the research and equipment development of low-voltage DC distribution in 2008–2019. During this research period, equipment lifecycle costs could not be brought down to a competitive level compared to conventional network technologies.

4. Monitoring of lifecycle costs

The development of Elenia's network is based on a long-term business plan. The business plan is founded on a comprehensive lifecycle cost analysis conducted in 2006–2008 regarding network technologies suitable for Elenia's network area and the network performance achievable with the different technologies. On the basis of the analysis, the underground cabling of the network was chosen as the strategic foundation for the business plan. The business plan defines the cost development goals for the underground cable network construction with regard to construction work, component prices, maintenance and fault management. These have been turned into annual goals, the realisation of which has been monitored and, thus far, achieved. The business plan is updated annually on the basis the previous year's performance and general cost development, such as inflation and changes in the operating environment.

As the useful life of electricity network components is long, it is not possible to change the basic elements of the network strategy annually. Instead, choices have been made to support the chosen foundation strategy, such as increasing automation in the overhead line network to be maintained and developing network management systems. We are actively following how network solutions based on new technology, such as battery energy storage systems and demand response services, develop as well as piloting alternative solutions to increase cost knowledge.



Cost comparison of solutions used in the development zones

1. Solutions used in the development zones

Elenia uses underground cabling extensively in the medium-voltage network in all development zones. In addition to the medium-voltage network built with underground cabling, we maintain a significant amount of medium-voltage overhead line network built in previous decades. Structures widely used in the overhead line network include overhead lines and insulated overhead lines. In the medium-voltage network, overhead cables are also used in some places and there is one electricity storage unit.

Elenia uses underground cabling extensively in the low-voltage network in all development zones. In addition to the low-voltage network built with underground cabling, we maintain a significant amount of low-voltage overhead line network built in previous decades. The technology that is widely used in the low-voltage network is the AMKA overhead cable. In the low-voltage network, overhead lines are also used in some places and there is one 1-kV electricity distribution site.

Table 11 shows the suitability of different electricity distribution solutions for the conditions in Elenia's development zones, taking into account the level of security of electricity supply according to the quality requirements of the Electricity Market Act, the customers that are critical for the functioning of society, the requirements set by zoning and land use as well as the electricity distribution quality and network capacity requirements set in standards.

Underground cabling is a solution that is suitable for all development zones due to its reliability and relatively minor negative effects on land use. Overhead line solutions are not possible in urban and densely populated areas because of reasons related to land use. Some of the use of electricity in urban and densely populated areas requires a level of security of electricity supply that is higher than the level defined in the quality requirements of the Electricity Market Act and cannot be achieved with overhead line solutions. On the other hand, 1-kV and LVDC electricity distribution solutions are not suitable for urban and densely populated environments due to their insufficient electricity distribution capacity.

Trunk line connections between densely populated areas and in sparsely populated rural areas ensure the security of electricity supply in electricity distribution to a significant share of the customers. These connections are required to have a high level of reliability and thus overhead line solutions, excluding the widened line corridor, do not make it possible to achieve the quality requirements of the Electricity Market Act. The creation of a widened line corridor in the overhead line network requires the clearing of trees from a significant additional area and therefore requires cooperation with landowners. Practice has shown that the creation of a widened line corridor for the whole network section is very challenging: in practice, there remains narrower sections along the route, with low security of electricity supply, and the corridor route ends up being winding. For these reasons, lifecycle costs become technically and economically unreasonable. 1-kV and LVDC electricity distribution solutions are not suitable for high-capacity trunk line connections due to their insufficient electricity distribution capacity.

	Underground cable	Overhead line	Widened line corridor	Insulated overhead line	Overhead cable	1-kV electricity distribution	Electricity storage units	LVDC	Demand response services
Urban areas	Suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Insufficient availability
Densely populated areas	Suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Insufficient availability
Trunk line connections between densely populated areas	Suitable	Not suitable	Suitable with reservations	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Insufficient availability
Trunk line connections in sparsely populated rural areas	Suitable	Not suitable	Suitable with reservations	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Insufficient availability
Spur line in sparsely populated rural areas	Suitable	Suitable	Suitable	Suitable	Suitable with reservations	Suitable in part	Not suitable	Suitable in part	Insufficient availability
Overhead line network to be maintained in sparsely populated rural areas	Suitable	Suitable	Suitable	Suitable	Suitable with reservations	Suitable in part	Not suitable	Suitable in part	Insufficient availability
Demand response solutions for the security of supply	Suitable	Suitable	Suitable	Suitable	Suitable with reservations	Suitable in part	Suitable	Suitable in part	Insufficient availability

Table 11: Suitability of network development solutions for different development zones

In principle, several solutions are suitable for the spur line in sparsely populated rural areas, the overhead line network to be maintained and the "demand response solutions for the security of electricity supply" development zone. However, the overhead cable solutions of the medium-voltage network have proved in practice to be challenging in terms of the security of electricity supply and safety. The overhead cable network is susceptible to faults caused by trees during storms and under snow loads, for example. Faults in the overhead cable network are typically more difficult to locate than faults in other overhead line solutions, and repairing them is many times slower and more expensive. The use of 1-kV or LVDC electricity distribution solutions is only possible in cases where it is certain that the demand for power in the network section in question will not increase significantly or that it will not be necessary to expand the network substantially at a later stage. Such cases include, for example, islands and, in some cases, lakeside areas. The suitability of demand response services for network development was investigated in a research project interviewing various commercial demand response service providers. The conclusion of the study was that demand response services do not yet replace traditional network development methods, because the demand responses suitable for use by distribution system operators were poorly available and, on the other hand, it is not yet possible to allocate them in a timely manner to a certain part of the network in the absence of technical solutions, standardised demand response products and a public marketplace. Thus, demand response services are not yet suitable as such for any development zone, but Elenia will monitor the development of the demand response market, while promoting technical solutions and the emergence of a market. For example, we participate in the definition of a new demand response interface.

[5] *Vanguard Consulting Oy: Selvitys markkinaehtoisten joustopalveluiden saatavuudesta jakeluverkoille -report of results -Finnish Energy* Available here

2. Description of the electricity distribution solutions proposed for the development zones

The following section presents the general descriptions of the electricity distribution solutions with the lowest lifecycle costs, development zone by development zone, and the electricity distribution solutions for which the costs have been compared. Investment costs consist of costs related to network construction. Operational costs consist of maintenance activities carried out on the basis of the findings of the inspections conducted according to the maintenance programme and the repair of faults, if any. In addition, the imputed harm caused due to outages (regulatory outage costs), in accordance with the regulatory methods of electricity network operations, is taken into account in costs. Fault repair costs and the regulatory outage costs have been calculated on the basis of the actual realised costs incurred by Elenia and the fault frequency. In addition, losses caused by the compensation of the reactive power of the cable network are taken into account in operational costs.

Electricity distribution solutions with the lowest lifecycle costs

The "Urban areas" and "Densely populated areas" development zones

In urban and densely populated areas, the medium-voltage and low-voltage networks are built with underground cabling. In connection with renewal, underground cables are installed alongside other existing infrastructure or infrastructure being built. Cable cross-sections are typically 150–240 mm^2 in both the medium-voltage and the low-voltage network. Disconnector devices are used in all secondary substations in such a way that the fault location can be isolated and electricity supply can be restored with ring connections. Secondary substation automation, remote-controlled disconnectors and fault indication devices are installed in suitable locations. In these areas, zoning and land use do not make it possible to use overhead line solutions and it is not possible to meet the quality requirements of the Electricity Market Act.

The typical project scope of the “Urban areas” and “Densely populated areas” development zones is from a few hundred metres to about one kilometre. The investment costs of the projects include the investment costs of equipment needed for the compensation of the earth fault current and reactive power of the cable network.

Trunk line connections between densely populated areas and in sparsely populated rural areas and the spur line in sparsely populated rural areas

In the development zones 3–5, the solution with the lowest lifecycle costs is the underground cabling of the medium-voltage network. Underground cables are primarily installed in the road area or another existing infrastructure zone. Cable cross-sections are typically 95–150 mm² in the trunk lines of both the medium-voltage and the low-voltage network. In the development zone 5, the cable cross-section of 50 mm² is also widely used in the medium-voltage network. The aim is not to build underground cabling for all parts of the network at the same time, but instead, for example, some of the branch lines (development zone 5) leaving the trunk line (development zones 3–4) are renewed when the branch line needs to be replaced due to its condition.

In connection with the cabling of the medium-voltage network, we install remote-controlled disconnectors in kiosk-style secondary substations. We also add fault detection devices to the cable network nodes and to the boundaries of the cable and overhead line network. This makes it possible to isolate fault areas quickly. The low-voltage network is turned into underground cabling at the same time as the medium-voltage network in the same area. Low-voltage overhead line network sections which diverge from the medium-voltage network and are in good condition are maintained in a controlled manner until the end of their lifecycle, after which they are replaced with underground cabling. Typically, approximately 70 per cent

of the low-voltage network in the project area is turned into underground cabling at the same time as the medium-voltage network. The remaining 30 per cent is renewed at the end of the network lifecycle, which is calculated to be 25 years after the initial investment. Investment costs include the investment costs of equipment needed for the compensation of the earth fault current and reactive power of the cable network.

Overhead line network to be maintained in sparsely populated rural areas

Our medium-voltage network has sections that can be maintained as overhead lines in a controlled manner until the end of their lifecycle, as far as the development of security of electricity supply and the age and condition of the network are concerned. In the example calculation for the development zone, we compare the realisation of the same underground cabling investment at the beginning of the review period and after the end of the assumed useful life of the overhead line network, 15 years from the beginning of the review period. The remaining value of the network to be dismantled has not been taken into account in the calculation. Underground cabling is carried out according to the equivalent principles as in trunk line connections between densely populated areas, trunk line connections in sparsely populated rural areas and the spur line in sparsely populated rural areas.

Operational costs consist mainly of actions and fault repairs according to the maintenance programme. The line corridors of the overhead line network are photographed and laser-scanned regularly. Line corridors are cleared of trees at regular intervals as well as whenever necessary on the basis of inspection findings. The network has undergone extensive forest management in areas adjacent to it outside the line corridor to improve the security of electricity supply. These forest management activities have been carried out in 2016–2021, and their costs have not been included in the lifecycle cost comparison.

Demand response solutions for the security of supply

In the development zone 7, the network is maintained as an overhead line network and the security of electricity supply in accordance with the Electricity Market Act is ensured by an electricity storage solution. The electricity storage unit is a battery pack, with an assumed technical life of 15 years. At the end of the lifecycle of the electricity storage solution and the overhead line network to be maintained, the network will be replaced with underground cabling in the same way as in other development zones located in sparsely populated rural areas.

In addition to actions carried out according to the maintenance programme, the line corridors of the overhead line network are photographed and laser-scanned regularly. Line corridors are cleared of trees at regular intervals as well as whenever necessary on the basis of inspection findings. In addition to maintenance and fault management, the operational costs include the service fee paid to the battery pack operator for the use of the battery pack for the needs of the electricity network. In the battery pack solution applied by Elenia, the battery pack serving as an electricity storage unit is placed at the beginning of the medium-voltage network branch, connecting it with connection equipment. The connection equipment features a circuit breaker, which allows the branch to be isolated from the rest of the electricity network and to be fed as an island by means of the battery pack. Similarly, it is possible to isolate a fault in the branch with the circuit breaker without interrupting electricity supply in the rest of the electricity network. The latter case benefits the network outside the development zone, but it has not been taken into account in the example calculations. The impact may be significant, depending on the fault frequency of the branch.

Other compared electricity distribution solutions

The development zones' electricity distribution solutions with the lowest costs have been compared to other technically feasible electricity distribution solutions that meet the quality requirements of the Electricity Market Act, as indicated in Table 11.

The operational costs of all solutions consist of actions and fault repairs according to the maintenance programme. The electricity network is inspected according to the maintenance programme and the necessary maintenance actions are carried out on the basis of the findings. Fault repair costs and the harm caused due to outages have been calculated on the basis of the realised costs incurred by Elenia and the fault rates, to the extent that the solution is used by Elenia.

Overhead line network

The overhead line network used in the comparison is straighter and slightly shorter than an underground cable network. There are slightly fewer secondary substations compared to the underground cable network. The network is partly located in fields and by the road, as indicated in Table 9. Typical medium-voltage network cable types and cross-sections are ACSR 54/9 (Raven), ACSR 85/14 (Pigeon) and AAC 132 in the development zones 3 and 4 and ACSR 34/6 (Sparrow) and ACSR 54/9 (Raven) in the development zones 5–7. The low-voltage network is an AMKA overhead line network with typical cross-sections of 35 mm² and 70 mm².

The line corridor is created and maintained at the normal width, with an area of a width of about 10 metres clear of trees.

Widened line corridor

The widened line corridor network used for the comparison has a technical structure that is equivalent to the structure of an overhead line network. The key difference is the width of the line corridor. The line corridor is created in an extra-wide form: all trees that could bend over or fall on the overhead line are cleared from the vicinity of the line. In this case, the width of the line corridor is typically 30 metres. The low-voltage network is an AMKA overhead line network with typical cross-sections of 35 mm² and 70 mm².

Elenia does not have widened line corridor networks in use so the fault frequency has been estimated based on literature[6].

Insulated overhead line

The medium-voltage insulated overhead line network used for the comparison has a route and secondary substation frequency that are equivalent to those of an overhead line network. Conductors are made of insulated overhead line with a thin layer of insulation on the surface of the actual conductor material, which can withstand the leaning of the fallen tree against the conductor without interrupting electricity distribution. Typical cross-sections are PAS 95 mm² and PAS 150 mm² in the development zones 3–4 and PAS 50 mm² and PAS 95 mm² in the development zones 5–7.

Due to the insulation used in insulated overhead lines, the gap between the conductors can be reduced when compared to an overhead line network, which also means that the width of the line corridor is slightly narrower than in an overhead line network. An area of a width of about 6 metres is cleared of trees.

Overhead cable

The medium-voltage overhead cable used for the comparison has a route and secondary substation frequency that are equivalent to those of an overhead line network. In an overhead cable structure, the conductors are insulated and typically three phase conductors are stranded around a steel support wire. Typical cross-sections in overhead cable structures are 25 mm², 50 mm² and 95 mm². Typically, the maximum cross-section used in an overhead cable structure is 120 mm², which limits the usability of the overhead cable solution in network sections with a high demand for power. Larger cross-sections would require much heavier pole structures.

Due to the insulation, a tree leaning against the conductor does not usually cause an interruption in electricity distribution but the tree or other foreign objects can damage the insulation material, which can later lead to a fault. Such faults are challenging to locate and fault repairs in the overhead cable network are significantly slower than in the overhead line network. Due to the structural characteristics of the overhead cable network, the network must be inspected after major power disruptions: it may be that the fall of conductors from pole brackets does not result in an interruption in electricity distribution but creates a potential safety risk. This increases disruption-related costs in overhead cable structures. The structure allows for a narrower line area than other overhead line structures. An overhead cable does not require an actual line corridor to be cleared. An area of a width of about 1–2 metres is cleared of trees.

---

[6] *Partanen, Jarmo: Sähkönsiirtohinnat ja toimitusvarmuus. 2018.* Available here

1-kV electricity distribution

1-kV electricity distribution makes it possible to increase the transmission distance of the low-voltage electricity network from approximately one kilometre, typically used in low-voltage 0.4-kV distribution, to up to 8 kilometres. The same structures as in other low-voltage networks can be used the lines, and the network can built as overhead lines or underground cables. In the example calculations, half of the 1-kV electricity distribution solution is assumed to consist of overhead lines and half of underground cables. In contrast to normal medium-voltage and low-voltage electricity distribution, the 1-kV electricity distribution solution requires that the voltage level must be converted from 20-kV medium voltage to 1-kV low voltage and from 1-kV low voltage to 0.4-kV low voltage. In the 1-kV low-voltage network, electrical protection is typically implemented with circuit breakers instead of queue fuse switches normally used in the low-voltage network. The technical and economical power range of 1-kV low voltage is 10–60 kW. The power distribution capacity decreases substantially as the distance increases.

DC system (LVDC)

In the Low Voltage Direct Current system (LVDC), the AC voltage traditionally used in the electrical network is rectified by a rectifier installed at the beginning of the input branch, and the distribution of electricity takes place at DC voltage. An inverter is installed before the customer's connection point, converting the DC voltage into AC voltage again. Various technical variations of LVDC systems have been proposed in the study, but life cycle calculations were done on the assumption that the system is unipolar and comprehensive, that is, the two-wire system and inverters are installed directly at each customer's connection point. The network will be built as an underground cable network.

LVDC provides a cost benefit when low-voltage network materials can be used in construction with certain reservations, but the transmitted power is higher than AC at low voltage and slightly higher than 1 kV at AC voltage. The technical and economical power range of LVDC is 10–75 kW. Elenia has piloted LVDC solutions, but the implementation was not technically and economically viable and the pilots have already been dismantled and replaced with medium-voltage underground cable. The LVDC implementations were pilot projects, so using the actual costs to calculate life cycle costs would not make sense. Literature has been used to assess up-to-date investment costs[7].

Demand response services

Demand response services are a broad umbrella term that refers to the procurement of demand response in electricity consumption or production through direct bilateral agreements or from the public market. Demand response can involve either reducing consumption or increasing production, and correspondingly increasing consumption or reducing production. Technically, demand response can be any controlled electricity consumption, ranging from a private customer's hot water boiler to an entire factory process, for example. The transmission system operator Fingrid actively trades various demand responses when balancing the consumption and production of the Finnish electricity system. In contrast to main grid-level demand response services, the demand response utilised in the distribution network must be allocated to a specific part of the network, while in the main grid, demand response can be obtained from anywhere in the national grid system. A flexible marketplace suitable for the needs of the distribution system operator is not yet in production use, but Elenia participates in the work of defining the demand response interface led by the transmission system operator Fingrid, and the demand response market is expected to develop significantly in the coming years.

An example of the use of demand response services in the development of the network could be that, as the consumption behaviour of private customers increasingly coincides with the lowest-price exchange electricity hours, the distribution substation may become overloaded. Instead of investing in a new larger distribution substation, the network company could purchase demand response regionally during times of heavy load. In practice, it is not yet possible to precisely allocate demand response to a certain part of the network due to the lack of supply and technical solutions. On the other hand, the development of the network must take into account the long, often up to 50-year useful lives of investments. There is great long-term uncertainty associated with local demand response capacity and its availability, because a network company cannot rely on customers' willingness and ability to be flexible in the right place at the right time, also several years from now. However, at best, demand response could buy additional time to make the necessary investments. On these grounds, therefore, demand response services as such are not suitable as the main way of developing the network in any development zone.

---

[7] *Partanen, Jarmo: Sähkönsiirtohinnat ja toimitusvarmuus. 2018.* Available here

3. Lifecycle cost comparison for the development zones

An example project that serves as a model of a typical project entity has been defined for the development zones, and its main characteristics are summarised in Table 12.

Table 12: Characteristics of the example projects in the development zones

	Urban areas	Densely popu-lated areas	Trunk line connections between densely populated areas	Trunk line connec-tions in sparsely populated rural areas	Spur line in sparsely popu-lated rural areas	Overhead line network to be maintained	Demand response solutions for the security of supply
Length of the line, medium voltage [km]	0.5 km	0.6 km	15.0 km	17.0 km	5.5 km	6.5 km	10.0 km
Length of the line, low voltage [km]	0.6 km	0.7 km	20.0 km	22.0 km	5.0 km	8.0 km	10.0 km
Mean power [kW]	750 kW	618 kW	292 kW	293 kW	47 kW	146 kW	170 kW
Load change [% per year]	1,5 % / a	3,0 % / a	0,9 % / a	0,9 % / a	-0,5 % / a	-0,5 % / a	-0.5 % / a
Forest coverage per-centages of the over-head line network	-	-	56 %	62 %	62 %	74 %	72 %

In addition to the information presented in the table, the lifecycle cost review has been conducted for a 50-year review period with a calculated 4% interest rate. In the lifecycle cost comparison, the technical life of both cable and overhead line network solutions is assumed to be 50 years. Based on our experience, the life expectancy of the overhead line network is likely to be shorter in practice due to the more environmentally friendly impregnating agents currently in use in the poles.

Below you can see the lifecycle cost comparison for all technically feasible electricity distribution solutions in each development zone. The solution with the lowest lifecycle costs is underlined.

	Underground cable
Table 13: Development zone 1 Urban areas: Lifecycle cost comparison of the example project	
Lifecycle cost	**236,850**
Cost of initial investment	229,450
Other investment costs	1,500
Operational costs	3,600
Harm caused due to outages (regulatory outage costs)	2,300
Table 14: Development zone 2 Densely populated areas: Lifecycle cost comparison of the example project	
Lifecycle cost	**169,100**
Cost of initial investment	158,700
Other investment costs	1,800
Operational costs	5,500
Harm caused due to outages (regulatory outage costs)	3,100

Not suitable: Overhead line, Widened line corridor, Insulated over-head line, Overhead cable, 1-kV electricity distribution, Electricity storages

	Underground cable	Widened line corridor*
Table 15: Development zone 3 Trunk line connections between densely populated areas: Lifecycle cost comparison of the example project with different network technologies		
Lifecycle cost	**1,389,850**	1,483,100
Cost of initial investment	1,161,100	1,196,000
Other investment costs	106,750	-
Operational costs	95,800	142,450
Harm caused due to outages (regulatory outage costs)	26,200	144,650
Table 16: Development zone 4 Trunk line connections in sparsely populated rural areas: Lifecycle cost comparison of the example project with different network technologies		
Lifecycle cost	**1,544,800**	1,732,500
Cost of initial investment	1,266,600	1,383,450
Other investment costs	120,100	-
Operational costs	128,350	173,450
Harm caused due to outages (regulatory outage costs)	29,750	175,600

Not suitable: Overhead line, Insulated overhead line, Overhead cable, 1-kV electricity distribution, Electricity storage, *Widened line corridor suitable with reservations

Table 17: Development zone 5 Spur line in sparsely populated rural areas: Lifecycle cost comparison of the example project with different network technologies

	Under-ground cable	Overhead line	Widened line corridor	Insulated overhead line	Overhead cable**	1-kV electricity distribution***	LVDC***
Lifecycle cost	**362,750**	431,700	444,150	438,900	517,100	471,350	647,250
Cost of initial investment	296,450	316,800	381,600	359,800	320,500	386,650	527,900
Other investment costs	32,350	-	-	-	-	-	100,500
Operational costs	31,250	84,100	54,750	68,450	141,750	55,400	11,750
Harm caused due to outages (regulatory outage costs)	2,700	30,800	7,800	10,650	54,850	29,300	7,100

Not suitable: Electricity storage, **Overhead cable suitable with reservations, ***1-kV electricity distribution and LVDC suitable in part

In our network area, we have identified the areas where the existing network and other characteristics of the area make it possible to use the existing network in a controlled manner until the end of its useful life. Table 18 shows the lifecycle cost calculations for this development zone (Overhead line network to be maintained).

Table 18: Development zone 6 Overhead line network to be maintained in sparsely populated rural areas: Lifecycle cost comparison of the example project with different network technologies

	Underground cable	Overhead line	Widened line corridor	Insulated overhead line	Overhead cable**	1-kV electricity distribution***	LVDC***
Lifecycle cost	**542,700**	691,100	597,750	598,150	770,550	687,050	781,550
Cost of initial investment	447,750	429,750	507,500	481,350	434,150	510,500	581,650
Other investment costs	44,850	-	-	-	-	-	127,700
Operational costs	45,650	129,750	65,000	82,300	158,400	94,750	46,100
Harm caused due to outages (regulatory outage costs)	4,450	131,600	25,250	34,500	178,000	81,800	26,100

Not suitable: Electricity storage, **Overhead cable suitable with reservations, ***1-kV electricity distribution and LVDC suitable in part

Table 19: Development zone 7 Demand response solutions for the security of supply: Lifecycle cost comparison of the example project with different network technologies

	Maa-kaapeli	Avojohto	Levennetty johtokatu	Päällystetty avojohto	Ilma-kaapeli	1 kV sähkönjakelu	Sähkö-varastot	LVDC
Lifecycle cost	**756,550**	989,500	903,950	907,550	1,255,750	1,070,500	815,400	1,190,250
Cost of initial investment	615,000	632,500	749,100	709,850	639,100	732,650	225,000	876,500
Other investment costs	61,700	-	-	-	-	-	375,750	214,400
Operational costs	62,000	156,650	104,250	128,550	260,050	148,050	135,350	52,600
Harm caused due to outages (regulatory outage costs)	17,850	200,350	50,600	69,150	356,600	192,800	79,300	46,750

**Overhead cable suitable with reservations, ***1-kV electricity distribution and LVDC suitable in part

The costs presented do not include standard compensations, compensation for damages or the incentive effects of the regulatory methods of electricity network operations.

Long-term plan

Elenia's investments in meeting the operational quality requirements of the electricity distribution network

In our own monitoring, we consider medium-voltage, secondary substation and low-voltage network investments as one entity and investments in the high-voltage distribution network and substations as another. Therefore, the component division defined for the development plan allows us to provide only indicative figures, with estimates based on annual replacement investments. Actual investment costs are presented at the value of money in the year in which the investment is made. Planned investment costs are presented at the value of money in 2024. Low-voltage network investments do not include meter investments. Investments do not include replacement investments to be made for connecting new production and consumption into the network in 2024–2033.

	Average, EUR 1,000 per year	Total, EUR 1,000	Comments/Further details
Table 20: High-voltage distribution network, network investments in 2014–2036			
High-voltage distribution network in 2014–2021	1,660	13,279	Actual investments in 2014–2021
High-voltage distribution network in 2022–2028	7,581	53,067	Actual investments in 2022–2023 and investments according to the plan in 2024–2028
High-voltage distribution network in 2029–2036	10,813	86,503	Investments according to the plan in 2029–2036
Table 21: Substations, network investments in 2014–2036			
Substations in 2014–2021	7,436	59,491	Actual investments in 2014–2021
Substations in 2022–2028	9,407	65,852	Actual investments in 2022–2023 and investments according to the plan in 2024–2028
Substations in 2029–2036	6,762	54,097	Investments according to the plan in 2029–2036
Table 22: Medium-voltage network, network investments in 2014–2036			
Medium-voltage network in 2014–2021	50,302	402,419	Actual investments in 2014–2021
Medium-voltage network in 2022–2028	36,458	255,208	Actual investments in 2022–2023 and investments according to the plan in 2024–2028
Medium-voltage network in 2029–2036	43,201	345,610	Investments according to the plan in 2029–2036
Table 23: Secondary substations, network investments in 2014–2036			
Secondary substations in 2014–2021	23,120	184,958	Actual investments in 2014–2021
Secondary substations in 2022–2028	13,274	92,917	Actual investments in 2022–2023 and investments according to the plan in 2024–2028
Secondary substations in 2029–2036	14,918	119,344	Investments according to the plan in 2029–2036
Table 24: Low-voltage network, network investments in 2014–2036			
Low-voltage network in 2014–2021	26,629	213,029	Actual investments in 2014–2021
Low-voltage network in 2022–2028	29,525	206,676	Actual investments in 2022–2023 and investments according to the plan in 2024–2028
Low-voltage network in 2029–2036	43,623	348,986	Investments according to the plan in 2029–2036
Table 25: Entire electricity network, network investments in 2014–2036			
Total in 2014–2021	109,147	873,176	Actual investments in 2014–2021
Total in 2022–2028	96,246	673,719	Actual investments in 2022–2023 and investments according to the plan in 2024–2028
Total in 2029–2036	119,318	954,541	Investments according to the plan in 2029–2036

1. Maintenance costs to meet the quality requirements

Actual maintenance costs are based on the budget monitoring of the maintenance work performed. The division of costs among different components is an indicative estimate as not all maintenance work is component-specific. Maintenance costs do not include fault repair costs arising from acute electricity network repair needs. Planned maintenance costs are based on the long-term maintenance plan, which we have prepared on the basis of the operations, not the components. As maintenance is an activity that maintains the security of electricity supply, reported costs include the estimated maintenance programme costs in their entirety. Actual maintenance costs are presented at the value of money in the year in which maintenance was carried out. Planned costs are presented at the value of money in 2024.

	Average, EUR 1,000 per year	Total, EUR 1,000	Comments/Further details
Table 26: High-voltage electricity network, maintenance costs in 2014–2036			
High-voltage electricity network in 2014–2021	1,211	9,690	Actual maintenance costs in 2014–2021
High-voltage electricity network in 2022–2028	1,067	7,469	Actual maintenance costs and maintenance costs according to the plan in 2022–2028
High-voltage electricity network in 2029–2036	1,254	10,031	Maintenance costs according to the plan in 2029–2036
Table 27: Substations, maintenance costs in 2014–2036			
Substations in 2014–2021	1,457	11,658	Actual maintenance costs in 2014–2021
Substations in 2022–2028	1,648	11,534	Actual maintenance costs and maintenance costs according to the plan in 2022–2028
Substations in 2029–2036	1,963	15,703	Maintenance costs according to the plan in 2029–2036
Table 28: Medium-voltage network, maintenance costs in 2014–2036			
Medium-voltage network in 2014–2021	3,487	27,899	Actual maintenance costs in 2014–2021, including EUR 18,303,000 actual costs according to the maintenance programme and EUR 9,596,000 in costs from forest management in areas adjacent to the electricity network in 2014–2021
Medium-voltage network in 2022–2028	1,930	13,512	Actual maintenance costs and maintenance costs according to the plan in 2022–2028, including the costs according to the maintenance programme for 2022–2028 and EUR 222,000 in costs arising from forest management in areas adjacent to the electricity network in 2022
Medium-voltage network in 2029–2036	1,261	10,085	Maintenance costs according to the plan in 2029–2036
Table 29: Secondary substations, maintenance costs in 2014–2036			
Secobdary substations in 2014–2021	572	4,577	Actual maintenance costs in 2014–2021
Secobdary substations in 2022–2028	853	5,972	Actual maintenance costs and maintenance costs according to the plan in 2022–2028
Secobdary substations in 2029–2036	927	7,419	Maintenance costs according to the plan in 2029–2036
Table 30: Low-voltage network, maintenance costs in 2014–2036			
Low-voltage network in 2014–2021	1,576	12,610	Actual maintenance costs in 2014–2021
Low-voltage network in 2022–2028	1,903	13,320	Actual maintenance costs and maintenance costs according to the plan in 2022–2028
Low-voltage network in 2029–2036	1,709	13,669	Maintenance costs according to the plan in 2029–2036
Table 31: Entire network, maintenance costs in 2014–2036			
Total in 2014–2021	8,304	66,433	Actual maintenance costs (incl. the maintenance programme and forest management in areas adjacent to the electricity network) in 2014–2021
Total in 2022–2028	7,401	51,807	Actual maintenance costs and maintenance costs according to the plan including the costs of the maintenance programme in 2022–2028 and forest management in areas adjacent to the electricity network in 2022
Total in 2029–2036	7,113	56,907	Maintenance costs according to the plan in 2028–2036

2. Development of the security of electricity supply requirements for places of use

The reported figures are indicative and will be specified in the annual planning. The values are based on the number of places of electricity use in 2023 and do not take into account the increase in the number of customers.

	Change during the review period, number	Total number of customers in places of use that meet the quality requirements, at the end of the period	% of all	Comments/ Further details
Table 32: Places of electricity use that meet the quality requirements, in zoned areas in 2014–2036				
in 2014–2021	134,275	222,129	87.4 %	Actual in 2014–2021
in 2022–2023	5,987	228,116	88.4 %	
in 2024–2028	14,078	242,194	93.8 %	
in 2029–2036	15,941	258,135	100 %	
Table 33: Places of electricity use that meet the quality requirements, outside zoned areas in 2014–2036				
in 2014–2021	76,747	117,248	65.1 %	Actual in 2014–2021
in 2022–2023	15,299	132,547	73.3 %	
in 2024–2028	18,544	151,091	83.6 %	
in 2029–2036	29,705	180,796	100 %	
Table 34: Places of electricity use that meet the quality requirements, in areas subject to a quality requirements level based on local conditions, in 2014–2036				
in 2014–2021	231	231	21.3 %	Actual in 2014–2021
in 2022–2023	0	231	21.1 %	
in 2024–2028	0	231	21.1 %	
in 2029–2036	863	1,094	100 %	

3. Development of the quality requirements for the electricity distribution network

The reported figures are indicative and will be specified in the annual planning.

	Low voltage (0.4–1.0 kV)	Medium voltage (1–70 kV)
Table 35: Network that meets the quality requirements, %		
at the end of 2023	67 %	63 %
at the end of 2028	76 %	74 %
at the end of 2036	91 %	93 %

4. Underground cabling rate of the electricity distribution network at different voltage levels, after actions on the dates defined in section 119 of the Electricity Market Act

The reported figures are indicative and will be specified in the annual planning.

	Low voltage (0.4–1.0 kV)	Medium voltage (1–70 kV)
Table 36: Underground cabling rate after transition periods, %		
at the end of 2023	66.8 %	62.2 %
at the end of 2028	75.7 %	73.3 %
at the end of 2036	91.2 %	92.6%

5. New production and loads requiring distribution network investments over the next 10 years

In 2024–2028

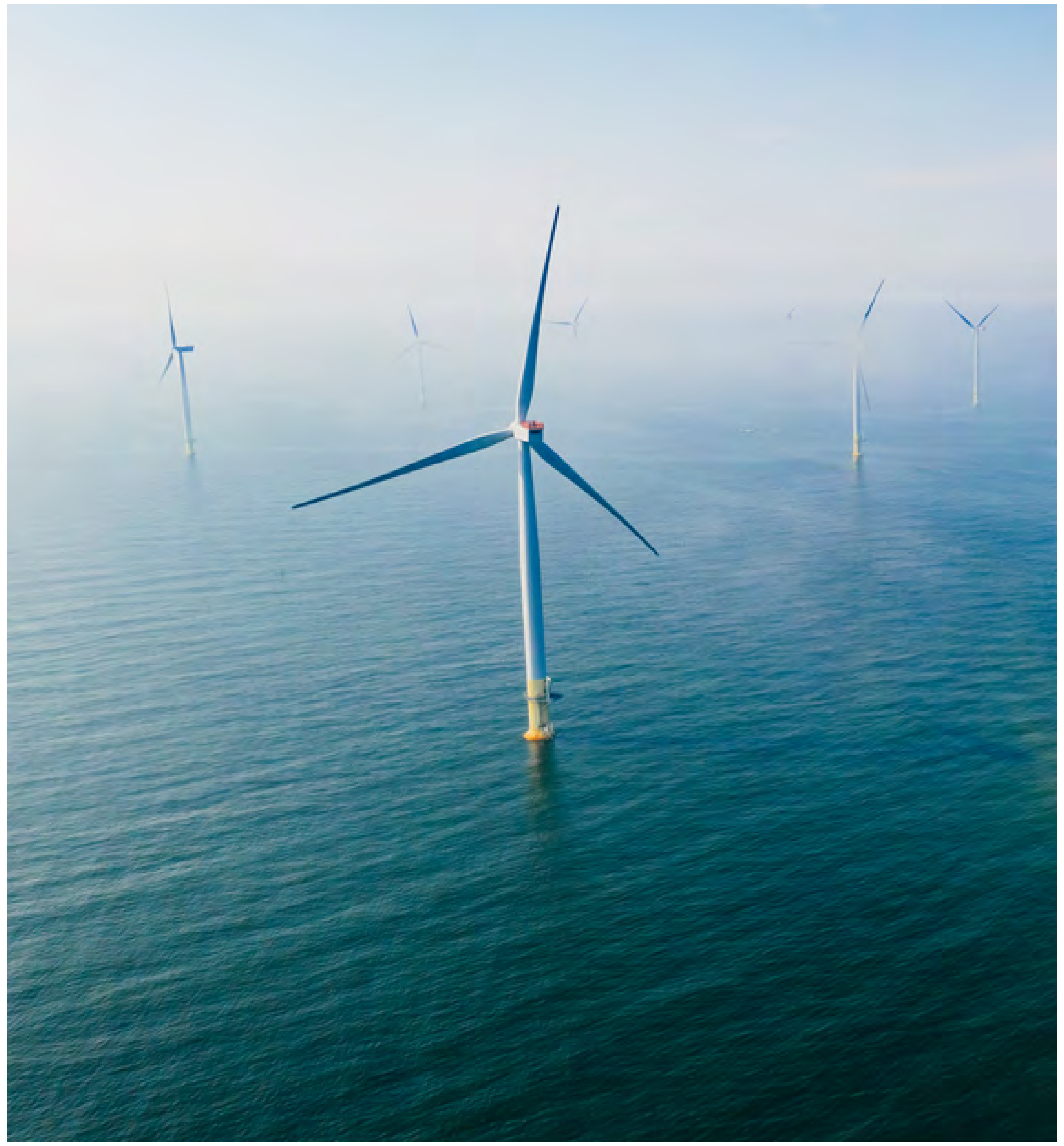
The volume of wind power generation will increase and require investments in the high-voltage distribution network, including parts of the network, where there would not have been otherwise a need for investments. In Elenia's network area, wind power generation is concentrated in North Ostrobothnia and the northern parts of Central Finland, where the increase in electricity consumption and the number of connections is otherwise smaller due to the decrease in the region's population. Early in the decade, wind power was almost the sole driver of investments in the high-voltage network. Towards the end of the review period, the situation is changing and wind power projects nominal connection power has increased so much that they are more and more directly connected to the 400kV main grid. However, there will be solar power, electricity storage and electric boiler projects that require 110kV distribution line investments.

The gross consumption of electricity is predicted to increase in Elenia's network area by approximately 25 per cent over the next ten years. The most significant growth is in manufacturing industry, as due to carbon neutrality targets, many processes previously based on incineration will be replaced by electricity. Similarly, district heating companies will invest heavily in electric boilers, and their power needs impose significant requirements on the supplying electricity network. Not all new loads or all new production are located in the high-voltage distribution network, but the capacity need for connections to lower voltage levels is also multiplied by the increase in the capacity need of the high-voltage network. Fully electric vehicles and plug-in hybrids will also become more common and the power required to charge them will pose a challenge to the low-voltage network. In the future, the charging of electric cars and other high-power consumption will increasingly occur during the lowest-price hours of exchange electricity, which means that the capacity of low-voltage lines and distribution substations must be increased. More electricity will be consumed in the heating of homes when other fuels are replaced by heat pumps.

In 2029–2031

In the future, wind farms are expected to grow in size, making their connectivity to the 110 kV high-voltage distribution network a challenge from the distribution capacity perspective. The solution to this could be for parks to connect directly to the main grid, but if high-voltage distribution system operators were also allowed to build a 400kV transmission line network, the companies would have better opportunities to participate in solving the capacity shortage of wind power. Solar power and electricity storages are expected to be connected to the high-voltage distribution network, especially during this latter review period. Geographically, investments are expected to have greater distribution than wind power, which is concentrated in Northern Ostrobothnia and the northern parts of Central Finland in Elenia's network area. As for consumption, new connections are expected for data centres in particular. They are assumed to take place in areas with strong and secured connections to the main grid, as the connections require a backup supply connection and the power requirement may be hundreds of megawatts.

Towards the end of the decade, electricity consumption in industry is expected to be significant in growing industrial areas. New zero-emission production is expected to encourage new investments in energy-intensive industries. Heavy duty electric vehicles are expected to become more common by the end of the decade, when the charging power of trucks and lorries is expected to grow to the megawatt range. Heavy duty vehicles are



critical for the security of supply, while charging points will be concentrated at service stations. The result of this is that a significant need for charging power for heavy duty vehicles will be concentrated in a geographically small area, which must be secured so that a single disturbance in distribution will not paralyse all traffic. The main roads 4 and 9 cross a large part of Elenia's network area, so it is reasonable to assume that charging heavy duty vehicles will require Elenia to invest in the high-voltage distribution network and medium-voltage network.

6. Significant investments due to new production and loads over the next 10 years (in euros)

Table 37 provides an estimate of the distribution network investments to be made in order to make it possible to connect new production and new loads.

Table 37: Significant distribution network investments to be made in order to connect new production and new loads in 2024–2033

	2024–2028 [EUR 1,000]	2029–2033 [EUR 1,000]
High-voltage network and substations	99,747	215,472
Increase of the distribution network capacity in connection with upgrading	54,885	179,986
Distribution network expansion investments	33,300	31,372
Smart meters	49,943	11,926
Total	**237,875**	**438,756**

Investments in the high-voltage network and substations will be made, above all, to enable the connection of wind power, solar power and electricity storages. It is expected that the charging infrastructure required by heavy duty electric vehicles will also require investments in the high-voltage distribution network towards the end of the decade. In addition, investments in the high-voltage distribution network will be made mainly in the vicinity of densely populated areas, in order to increase distribution capacity and improve the security of electricity supply. Several substations will be expanded to increase capacity.

In connection with upgrades to the medium-voltage and low-voltage network, network capacity will be increased to make it possible to connect new production and new loads. Stronger lines will be built and an increase in the capacity of distribution transformers will be made possible by structural choices in secondary substations and by increasing the number of secondary substations. In addition, network capacity will be increased based on the needs of customers so that more production or consumption can be connected to the network. The distribution network will be expanded by connecting new residential and industrial areas to it. Investments to be made for individual consumer connections are not included in the figures.

The new smart meters enable more accurate metering and thus more accurate determination of network capacity as the use of electricity changes due to the energy transition. In addition, they offer remote control options for the needs of the developing electricity market.

7. Illustration of connecting new production and new loads in the network area

In Elenia's network area, wind power generation is concentrated in North Ostrobothnia, where the increase in electricity consumption and the number of new connections is otherwise smaller due to the decrease in the region's population, among other reasons. The operational and under-construction wind power projects connected to Elenia's network can be seen in the map service on Elenia's website.

The focus of the electrification of transport will be on the main roads. Significant electric vehicle charging stations are expected to be concentrated along roads 4 and 9, with implications for the development of the distribution network in the area. Figure 4 illustrates Elenia's network area and the main roads through it.

With the electrification of industry and the development of new industrial areas, the need for power will increase, especially in the Hämeenlinna and Pirkanmaa regions. The electrification of industry is expected to be concentrated near growth centres and in existing industrial areas.

The free capacity of Elenia's distribution network has been illustrated in the Elenia Avoin service in connection with the consultation of the development plan. The service visualises the available capacity of the low-voltage network at the secondary substation level and the capacity of the medium-voltage network at the feeder level on a map. The aim of the service is to illustrate the general situation of electricity network capacity, while ensuring the security of customers so that the exact line routes of the medium-voltage network are not published.

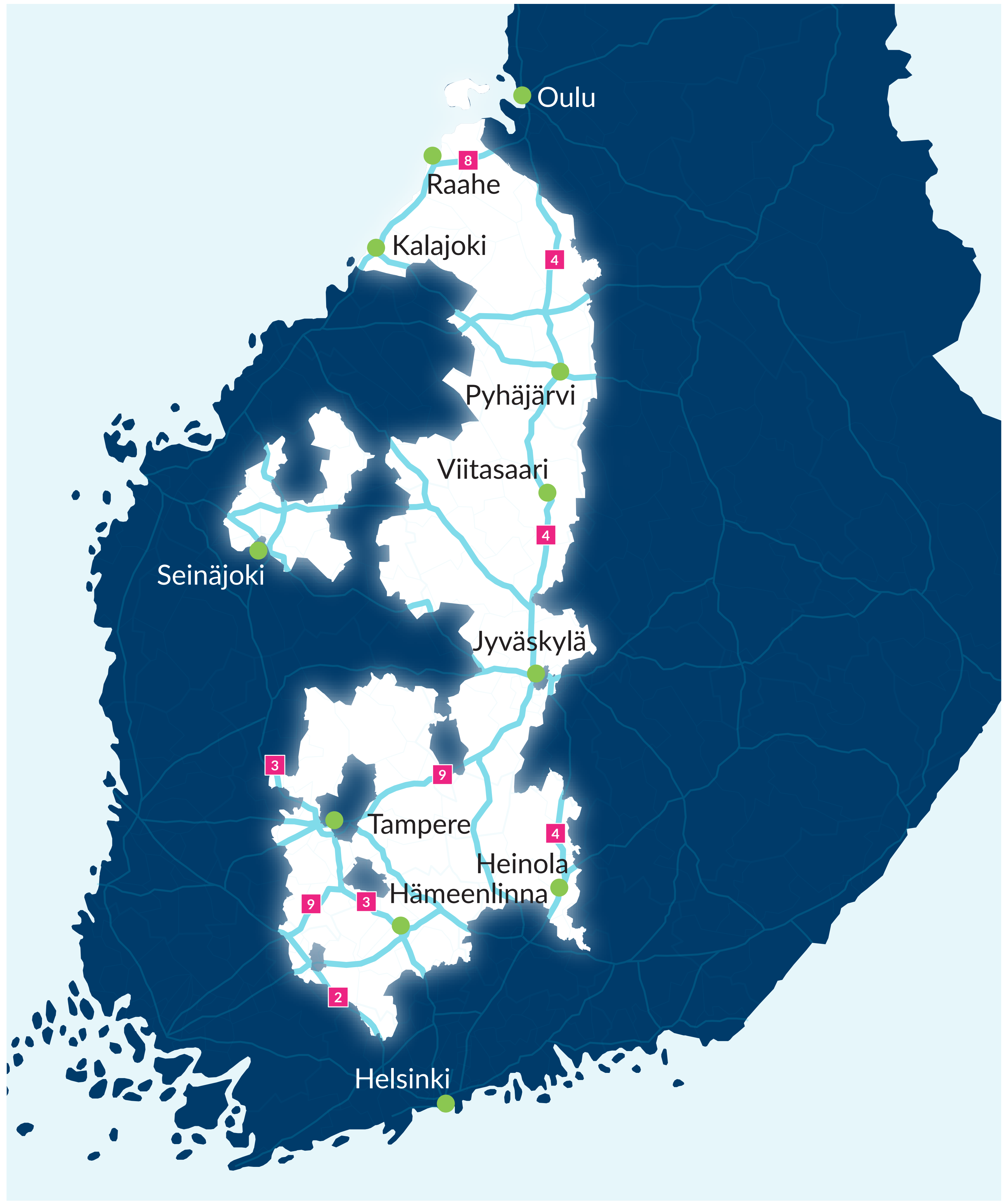
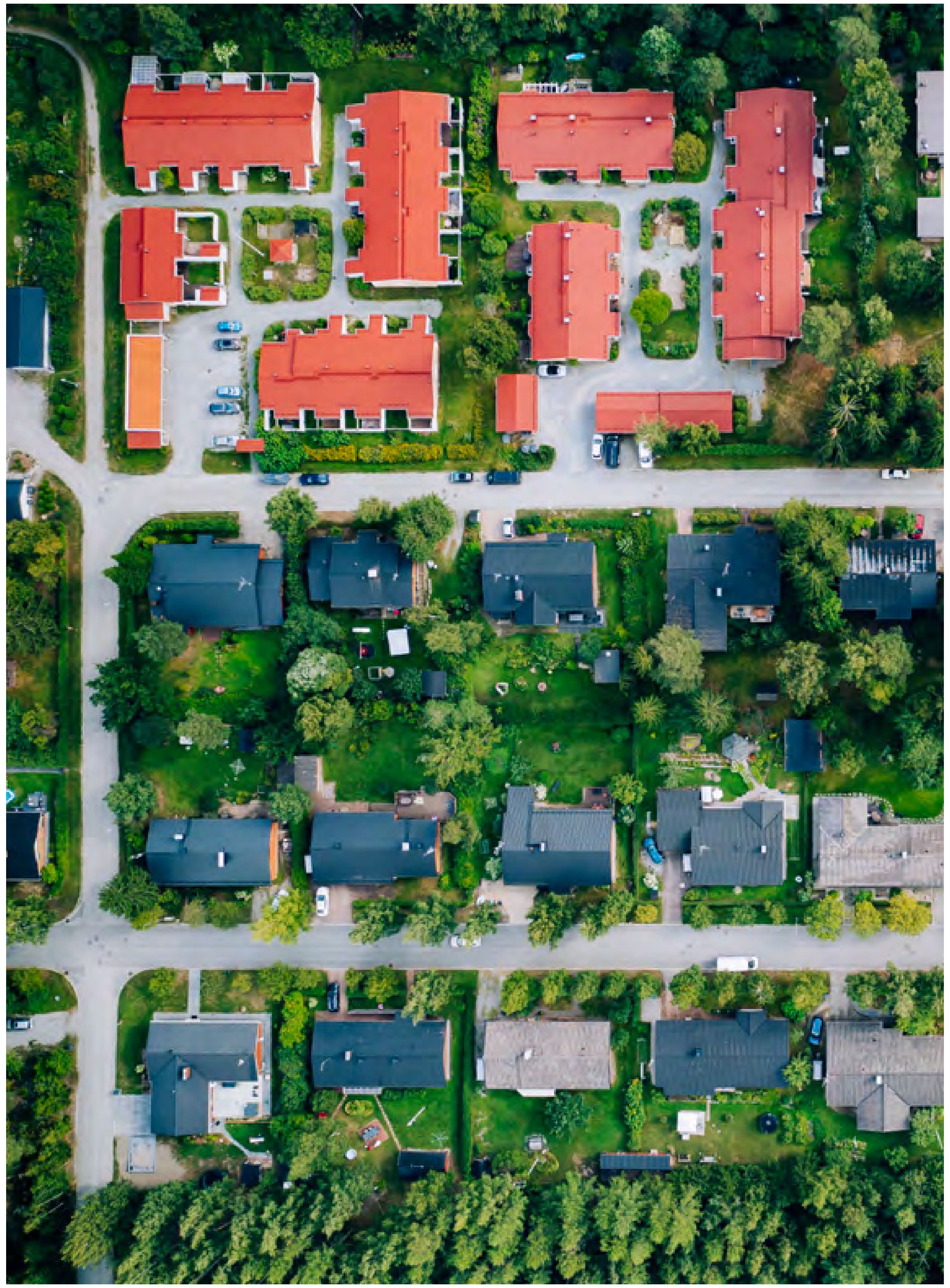


Figure 4: Elenia's network area and main roads.

Electricity distribution network development actions in the current and next year



1. Elenia's investments in meeting the quality requirements (current and next year)

Investment amounts under the given component division are indicative on an annual basis, with estimates based on annual replacement investments. In our own monitoring, we consider medium-voltage, secondary substation and low-voltage network investments as one entity and investments in the high-voltage distribution network and primary substations as another. Annual investment costs are presented at the value of money in 2024. Investments do not include replacement investments to be made for connecting new production into the network. Low-voltage network investments do not include meter investments.

Table 38: Electricity network replacement investments in 2024 and 2025

	2024, EUR 1,000	2025, EUR 1,000	Total, EUR 1,000
High-voltage electricity network	11,807	11,614	23,421
Substations	7,156	11,904	19,060
Medium-voltage network	26,063	27,703	53,766
Secondary substations	9,023	9,586	18,609
Low-voltage network	22,410	23,855	46,265

Planned maintenance costs are based on the long-term maintenance plan, which has been prepared on the basis of the operations, not the components. As maintenance is an activity that maintains the security of electricity supply, reported costs include the estimated maintenance programme costs in their entirety. Costs do not include fault repair costs. All costs are presented at the value of money in 2024.

Table 39: Electricity network maintenance costs in 2024 and 2025

	2024, EUR 1,000	2025, EUR 1,000	Total, EUR 1,000
High-voltage electricity network	1,119	1,076	2,195
Substations	1,498	1,742	3,240
Medium-voltage network	1,994	1,944	3,938
Secondary substations	818	849	1,667
Low-voltage network	2,119	1,997	4,116

2. Places of use in Elenia's network that will be within the scope of the quality requirements after the actions of the current and next year

	2024	2025	Comments/Further details
Table 40: Places of use within the scope of the quality requirements in zoned areas in 2024–2025			
Zoned area Meets the operational quality requirements of the electricity distribution network (number)	229,337	235,606	The figures are annual estimates based on planned projects and annual investments.
Table 41: Places of use within the scope of the quality requirements outside zoned areas in 2024–2025			
Areas other than zoned areas Meets the operational quality requirements of the electricity distribution network (number)	135,997	138,961	The figures are annual estimates based on planned projects and annual investments.
Table 42: Places of use within the scope of the quality requirements in areas subject to a quality requirements level based on local conditions, in 2024–2025			
Areas subject to a quality requirements level based on local conditions Meets the operational quality requirements of the electricity distribution network (number)	231	231	The figures are annual estimates based on planned projects and annual investments.

3. Actions in the current and next year by development zone

Information systems, automation and smart metering devices

1. The operation support system and the operation and control information system will be revised so that in the end, the operation supervisor and operation planner will have a tool that provides an even better and more real-time overview of the electricity network through metering, analytics, advanced calculation and automatic network monitoring. The work will require a significant amount of work and, in particular, development work with system partners, and it will take several years.
2. We will continue the cyber security work of automation and information system environments.
3. We will continue to develop the features and use of the next-generation smart meters in different information systems. The new metering system enables the proactive management of changing production and load situations in the electricity network in a more comprehensive way. The aim is to enable Elenia's customers to participate in the demand response market in the future.
4. We will continue to increase network automation and fault indication as part of conventional network investments.

High-voltage distribution network

1. The 110-kilovolt high-voltage distribution network will mainly be built as an overhead line network, but some sections will be built with underground cabling for land-use reasons. The security of electricity supply of the high-voltage distribution network will be ensured by maintaining the conductors and line corridors of the overhead line network so that they can withstand falling or bending trees. Substation investments are also include earth fault current and reactive power compensation equipment and upgrading and replacing switchgear, control gear and secondary equipment. Substation switchgear and control gear are typically used until the end of their lifecycle but at the same time, investments significantly improve the reliability of substations. The maintenance programme actions will also be carried out in the development zones.

Development zones 1–2

1. Electricity networks that are located in urban and densely populated areas and supply electricity to these areas will be upgraded as necessary, mainly in cooperation with municipalities as land use develops. In addition, joint construction will be carried out with other operators that build and maintain civil engineering networks. The maintenance programme actions will also be carried out in the development zones.

Development zones 3–5

1. The medium-voltage network will be upgraded with underground cabling so that connections with sufficient capacity and reliable security of electricity supply will be established between densely populated areas and between substations. The trunk lines of the medium-voltage network will be upgraded, from substations onwards. Remote-controlled disconnector devices and fault indication devices will be installed at the boundary between the overhead line branches and the development zone 6. With them, faults can be detected and the branches can be isolated from the feeding trunk line with the least possible amount of switchings. The maintenance programme actions will also be carried out in the medium-voltage network.
2. The low-voltage network will be built with underground cabling in the same area as the medium-voltage network where this is technically and financially justified in connection with the installation of medium-voltage cabling. The maintenance programme actions will also be carried out in the low-voltage network.
3. In addition, the medium-voltage and low-voltage networks in the development zones will be upgraded even in a fast schedule, as far as possible, in cooperation with other operators that build and maintain civil engineering networks. This makes it possible to upgrade the network cost-efficiently, minimising the inconvenience caused to users in the areas in question.

Development zone 6

1. Maintenance programme actions will be carried out for the medium-voltage network in a way that ensures the network's safety and security of electricity supply. In the medium-voltage network, individual poles and cross-arms will be replaced on the basis of inspection findings. Enhanced maintenance actions, such as tree-clearance by helicopter, that have impacts over a period of 5–10 years will also be concentrated in the development zone.
2. The maintenance programme actions will be carried out in the low-voltage network.

Development zone 7

1. The operation of existing and new battery packs to be installed will monitored and analysed with a view to possible further development and new locations.

2. The maintenance programme actions will be carried out in the network of the development zone.

Table 43: Share of network to be upgraded by development zone, km

	Urban areas	Densely populated areas	Trunk line connections between densely populated areas	Trunk line connections in sparsely populated rural areas	Spur line in sparsely populated rural areas	Overhead line network to be maintained	Demand response solutions for the security of supply	Total
Medium-voltage network	0	6.6	189	96.5	424.4	2.6	1.3	720.4
Low-voltage network	0	36	212.6	115.3	573.2	68.7	0	1,005.8

4. Distribution network meeting the quality requirements after the actions of the current and next year

Table 44: Electricity network that meets the quality requirements, in 2024–2025

2024					
Voltage level	**0.4 kV**	**20 kV**	**45 kV**	**110 kV**	**Total**
Network that meets the quality requirements, km	31,933	18,337	331	1,525	52,126
2025					
Voltage level	**0.4 kV**	**20 kV**	**45 kV**	**110 kV**	**Total**
Network that meets the quality requirements, km	32,888	19,048	330	1,573	53,839

5. Underground cabling rate of the electricity distribution network at different voltage levels after the actions of the current and next year

Table 45: Underground cabling rate of the electricity network at the end of 2024 and 2025

2024					
Voltage level	**0.4 kV**	**20 kV**	**45 kV**	**110 kV**	**Yhteensä**
Underground cabling rate, %	68.2 %	64.1 %	23.6 %	0.8 %	65.1 %
2025					
Voltage level	**0.4 kV**	**20 kV**	**45 kV**	**110 kV**	**Yhteensä**
Underground cabling rate, %	69.6 %	66.0 %	25.5 %	0.8 %	66.7 %

6. Share of joint construction of planned investments

Table 46 provides an estimate of the route length that involves joint construction and its share of the total route length to be built.

Table 46: Share of joint construction of the route length to be built

	2024	2025	Comments/Further details
Share of joint construction [km]	20	31	51
Share of joint construction [%]	4.7 %	6.5 %	5.6 %

7. Publication of investments in the Verkkotietopiste service

Elenia's major cabling project areas are automatically entered into the Verkkotietopiste service through a dedicated interface. Projects are entered into the Verkkotietopiste service on a daily basis once their implementation decision is made. Typically, projects for the following year are entered into the Verkkotietopiste service by the end of June at the latest. However, projects that are less suitable for joint construction, such as the construction of connections, are not entered into the Verkkotietopiste service, as their turnaround time is typically short and their potential for joint construction is low.

8. Distribution network investments to be made in order to connect new production and loads in the current and next year

Table 47 shows the significant distribution network investments to be made in the current and next year in order to connect new production and new loads.

Table 47: Significant investments to be made in the current and next year in order to connect new production and new loads (6a)

	2024 [EUR 1,000]	2025 [EUR 1,000]	Comments/ Further details
High-voltage network and substations	16,182	12,190	
Increase of the distribution network capacity in connection with upgrading	3,114	5,967	
Distribution network expansion investments	6,338	6,906	
Smart meters	24,154	15,826	
Total	**49,788**	**40,889**	**90,677**

During 2024 and 2025, we will launch the upgrading of seven 110-kV transmission line, which will enable the connection of new production and consumption. In addition, investments in the high-voltage distribution network will be made mainly in the vicinity of densely populated areas, in order to increase distribution capacity and improve the security of electricity supply. Several substations will be expanded to increase capacity. The transmission system operator Fingrid requires the implementation of local disconnection protection if a production site or electricity storage of more than 1 MVA is connected to the medium-voltage network. 110 kV voltage transformers are added to several substations and protection changes are made, as the demand for production and electricity storage connections has increased significantly.

In connection with upgrades to the medium-voltage and low-voltage network, network capacity will be increased to make it possible to connect new production and new loads. Lines with higher capacity will be builtand an increase in the capacity of distribution transformers will be made possible by structural choices in secondary substations and by increasing the number of secondary substations. In addition, network capacity will be increased based on the needs of customers so that more production or consumption can be connected to the network. The distribution network will be expanded by connecting new residential and industrial areas to it. Investments to be made for individual consumer connections are not included in the figures.

In 2024–2025, we will continue the large-scale project to install next-generation smart meters, which was started in 2021. The new meters enable more accurate metering and thus more accurate determination of network capacity as the use of electricity changes due to the energy transition. In addition, they offer remote control options for the needs of the developing electricity market.

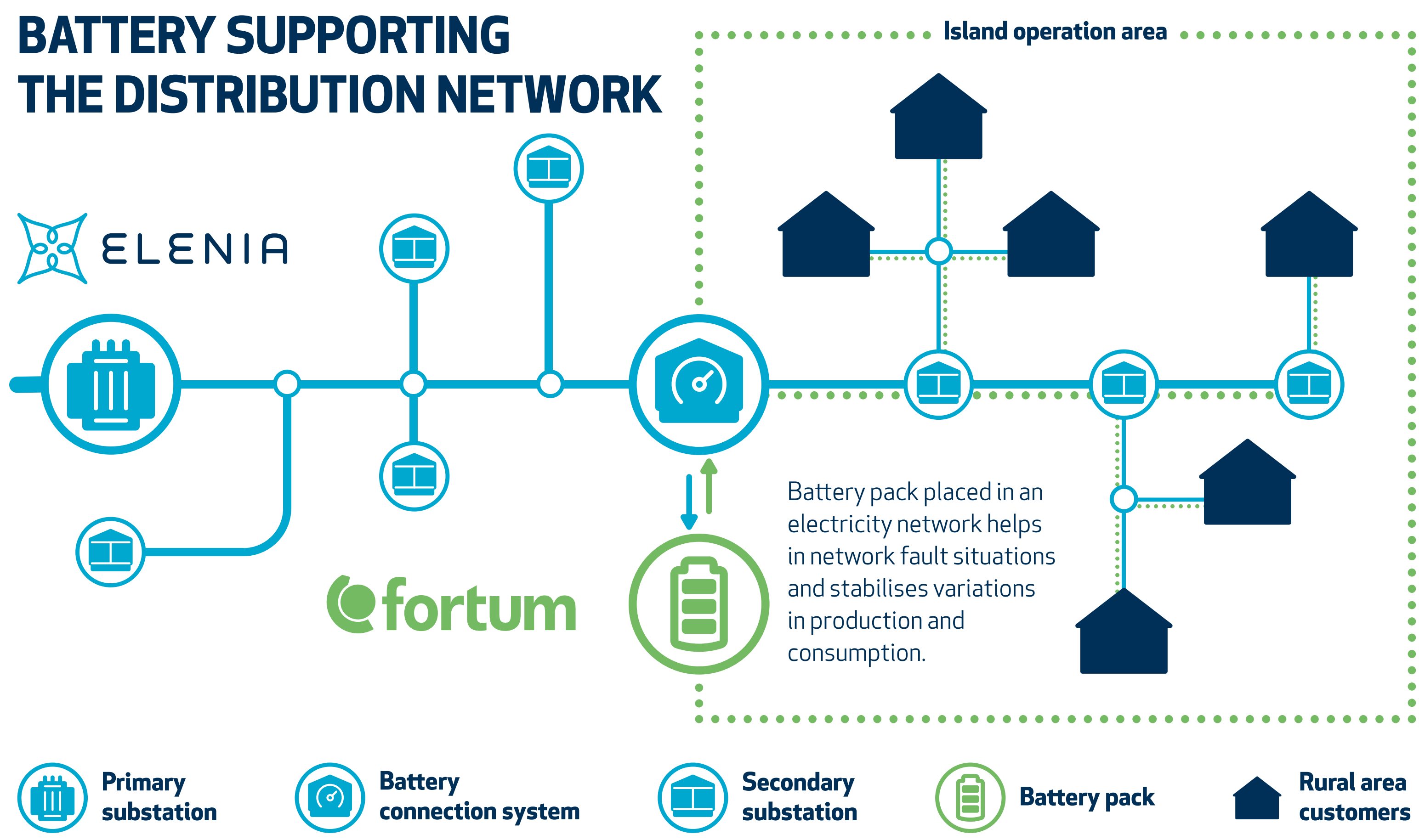


Figure 5: Principles of Elenia's battery concept

9. Use of demand response services in the current and next year

During 2024, Elenia will participate in developing the national demand response interface. In addition, demand response will be promoted by offering the features of the next-generation meters and through discussions with market participants. In addition to these measures, Elenia will survey the use and potential of its new load control solutions with its customers.

In 2021, Elenia launched an innovation partnership procurement process for a market-based battery solution that is suitable for the distribution network. In the normal situation, the battery energy storage system operates in the frequency control market, and in the event of a disturbance in the power supply network, it supports the distribution network by supplying the branch behind the battery as a separate island. The partners selected in the procurement process were Fortum Power and Heat Oy and Merus Power Dynamics Oy. The innovation partnership procurement involves co-creation, and the first developed battery energy storage system solution will be completed in 2024. The performance of the new equipment will be closely monitored in the coming years and the decision on the wider use of the equipment will be made on the basis of the results.

We have identified potential locations in our network where improving the security of electricity supply will be cost-efficient in the near future with the aid of electricity storage units. These areas form the "Demand response services for the security of supply" development zone, which is described in more detail in section 3. The electricity storage units will be battery packs connected to the medium-voltage level. The first battery equipment pilot was commissioned in 2020. The development of the new system has had its own challenges, and the production use of the new battery equipment implemented as an innovation partnership procurement has been delayed from the original plan, but the first two systems will be commissioned during 2024. The estimated costs and benefits during their lifecycle are presented in Table 48.

Table 48: Estimated costs and benefits of using demand response services

	2024 [EUR 1,000]	2025 [EUR 1,000]	Total [EUR 1,000]	Comments/ Further details
Deployment costs	450.0	225.0	675.0	2 locations in 2024, 1 location in 2025
Operational costs	28.2	40.8	69.0	
Cost benefits	-	-	680.0	Savings in regulatory outage costs (harm caused due to outages), estimated over the lifecycle

The lifecycle of a battery pack is estimated to be 15 years. Customers both inside and outside the battery storage island benefit from the shortening of the interruption time in the network section secured by the battery pack and from a separate protection zone achieved with the protection and circuit breaker equipment connected to the battery pack. Faults in the section beyond the battery pack can be isolated without any interruption perceivable in the rest of the network. For Elenia, the cost benefits consist of savings in regulatory outage costs (harm caused due to outages), among other things. In addition, the converter equipment of the battery pack can be used for compensating reactive power. This cost benefit is not included in the estimate.

Electricity distribution network development actions in the preceding two years

1. Investments in meeting the quality requirements (the preceding two years)

The table shows the electricity network replacement investments in 2022 and 2023. Investments are reported as book values at the value of money in the year in which they are made.

Table 49: Electricity network replacement investments by voltage level in 2022 and 2023

	2022 [EUR 1,000]	2023 [EUR 1,000]	Total	Comment/ Further details
High-voltage electricity network	-	-	-	
Substations	14,029	6,627	20,656	
Medium-voltage network	48,204	31,769	79,973	*
Secondary substations	21,360	11,036	32,396	
Low-voltage network	35,711	19,848	55,559	

*The division between the medium-voltage network, secondary substations and the low-voltage network is indicative

2. Maintenance costs to meet the quality requirements (the preceding two years)

The table shows the actual electricity network maintenance costs in 2022 and 2023. Costs are reported as book values at the value of money in the year in which they were incurred.

Table 50: Actual electricity network maintenance costs by voltage level in 2022 and 2023

	2022 [EUR 1,000]	2023 [EUR 1,000]	Total	Comment/ Further details
High-voltage electricity network	1,012	963	1,975	
Substations	1,529	1,429	2,958	
Medium-voltage network	1,989	2,082	4,071	*
Secondary substations	1,021	763	1,784	
Low-voltage network	1,848	1,718	3,566	

* Including costs according to the maintenance programme in 2022: EUR 1,767,000 and 2023: EUR 2,082,000 and forest management in areas adjacent to the electricity network in 2022: EUR 222,000.

3. Places of use within the scope of the quality requirements after the preceding actions

Information about actual figures are based on information reported from the network information system.

Table 51: Places of use within the scope of the quality requirements in zoned areas in 2022 and 2023

Zoned area	2022	2023
Places of use that meet the operational quality requirements of the electricity distribution network (number)	224,197	228,116

Table 52: Places of use within the scope of the quality requirements outside zoned areas in 2022 and 2023

Outside zoned areas	2022	2023
Places of use that meet the operational quality requirements of the electricity distribution network (number)	127,536	132,547

Table 53: Places of use within the scope of the quality requirements in areas subject to a quality requirements level based on local conditions, in 2022–2023

Areas subject to a quality requirements level based on local conditions	2022	2023
Places of use that meet the operational quality requirements of the electricity distribution network (number)	231	231

4. Actions in the preceding two years by development zone

Information systems, automation and smart metering devices

1. We continued to increase network automation and fault indication as part of conventional network investments.
2. Projects that enhance cyber security have been implemented in automation and system environments.
3. The operation of the automatic fault location, disconnection and supply restoration system was developed to better correspond to the current network topology, as well as to make better use of the information available from the fault indicators.
4. The project to install next-generation smart meters started in 2021 and large-scale replacements will continue until 2025. The project reached the halfway point in 2023, when 200,000 Elenia customers had already received a new smart meter.
5. Together with our system partner, we developed a power distribution calculation tool that works in the operation support system and is able to use real-time metering data from the electricity network, as well as customer-specific metering data from the new smart meters. The power distribution calculation based on the network data is scaled according to actual metering to correspond to the current load situation in the network, and the calculation continuously runs in the background of the operation support system, alerting about potential overloads of network components, as well as to voltage limits being exceeded or undercut.

High-voltage distribution network

1. The 110-kilovolt high-voltage distribution network has mainly been built as an overhead line network, but some sections has been built with underground cabling for land-use reasons. The security of electricity supply of the high-voltage distribution network has been ensured by maintaining the conductors and line corridors of the overhead line network so that they can withstand falling or bending trees. Substation investments were made by increasing earth fault current and reactive power compensation equipment and by upgrading and replacing switchgear, control gear and secondary equipment. Substation switchgear and control gear are typically used until the end of their lifecycle but at the same time, investments significantly improve the reliability of substations. The maintenance programme actions have also been carried out in the development zones.

Development zones 1–2

1. Urban and densely populated areas and the medium-voltage network supplying electricity to them are extensively built with underground cabling. Underground cabling has been started from substations and targeted at areas where it has been possible to replace the entire supply route with underground cables. The maintenance programme actions have also been carried out in the areas.
2. The low-voltage network has been built with underground cabling in the same area as the medium-voltage network where this has been technically and financially justified in connection with the installation of medium-voltage cabling. The maintenance programme actions have also been carried out in the area.
3. In addition, the medium-voltage and low-voltage networks in urban and densely populated areas have been built even in a fast schedule, as far as possible, in cooperation with other operators that build and maintain civil engineering networks. In difficult areas, this has made it possible, to some extent, to upgrade the network cost-efficiently, minimising the inconvenience caused to users in the areas in question.

Development zones 3–5

1. The medium-voltage network has been upgraded with underground cabling so that connections with sufficient capacity and reliable security of electricity supply have been established between densely populated areas and between substations. The trunk lines of the medium-voltage network have been built with underground cabling, from substations onwards. Remote-controlled disconnector devices and fault indication devices have been added at the beginning of overhead line branches. With them, faults can be detected and the branches can be isolated from the feeding trunk line with the least possible testing connections. The maintenance programme actions have also been carried out in the areas.
2. The low-voltage network has been built with underground cabling in the same area as the medium-voltage network where this has been technically and financially justified in connection with the installation of medium-voltage cabling. The maintenance programme actions have also been carried out in the area.
3. In addition, the medium-voltage and low-voltage networks in the development zones have been built even in a fast schedule, as far as possible, in cooperation with other operators that build and maintain civil engineering networks. This has made it possible to upgrade the network cost-efficiently, minimising the inconvenience caused to users in the areas in question.

Development zone 6

1. Maintenance programme actions have been carried out for the medium-voltage network in a way that ensures the network's safety and security of electricity supply. In the medium-voltage network, individual poles and cross-arms have been replaced on the basis of inspection findings. In the development zone, forests in areas adjacent to the electricity network have been managed extensively.
2. The maintenance programme actions has been carried out in the low-voltage network.

Development zone 7

1. New battery systems have been developed together with an energy company and an equipment manufacturer.
2. The operation of the pilot site in Elenia's network has been monitored and analysed.
3. The maintenance programme actions has been carried out in the network of the development zone.

5. Electricity distribution network meeting the quality requirements after the actions of the preceding two years

Information about actual figures are based on information reported from the network information system.

Table 54: Network that meets the quality requirements, in 2022–2023

2022					
Voltage level	**0.4 kV**	**20 kV**	**45 kV**	**110 kV**	**Yhteensä**
Network that meets the quality requirements, km	26,506	17,632	326	1,434	45,898
2023					
Voltage level	**0.4 kV**	**20 kV**	**45 kV**	**110 kV**	**Yhteensä**
Network that meets the quality requirements, km	27,705	18,342	329	1,477	47,853

Table 55 shows the route length that involved joint construction and its share of the total route length built.

Table 55: Share of joint construction of the route length built

	2022	2023	Comments/ Further details
Share of joint construction [km]	114	57	171
Share of joint construction [%]	8.3 %	9.7 %	8.7 %

6. Significant distribution network investments made in order to connect new production and new loads in the preceding two years

Table 56 shows the significant network investments made in order to connect new production and new loads.

Table 56: Significant investments made in order to connect new production and new loads in the preceding two years

	2022 [EUR 1,000]	2023 [EUR 1,000]	Comments/ Further details
High-voltage network and substations	4,799	11,718	
Increase of the distribution network capacity in connection with upgrading	9,063	5,898	
Distribution network expansion investments	10,095	9,401	
Smart meters	13,287	21,194	
Total	**37,244**	**48,211**	**85,455**

In the high-voltage network, two completely new 110 kV distribution lines were built, one line was overhauled, and modifications were made to three existing lines in order to connect them to the new substations built in the main grid. In total, these projects built 73 km of new distribution lines. Several substations were expanded and, due to production and electricity storage connections ordered in the medium-voltage network, 110 kV voltage transformers were installed at five substations and protection changes were made. The above-mentioned investments in the high-voltage network and substations were primarily made to enable the connection of new production. In addition, investments in the high-voltage distribution network were made mainly in the vicinity of densely populated areas, in order to increase distribution capacity and improve the security of electricity supply.

Investments were also made in the medium- and low-voltage network for network connections for clean transition projects. Examples include construction projects for quick charging of electric cars and electricity storages. In connection with upgrades to the medium- and low-voltage network, network capacity has been increased to make it possible to connect new production and new loads. Stronger lines were built and an increase in the capacity of distribution transformers was made possible by structural choices in secondary substations and by increasing the number of secondary substations. In addition, network capacity was increased based on the needs of customers so that more production and consumption could be connected to the network. The distribution network has also been expanded to include new residential and industrial areas, for example. Investments made for individual consumer connections are not included in the figures.

The large-scale project to install next-generation smart meters launched in 2021 also continued in 2022–2023. These meters enable more accurate metering and thus more accurate determination of network capacity as the use of electricity changes due to the energy transition. In addition, they offer control options for the needs of the developing electricity market.

7. Use of demand response services in the preceding two years

Studies and pilot projects

As part of the new-generation smart meter replacement project, Elenia has promoted the implementation of demand response services through its own operations. The meters include, for example, a load control relay for customers' use, which can be programmed through the customer portal Elenia Aina to operate in the lowest-price exchange electricity hours. In addition, Elenia is involved in the development of a HAN gate reader for private use, that is, a home automation connection that allows customers to monitor their own consumption more accurately, as well as build various automated electrical equipment controls. The functions enabled by the new smart meters have not yet been realised as demand response services that can be used by the network company, but Elenia wants to actively promote and enable new solutions.

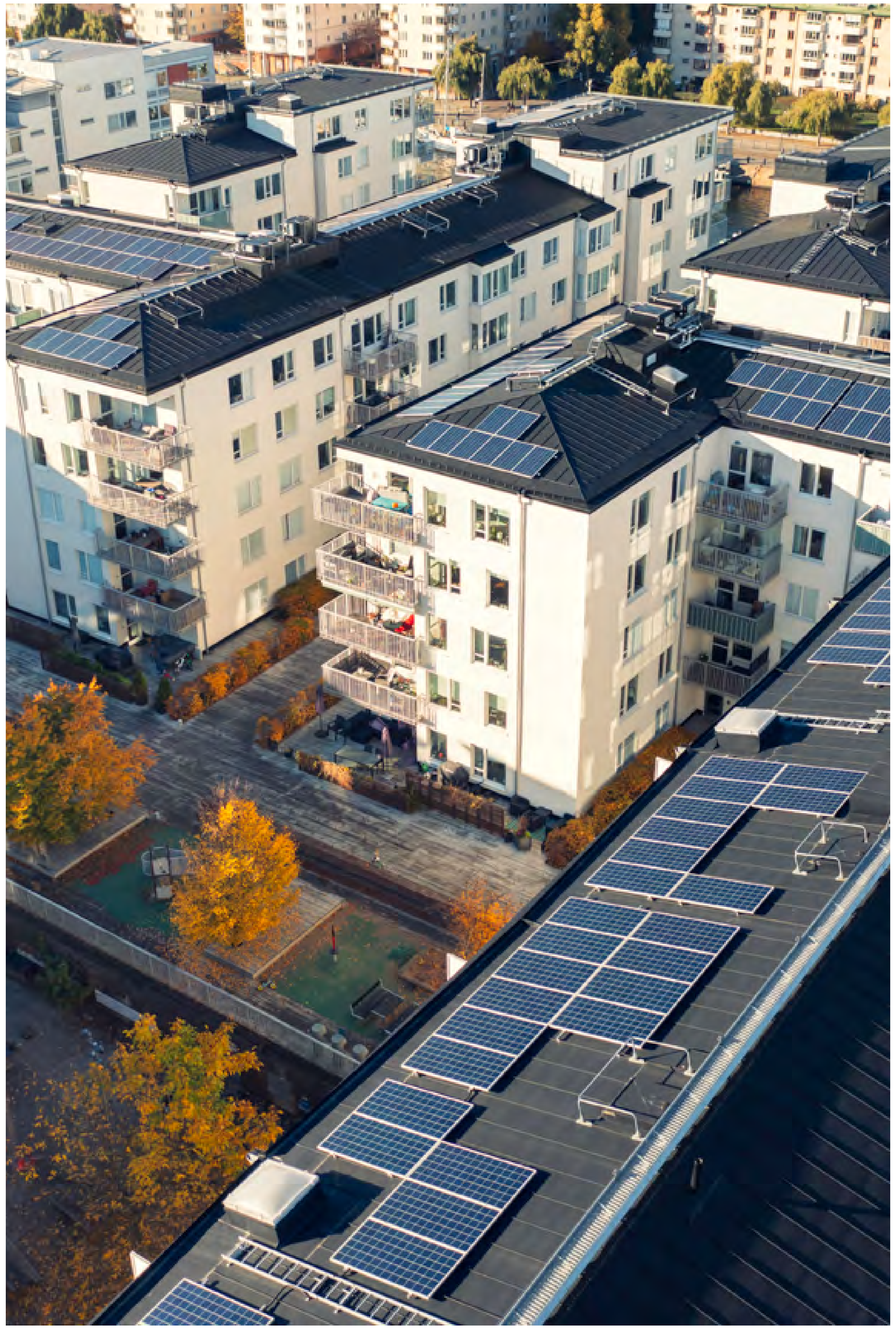
The pilot projects on the provision of security of supply demand response to electricity network customers, started in 2020 with the energy company Fortum, was also in operation from 2022 to 2023. In this pilot, a battery pack owned by Fortum was placed in Elenia's electricity network in Kuru so that it can feed electricity to over one hundred customers for approximately three hours during a power outage. The battery capacity of the pilot site is 300 kW and 220 kWh. The battery pack is deployed as the reserve capacity of the storage island completely automatically. New battery systems operating on a similar principle have been developed together with Merus Power Dynamics and Fortum.

Demand response services used

The Kuru pilot site is currently operating in the frequency reserve market and in Elenia's use in automatic isolated operation during disruptions. The benefits of the network company are realised when disruptions happen, approximately 5–10 times a year. The realised costs are presented in Table 57. In addition, reactive power compensation made with the converter will result in cost savings of approximately EUR 7,500 per year in reactive power fees, which have not been taken into account in the figures in Table 57. The actual development, design and construction costs of the new battery equipment are also presented in Table 57, although the equipment will not be commissioned until 2024.

Table 57: Actual costs of demand response services in 2022–2023

	2022 [EUR 1,000]	2023 [EUR 1,000]	Total	Comments/Further details
Deployment costs	102,6	0,2	102,8	Planning and construction of 2 projects to be installed in 2024
Operational costs	3	3	6	Pilot project in operation
Cost benefits	15	15	30	Annual savings in regulatory outage costs (harm caused due to outages), estimate



8. Performance in the preceding two years compared to the previous submitted development plan

The development plan submitted in 2022 and the actual outcomes for 2022 and 2023 are similar in principle. The most significant deviations and their reasons are presented below:

1. With regard to the high-voltage distribution network, the reported amounts of investments in euros made to connect new consumption and production were in total more than EUR 11 million less than the plans presented in the 2022 development plan in 2022 and 2023. However, the projects were launched according to plan, but some of the projects are so large in terms of construction volumes that they are spread over several calendar years. The actual results are reported according to the completed fixed assets, as are the key figures of electricity network operations submitted to the Energy Authority. Therefore, if the project is still in progress at the turn of the year, there is no completed fixed asset, and it is therefore not visible in the actual figures. In fact, the construction of the high-voltage distribution network has corresponded to the plan, but due to the reporting principles, the completed fixed assets are only visible with a delay in the case of long projects.

2. There are annual and line-level differences in replacement investments in the high-voltage distribution network and substations, but the high-voltage distribution network and substations must be treated as a single whole, even though they have been presented as separate lines in accordance with the provisions of the development plan. A single construction project often involves construction relating to both the substation and distribution lines, so the presented itemisation should be considered to be indicative. With regard to substations and distribution lines, the total actual replacement investments were approximately EUR 3 million higher than estimated in the 2022 development plan in 2022 and 2023. The overrun was due to an increase in costs caused by inflation, as well as the number of projects being higher than estimated, as customer-driven construction projects were rapidly implemented.

3. In 2022–2023, the total amount of realised replacement investments in the distribution network, i.e. the medium-voltage network, secondary substations and the low-voltage network combined, was approximately EUR 45 million more than estimated in the previous development plan. The main reason was the increase in costs, as as a result of the explosive rise in inflation, Elenia had to compensate contractors for fuel and materials in distribution network construction projects. The number of construction projects implemented was as planned.

9. The network operator must submit a map of the areas that meet the quality requirements

Elenia has submitted information about the areas that meet the quality requirements of the Electricity Market Act at the end of 2023 to the verkkotietopiste.fi service as part of the publication of the development plan. In addition, the Elenia Avoin service provides information about customer-specific security of electricity supply and a forecast of its development.

ELENIA AVOIN

Tell us your thoughts on the most important everyday service – electricity.

Our development plan feedback is open
in our Elenia Avoin service until June 2, 2024.
avoin.elenia.fi

ELENIA

Background materials

Appendix 1: Asset management policy
Appendix 2: Environmental policy
Appendix 3: Occupational health and safety policy
Appendix 4: Procurement policy
Appendix 5: Information security policy
Appendix 6: Environmental management system, ISO 14001 certificate
Appendix 7: Safety management system, ISO 45001 certificate
Appendix 8: Asset management system, ISO 55001 certificate
Appendix 9: Information security management system, ISO 27001 certificate
Appendix 10: Playbook for major power disruptions