2 2023

FINGRID

TRANSMISSION SYSTEM OPERATOR'S MAGAZINE / RENEWING THE ENERGY SYSTEM / *fingridlehti.fi*

LAURA IHAMÄKI AND ANTTI-JUHANI NIKKILÄ, FINGRID:

"Offshore wind power and industrial-scale solar power are on the rise."

Finland's competitive edge is its reliable electricity grid

Transmission system operators work closely together

Planning work requires dozens of pieces to fall into place before construction can begin on a new route or substation. “Planning encompasses environmental values, safety, and financial viability, in addition to very many other factors,” say Patrik Lindholm (behind) and Pasi Saari, Experts from the Grid Planning Unit, and Jenni-Julia Saikkonen, Specialist from the Land Use and Environment Unit.

Working together

Most of the work to design transmission line routes and substations is done by specialists around the same table.

The issues influencing substation designs include the environment, nature, land use, and the existing electricity transmission network.

The existing infrastructure and soil are carefully studied, as they can influence whether, for example, a main transformer can be transported to the site.

Substation sites are selected after carrying out nature inventories in the potential sites to identify any biotopes, species, and relics in the potential substation area.

Route planning involves studying where a transmission line can be built. If possible, they are built next to existing lines according to the national land use objectives. Routes are planned using maps and by visiting the sites.

When a new transmission line route is planned, special attention is paid to housing and nature. The aim is to identify a feasible route that minimises environmental harm and meets the technical objectives for further project planning and, ultimately, construction.

A statutory environmental impact assessment (EIA) is carried out when building 400-kilovolt transmission lines. The EIA determines how the various potential routes could affect for example birds and other wildlife, housing, economic activity, the climate, and the landscape. Interaction with landowners, authorities, and other stakeholders is a crucial aspect of an EIA.

An environmental study, a lighter-weight version of the EIA, is conducted for 110-kilovolt transmission line projects. ◆

IN 2022, FINGRID’S GRID PLANNING UNIT MADE A TOTAL OF

20 investment proposals.

THE COMBINED VALUE OF THESE WAS

EUR 800 million.

This sum includes transmission lines and substations.

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Fingrid will attend the Suomi Areena event in Pori from 27 to 30 June. See you there!

RENEWING
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REGULAR SECTIONS

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Finland is building a new industrial success story

FINLAND IS in prime position to create a new wave of industry that will resolve the world's emissions problems. The battery industry and clean steel have enormous export potential. Refined products made with green hydrogen, such as synthetic fuels for maritime and air transport and fossil-free fertilisers, are a growing industry with plenty of demand.

The new wave of industrialisation will require an immense amount of electricity. Fingrid estimates that electricity consumption in Finland could increase by up to 50 per cent as a result of industrial investments this decade.

Electricity will be a critical factor in this competition – it must be emission-free, inexpensive and reliable. And Finland can offer that electricity.

The opportunity to make the green transition a real industrial success story and a source of prosperity is well within Finland's grasp. Our competitive advantage in electrification is a diverse, clean and efficient electricity production infrastructure. A significant increase in electricity production this decade can be provided by highly competitive onshore wind power – one of the cheapest sources of renewable energy. There will be a lot of it, as long as there is demand for this electricity.

Competitive production combines with strong electricity networks to bring electricity reliably from producers to consumers. In the modern world, reliable electricity networks are among the most important factors in national competitiveness for industrial green transition projects.

Hopefully, Finland's new parliament and government will contribute to development.

Emission-free, inexpensive and reliable electricity will attract investments to Finland. However, international competition is fierce. Our success story hinges on wise choices and hard work. Hopefully, Finland's new parliament and government will contribute to this development.

In this regard, Fingrid has the following advice: permit processes must be faster. A practical resolution to the radar problem in eastern Finland must be identified. The government should also consider how to swiftly attract new forms of electricity production to ensure the supply of electricity in Finland.

The new energy landscape requires our decision-makers to act with foresight!


Sami Perttilä

Jukka Ruusunen
President & CEO
Fingrid

FINGRID

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New grid connections subject to temporary restrictions on the west coast

The dramatic growth in wind power and the regional concentration on the west coast poses a challenge to the stability of power plants and the power system as a whole.

Problem-solving requires new connections to the main grid and changes to the control systems in power plants. Until these changes bring some much-needed relief, we will be forced to restrict the grid connections of power plants and grid energy storage facilities connecting via power converters on the west coast.

SCOPE OF RESTRICTIONS:

- Converter-connected installations rated at more than one megawatt are not permitted to connect to the main grid or distribution network (this does not apply to connection agreements made before 1 May 2023)
- The restriction applies in the area marked on the map on our website: **fingrid.fi/rajoitukset_lansirannikko**. The area is approximate, so it is advisable to check with Fingrid whether installations can be connected if they are located at the edge of the area.
- Distribution network transmission lines fed from the network areas marked on the map are subject to the restriction.

The restrictions do not apply to individual converter-connected installations rated at less than one megawatt or synchronous machine power plants. New main grid connections will be completed in the region in 2027 and 2028.

We will notify our customers of any changes to the restrictions and when the restrictions are lifted.

THE MAXIMUM WIND POWER OUTPUT WILL BE OCCASIONALLY REDUCED DURING TRANSMISSION OUTAGES

In the coming months, during planned transmission outages we will set the maximum wind power output from the west coast at a level lower than normal. The change will have the greatest effect when peak wind power output coincides with planned transmission outages. This action will be taken in close cooperation with wind power producers. ◆

PROFILE

New challenges to resolve in the power system

Eveliina Seppälä is inspired by power system technology and relishes her return to more technical work.

TEXT MINNA SAANO | PHOTO FINGRID

For seven years, I worked on matters related to the electricity market at Fingrid, most recently in the Strategic Grid Planning unit. This spring, I moved to the Power System Engineering unit.

Before changing units, I was involved in coordinating Fingrid's electricity system vision. This work is done every few years for long-term planning purposes. It involves studying how production and consumption could change under four scenarios and the consequent impacts on the main grid.

In my new position in the Power System Engineering unit, it is interesting to get to grips with technical issues, examine various phenomena in the power system, and study how to address them.

As the energy revolution proceeds, a lot of wind and solar power is connecting to the grid, so new solutions are required for the functionality of the power system.

Solar and wind power connect to the grid through power converters, a different technical implementation than a conventional power plant that behaves as a synchronous machine. This gives rise to new challenges in ensuring that all the converter-connected production and consumption can be connected to the grid. I studied electrical engineering, and this new job feels like going back to my roots – it feels good." ◆

WHO?
Eveliina Seppälä

WORK
Specialist

FAMILY
Spouse

FREE TIME
Dance, avid reader of fiction

Transmission lines to be modernised in Nurmijärvi

Fingrid will modernise 11 kilometres of a 110-kilovolt transmission line in Nurmijärvi to improve the regional network.

The section of transmission line will be modernised using towers shared with Nurmijärven Sähkö in an existing right-of-way to minimise the land-use impacts. The project will enable Kesko's planned logistics centre to connect to the distribution system operator's network. The transmission line project will be completed in 2025/2026. ◆

Number of employees at Fingrid *(2022)*

499

Satakunta to gain three new substations

Fingrid will build new substations in Nakkila, Harjavalta and Kokemäki to serve new industrial plants.

Caruna, Lammaisten Energia, Länsi-Suomen Voima's hydroelectric power plant in Harjavalta, Kolsin Voima's hydroelectric power plant in Kolsi and Boliden's plants in Harjavalta will connect to the substations. The substations will be built with environmentally-friendly technology free of SF6 dielectric gas. They will be completed in 2026. ◆

The maintenance elite

FINGRID was ranked among the best companies in the International Transmission Operations and Maintenance Study (ITOMS), which measures the effectiveness of maintenance in transmission grids. The study examined the maintenance operations of 25 network operators from around the world in 2021. The study is carried out every second year, and Fingrid has participated since 1995. Fingrid has been recognised as one of the top performers ever since.

PRACTICAL QUESTION

How much energy does cooling consume, and how much does it cost?

Air conditioning is essential on hot summer days. Although cooling machines are not particularly expensive, Teemu Kettunen, Specialist at Motiva, advises using them in moderation. TEXT MARJO TIIRIKKA

1 Can solar panels provide the electricity needed for air conditioning?
This depends very much on the property. In detached houses with a roof free of shadows and pointing in a suitable direction, solar power can easily produce more electricity than the property consumes in the summer – including cooling.

Conversely, in tall apartment buildings with a high cooling requirement and a small roof area for solar panels, solar power may only cover a fraction of the electricity consumption from air conditioning. Panels can be installed on the façade to boost the building's solar power potential.

2 How is cooling handled in data centres?
Cooling can account for about a quarter of all the electricity a data centre consumes.

Finland offers good potential for data centres to use free cooling by taking cooling energy from the outdoor air, a body of water, or the soil and transferring it without a compressor to the place it is needed, usually via cooling water. If there is not enough free cooling, data centres often make up the difference using air conditioners with compressors, which consume more electricity than free cooling.

District cooling is another good option, provided the data centre is near a district cooling network. District cooling solutions normally allow waste heat to be recovered and transferred to the district heating network, making the system highly energy efficient.

3 How much does it cost to cool a detached house?
Using an air-source heat pump to cool a detached house for an entire summer consumes 100–500 kWh. If the electricity price is 15 cents per kilowatt-hour, the cost of cooling the house will be EUR 15–75 for the entire summer, depending on the device's power rating, cooling method, and areas to be cooled.

4 Cooling does not seem particularly expensive. If there is a heatwave, is it better to use an air conditioner than suffer the high temperatures?
Cooling should be used in moderation. Air-source heat pumps remove moisture from the air, so an indoor temperature of 24–25°C may feel suitable for many people during a heatwave.

The total electricity consumption of cooling devices – including the service sector – is significant, even in Finland, and it is worth considering the energy efficiency of cooling. For example, heat pumps enable more waste heat from cooling to be recovered. More and more attention has been paid to this in recent years. ◆

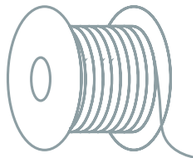
How does cooling affect the power system?

IN RECENT YEARS, the increased amount of cooling has been reflected in the power system by a slight increase in electricity consumption. When the temperature surpasses roughly +20°C for a prolonged period, consumption increases by approximately 50 MW/°C. However, the impact is considerably smaller than the opposite situation in the winter, when each additional degree below zero adds about 150 MW of electricity consumption.

A VISION OF THE POWER SYSTEM

The European energy revolution is just getting started, but it is picking up pace. Finland has a fantastic opportunity to prosper from this transition. Fingrid has envisioned four long-term scenarios for the power system.

COMPILED BY PEKKO NIEMI / INFOGRAPHIC BY LAURA YLIKAHRI



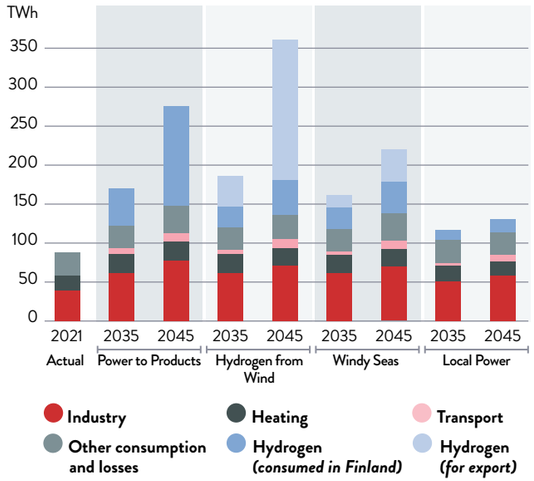
Current length of Fingrid's 400 kV network

5,100 km

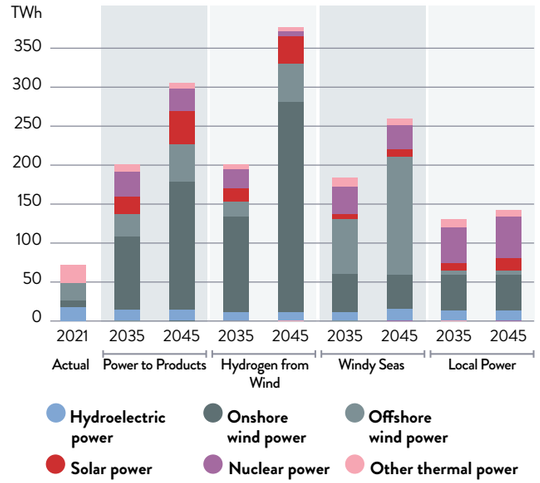
Length of 400 kV transmission lines to be built by 2033 under the current investment programme

3,200 km

Electricity consumption in the various scenarios



Electricity production under the various scenarios



Power to Products

- Finland develops to become a major exporter of products made from electricity (P2X products).
- The hydrogen required in P2X processes is produced close to the demand facilities, without centralised hydrogen storage facilities or a hydrogen network.

Hydrogen from Wind

- The hydrogen system acts as an energy storage facility, enabling very large-scale onshore wind power production.
- The rapidly changing structure of production and consumption presents a challenge for the technical functionality of the power system. This is reflected in a massive need for north-to-south energy transmission.

In addition to the development called for in the existing investment plan, new 400 kV transmission lines would be needed by 2035 with the following lengths:

3,800 km

6,100 km

Windy Seas

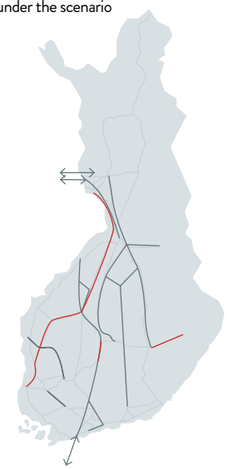
- Offshore wind power is the dominant form of electricity production.
- Electricity production is focused on the west coast, posing challenges for the transmission of electricity from the west coast to consumption concentrations.

Local Power

- Finland's total electricity consumption is modelled on the low-carbon roadmap, so consumption increases sharply, but less so than in the other scenarios.
- Electricity is produced from a variety of sources, the most important of which are onshore wind power, conventional nuclear power, SMR nuclear power and solar power.

Connectivity needs identified in multiple scenarios

— Fingrid's investment plan
— New strengthening required under the scenario



1,500 km

400 km

Find out more about the electricity system vision: fingrid.fi/en/electricity_system_vision_2023

OFFSHORE WIND POWER AND SOLAR POWER PLANTS GAIN MOMENTUM

Enormous wind power projects are being set up in the sea, while industrial-scale solar parks are being built on land. What makes them so compelling now, and how will these projects affect the power system of Finland?

TEXT VESA VILLE MATTILA / PHOTOS SUSANNA KEKKONEN AND SHUTTERSTOCK

“The growth period for offshore wind power will occur in the 2030s and 2040s,” say Laura Ihamäki and Antti-Juhani Nikkilä from Fingrid.

Finland's first offshore wind power plant built on foundations at sea is located in Tahkoluoto, Pori.

Numerous investors are planning new offshore wind power and solar power plants in Finland. This is reflected in a barrage of connection enquiries sent to Fingrid.

"So far, we have received more than 100 gigawatts of connection enquiries for offshore wind power and solar power," says **Laura Ihamäki**, Offshore Wind Power Expert at Fingrid.

Fingrid estimates that 7 GW of solar power production could operate in Finland by 2030. The first offshore wind power plants will come online at the turn of the 2030s, with the biggest growth in offshore wind power occurring in the 2030s and 2040s.

CATERING FOR THE GREEN TRANSITION AND HIGHER ELECTRICITY CONSUMPTION

In addition to onshore wind power, offshore wind power and industrial-scale solar power are accelerating the green transition by responding to the increased electricity consumption due to new consumption investments.

Another advantage is that offshore wind and solar power have different production profiles from onshore wind power.

In the best cases, large solar parks are relatively straightforward to build once a suitable area has been identified. However, building wind turbines in the sea is a different proposition entirely. Nevertheless, the location is attractive because it is possible to build much larger wind turbines at sea than on land. This compensates for the large upfront investment.

The 20-megawatt offshore wind turbine produces

2.5

times as much electricity each year as a 10-megawatt onshore wind turbine.

Still little offshore wind power

WIND POWER is divided into onshore and offshore according to where the power plants are located and where the electricity cables run.

Although the amount of offshore wind power worldwide is soaring, only about five per cent of all wind power plants are offshore. Europe has long pioneered offshore wind power, but China has caught up in recent years.

The only offshore power in Finland so far is the Tahkoluoto wind farm in Pori, where turbine foundations have now been laid on the seabed. Wind turbines have been built on artificial islands in Ajos, off the coast of the Port of Kemi.

"The largest offshore wind turbines in the world today are in the 15-megawatt category, while on land, they can reach about 10 megawatts. Designs for 25-megawatt offshore wind turbines are already on the drawing board," Ihamäki says.

The wind is also stronger at sea than on land, and offshore wind power can reach a capacity factor of more than 50 per cent, meaning that they operate at peak output for more than 50 per cent of the time. Consequently, the annual output of a 20-megawatt offshore wind turbine is 2.5 times as much as a 10-megawatt onshore wind turbine.

MAIN GRID, CONNECTIONS, AND FAULTS TO BE EXAMINED

There are still many uncertainties and matters for Fingrid to resolve related to the construction of offshore wind power.

Most offshore wind power projects are in the Gulf of Bothnia. When they are built, they will add to the already considerable pressure on the main grid on Finland's west coast.

According to the Windy Seas scenario in Fingrid's electricity system vision published in spring 2023, Fingrid would need to add up to 1,500 kilometres of new 400-kilovolt transmission lines to the main grid – in addition to the investments already included in the investment plan – to cater for 15 gigawatts of offshore wind power.

Industrial-scale solar power is needed for the green transition.

"If we can tempt new consumption facilities to connect to the same connection points as offshore wind power plants, there will be less need to strengthen the grid," says Ihamäki.

"We also need to start thinking about how to connect customers's high-voltage direct current transmission links to our power system."

The enormous size of individual offshore wind power projects – some of which have a production capacity two or three times that of Olkiluoto 3 – is also food for thought.

The dimensioning fault is the largest possible individual fault or disturbance that Fingrid prepares for. No individual fault should affect the operation of the main grid or bring it down.

"Because we do not intend to increase the dimensioning fault of the power system, the largest projects need to be divided into several parts. They would then connect to the national grid via separate connection lines to ensure that no individual fault could lead to the loss of more than 1.3 gigawatts of production."

PRACTICES AT SEA TAKING SHAPE

Finland's sea areas are divided into regional and economic zones, as well as the territorial waters of Åland.

The territorial water zone is closer to the coast, while the economic zone stretches into the waters of Finland's neighbouring countries, subject to international treaties.

Finland's territorial waters are administered by Metsähallitus, which leases sea areas to wind power operators using an auction model. The first project based on this approach is Vattenfall's offshore wind farm, which will be completed in the 2030s off the coast of Korsnäs.

The practices in other sea areas and the procedure for granting exclusive rights to construction projects are still subject to speculation.

Ihamäki points out that Fingrid's responsibility for all solar and wind farms is clearly delimited. Customers implement the plants and connection lines as far as Fingrid's designated connection points. The transmission system operator builds connections from there.

However, some countries are drawing up or experimenting with approaches based on political decisions where the transmission system operator assumes more responsibility for the connection lines to offshore wind power plants. Consolidating connection points have been planned in the sea with radial or looped connection lines.

OPERATING METHODS AND COMMUNICATIONS WILL BE DEVELOPED

As the amount of electricity generated by distributed wind and solar power plants with varying levels of output accounts for a larger share of production in Finland's grid, cooperation between Fingrid, control centre operators, and an increasing number of energy producers will become more important.

"Electricity production and consumption need to be more closely aligned, requiring an effectively managed flow of information in both directions," summarises **Kimmo Kaappola**, Business Development Manager of Caverion Industria Oy's wind power unit, which operates renewable assets from its 24/7 control centre.

He lists the following questions:

"How can we reconcile the technical and commercial aspects of running an electricity grid? How can we communicate situations such as network outages or the need to limit the output of solar and wind power plants in the event of an overload? How can solar and wind power producers contribute to the balancing power and reserve markets?"

Antti-Juhani Nikkilä, Senior Advisor at Fingrid, says that Fingrid is working with operators in the sector to seek new approaches. One example is exchanging information between ICT systems instead of making phone calls.

"The issue is fundamentally one of maintaining the system security of Finland's grid. Clear ground rules for compliance with the technical requirements, real-time situational awareness, up-to-date contact details, and contribution to the balancing energy market already facilitate large production hubs." ◆

TEXT VESA VILLE MATTILA

From wind to sun

Ilmatar Energy, which focuses on renewable energy, has also invested in industrial-scale solar power plants. The newest solar power plant just came online in Joroinen.

A DIVERSE energy production mix requires the use of renewable energy sources based on different weather phenomena with production profiles that complement each other.

Ilmatar Energy Oy began working on wind power more than a decade ago. The company now also aims to produce solar energy on an industrial scale.

A solar park with a rated output of five megawatts recently began operating in Joroinen. In the future, Ilmatar will be interested in solar power projects several times larger, and projects have already been announced in Pöytyä and Ähtäri.

"Different forms of energy production and the decentralisation of production will increase the security of the national energy supply and strengthen local economies in the places where power plants are built. Moreover, as a renewable energy superpower, Finland could also attract international industrial investments," says **Erkka Saario**, VP Projects.

PRODUCTION MAXED, COSTS CONTROLLED

Ilmatar follows a coherent strategy in wind and solar power production.

The company is responsible for developing its projects from start to finish. When an investment gets the green light, Ilmatar builds and owns the plant throughout its life cycle.

According to Saario, solar power plants need to be built in places where production can reach the maximum amount and good connectivity to the network keeps costs under control.

"Energy consumption is concentrated in southern Finland, so establishing solar power production there will reduce the strain on the rest of the main grid."

Saario notes that ensuring the stability of the grid may become a larger technical challenge for wind and solar power production.

"As energy producers, we would like more flexibility in network connections without compromising the stability of the grid and viability of investments." ◆

Gigantic green steel project

Blastr Green Steel, a Norwegian entity, is planning a low-carbon steel mill in Inkoo, where it plans to produce steel with significantly lower carbon dioxide emissions than conventional production.

TEXT TUIJA HOLTTINEN / PHOTO BLASTR GREEN STEEL/AFRY

We are planning a large steel mill with an annual output of 2.5 million tonnes of green steel," says **Antti Kaikkonen**, Managing Director of Blastr Green Steel in Finland.

He says there is substantial demand for green steel in the market.

"In our future customer base, it is clear that all companies using steel in their production operations want to reduce their carbon footprints. We aim to create the solutions to address this demand."

Similar projects are already underway elsewhere in the world, but Kaikkonen says that Blastr Green Steel has particularly ambitious emission reduction targets.

"We aim to reduce carbon dioxide by 90 per cent throughout the value chain, including not just the emissions from our steel production – known as Scope 1 emissions – but also Scope 2 and 3 emissions."

The project is proceeding according to schedule. It is currently in the preliminary study phase, and production should begin in 2027/2028. An agreement has been made with Fortum on the land area where the mill will be built. An environmental impact assessment and town planning are now underway.

"Lots of different phases are going on now. We are focusing our efforts on permits and the preliminary design of the mill. We have entered into discussions with potential technology suppliers, and we are preparing to seek external financing," Kaikkonen says.

Inkoo was chosen as the ideal place for the large green project thanks to its good infrastructure. The old, traditional industrial plot already has a strong electricity network and a substation connected to Fingrid's main grid.

Electrical energy is needed for the steel mill and for producing the hydrogen required for direct reduction.

"It is very important for us that the electrical infrastructure needed for the plant already exists. Building a new network of this strength would be a major undertaking. A further significant benefit is that Fingrid plans to strengthen the network further."

Antti Kaikkonen admits that the project's success hinges on cooperation and dialogue.

"The timetable and the project as a whole are ambitious, and many things will need to go right. I strongly believe that open cooperation will lead to a good outcome."◆

Three scopes of emissions

THE GREENHOUSE gas protocol (GHG Protocol) is a standard for measuring environmental impacts in three scopes.

- Scope 1 emissions arise as a consequence of the company's own operations, and the company can directly affect them.
- Scope 2 emissions are indirect emissions related to production, such as the emissions caused by electricity production.
- Scope 3 emissions include, among other things, the indirect emissions arising from the end use of products.

Source: greencarbon.fi

Getting the economic foundations into shape

OUR NEW GOVERNMENT'S priorities are to get the economy in order and kickstart economic growth. That is why it seemed strange that the pre-election debates this spring featured no serious discussion of Finland's actions to address the climate crisis and biodiversity loss.

"Unbelievable short-sightedness," I thought to myself.

The biggest challenge is that the actions required to mitigate the climate crisis and halt biodiversity loss are considered beyond the scope of serious economic debate.

This is despite the fact that strengthening nature and stopping the climate crisis are known to be the foundation for a sustainable economy. There is no point in building on flimsy foundations. The whole economy is directly or indirectly dependent on nature.

It is also well known that an enormous global market has emerged around the solutions to these problems – one that will be measured in the hundreds of trillions of euros in the coming decades.

The new government should take climate and nature action deadly seriously, especially since it aims to get Finland's economy in order.

The state should create an environment where these problems can mainly be resolved on market terms. It should also recognise that the climate crisis and biodiversity loss go hand in hand and are mutually reinforcing. Luckily, they can, to a large extent, be resolved simultaneously.

Actions to strengthen biodiversity, such as sustainable forest management or regenerative agriculture, are effective climate actions. However, some climate actions, such as renewable energy, with all the metals and building area it requires, may cause localised biodiversity loss.

The synergies of climate and nature action and the necessary compromises must be taken into account in the government's programme, national strategies, regulations, and local actions.

The new government should take climate and nature action deadly seriously.

This gives the economy a direct boost. When two major problems are resolved together, it leads to better cost-effectiveness, and well-intentioned actions will not drive the country from one crisis straight into another one.

Scientists have a thorough understanding of the inextricable link between biodiversity loss and the climate crisis. The government must now take the science seriously and take action.

I am not trying to claim that the action required will be easy. But it is clear that economic growth will be much more difficult to build without a robust foundation. ◆

Mari Pantsar
is an adjunct professor and a partner at Kari & Pantsar Co. She is also a defender of a sustainable planet and has worked in cleantech business development for over 20 years.

A RELIABLE ELECTRICITY GRID **GIVES FINLAND A COMPETITIVE EDGE**

The green transition in the power system will herald a new era of clean industry in Finland, and the presence of major industrial electricity consumers in the country ensures a positive return on renewable energy investments.

TEXT KATARIINA KRABBE / PHOTOS SAMPO KORHONEN

"Our company will need even more electricity in the future, and it is important for us that more renewable electricity production facilities are built," says Outi Ervasti, Vice President, Renewable Hydrogen at Neste.

The renewal of the power system is hugely significant for our business," says **Outi Ervasti**, Vice President, Renewable Hydrogen at Neste.

Neste will need much more electricity in the future, as its climate and business strategy calls for hydrogen production using renewable electricity.

The company aims to make its production entirely carbon-neutral by 2035.

"It is important to us that more renewable electricity production facilities are built, and Fingrid makes an important contribution to this by expanding the main grid in line with the electricity supply and demand. We will also need to take action to accommodate our future electricity needs. For example, we will need to increase the transmission capacity of the connecting line to the Kilpilahti industrial area," says Ervasti.

She says Neste must become more closely integrated into the electricity market and the entire electricity value chain.

"Large-scale process industries need a continuous power supply – refineries cannot shut down momentarily if the wind stops blowing or the sun stops shining. We are now thinking about the best ways of responding to large fluctuations in production in the future electricity market."

Hydrogen produced using renewable electricity holds an important position in Neste's climate and business strategy.

COOPERATION THAT EVERYONE BENEFITS FROM

Outi Ervasti thinks Finland is well-positioned to pioneer the exploitation of renewable energy.

"A strong power system enables cost-effective, large-scale solutions. I hope green hydrogen will also be used in Finland – primarily in high-grade industrial processes – instead of just exporting electricity or hydrogen to competitive markets in Central Europe. We should keep the added value in Finland," she emphasises.

The green transition will enable industrial renewal and entirely new businesses based on large-scale sector integration.

"When we make hydrogen, others will be able to exploit the heat and oxygen generated by the process."

The green transition will also enable economic growth:

"However, cooperation is essential – we can create new business opportunities where everyone wins. Investments must also be financially

“Flexible hydrogen production supports investments in renewable electricity production and the electricity network,” believes Saara Kujala, CEO of Ren-Gas Oy.

viable, and businesses need to learn to acquire funding. Startups, in particular, need more than just a good idea – they also need to be able to sell it to financiers.”

FLEXIBLE HYDROGEN PRODUCTION

Nordic Ren-Gas Oy, a project development company established in 2021, focuses its operations on the green transition and EU emission reduction targets.

Ren-Gas got off the starting grid thanks to funding from venture capitalist **Ilkka Herlin**. At the end of last year, Allianz, a German company, took a minority stake in the company.

Nordic Ren-Gas Oy plans to operate in the electricity flexibility market.

The company is developing production plants based on three main technologies.

Electrolysers use wind-generated electricity to break down water into hydrogen and oxygen, as Neste intends to do. The waste heat generated in this process is fed into the district heating networks of Ren-Gas’s partners in the energy distribution business.

Ren-Gas also recovers the carbon dioxide from the flue gases of its partners’ power plants. The company builds its production plants next to Finnish power plants – for example, it is planning a plant in Tampere next to the Tarastenjärvi waste-to-energy plant.

The third technology is synthesis, which uses hydrogen and carbon dioxide to create methane with exactly the same chemical composition as biogas for transport and fossil natural gas.

“We are currently developing plants in five locations, going through permit processes, and concluding business agreements. We are awaiting investment decisions in Tampere and Lahti towards the end of the year,” says **Saara Kujala**, CEO of Ren-Gas.

Ren-Gas also plans to operate in the electricity flexibility market – flexibility is naturally in demand throughout the EU.

“We hope the flexibility market will provide us the price signals to indicate that there is demand,” Kujala says.

In addition, Ren-Gas has modelled the electricity price trend under various scenarios, depending on whether Finland has flexible green hydrogen production.

“If there is no renewable hydrogen production, the electricity price will likely remain low. The price of wind power would then be even lower, carrying the risk of investors deciding against investments in renewable electricity generation. Flexible hydrogen production supports renewable electricity production investments and the electricity grid.” ◆

Finland is reindustrialising thanks to carbon-free electricity

MARKKU KIVISTÖ, Head of Industry, Cleantech, Invest In, Business Finland, is responsible for foreign cleantech investments in Finland. His clients are foreign industrial operators looking for a suitable base in the European market.

“Maximising the amount of carbon-free energy production will lay a strong foundation to build new Finnish industries, expertise, innovations, and well-being,” Kivistö says.

He mentions three focuses: a battery value chain working on the principles of sustainable development, the production of hydrogen and its derivatives, and CO_2-free industrial production.

“Industrial carbon emissions can be reduced if clean energy is available, transmitted, and stored. Low electricity prices, investments in the functioning of the main grid, and a uniform price area are competitive advantages that will attract investments to Finland.”

At the same time, Finland is reindustrialising.

“This is a unique opportunity to foster the growth of Finnish industry. We have the opportunity for more than EUR 100 billion in investments, EUR 100 billion in exports, and jobs for 100,000 people. This is also a part of the European Green Deal – the achievement of climate targets. We offer solutions to combat the energy crisis and climate change.”

SEAMLESS COOPERATION BETWEEN TRANSMISSION SYSTEM OPERATORS

The partnership between Finland's Fingrid, Sweden's Svenska kraftnät and Estonia's Elering is wide-ranging. The goal is a unified electricity system that uses as little carbon as possible and allows all these countries to get electricity at the market price.

TEXT PÄIVI BRINK / PHOTO SHUTTERSTOCK

A unified European electricity market is based on functioning cross-border transmission connections. The head of Fingrid's HVDC & FACTS unit, **Kimmo Nepola**, says it is important that the market has a comprehensive range of power generation options available.

"The importance of wind power is increasing all the time, but nuclear power and hydropower also play an important role as a leveller of generation fluctuations in renewable forms of energy and a guarantor of energy availability. With the help of cross-border connections, electricity price fluctuations remain smaller. The green energy transition requires strong transmission connections so that we can balance production and consumption," says Nepola.

In recent years, the most significant changes to Finland's cross-border connections have been related to the green energy transition and Russia's war in Ukraine. The export of electricity between Russia and Finland has completely ceased as a result of the war.

The transmission system operators (TSOs) of Finland, Sweden and Estonia have excellent relations, and they cooperate in many ways.

"We support each other if, for example, a neighbouring country has problems with cross-border connections. We borrow spare parts, exchange information and experiences, coordinate power outage times and transfer replacement electricity to each other as needed. When we build or renovate joint transmission connections, we also do planning and research together. At the moment, for example, we are renewing the automation systems controlling HVDC connections and conducting seabed research."

Effective cooperation also includes continuous maintenance.

"There are surprisingly few problems with our cross-border connections, and a lot of work is being done to ensure they work. It is great that each of these TSOs has the will to keep the transmission connections in shape. It's clear that we respect each other," says Nepola.

AURORA LINE INCREASES ELECTRICITY TRADE BETWEEN FINLAND AND SWEDEN

Svenska kraftnät and Fingrid are jointly building a new 400 kV transmission line from Pyhänselkä in Finland to Messaure in Sweden. The name of the project is Aurora Line. The steel industry currently been built in northern Sweden needs a lot of carbon-free electricity, which is also produced in northern Finland's wind farms and at the Olkiluoto 3 nuclear power station. Similarly, electricity produced by hydropower, for example, is brought to Finland from Sweden. Aurora Line is estimated to be completed in 2025.

Svenska kraftnät's Asset Manager **Dag Ingemansson** says that Sweden is just about to enter the Aurora Line construction phase. Poles are already being erected on the Finnish side.

"Working cross-border connections ensure that the main grid and power generation facilities are utilized as efficiently as possible on both sides of the border. At the same time, we enable the realisation of the green energy transition. In the past, more electricity was exported from Sweden to Finland than in the other direction, but now the amount of exports from Finland to Sweden is increasing," says Ingemansson.

He says that it is easy to work with Fingrid. The cooperation has been continuing for a long time, as the undersea Fenno-Skan connection has been operating between the southern coasts of the two countries since the 1980s.

"We have common interests, and we actively share information. Our communication is informal and we respond to each other's requests quickly. We understand each other."

THE PLANNING OF ESTLINK 3 HAS ALREADY STARTED

There are two EstLink undersea cables between Estonia and Finland, and a third one is being planned.

"The EstLink connections are very important for both countries and the entire Baltic region. Cross-border connections guarantee the functioning of the electricity market and increase the operational reliability of the main grids," says Elering's Head of HVDC and Power Plant Unit **Reigo Haug**.

According to Haug, it is important that European grid companies share experiences and learn from each other.

"When there was a phase reactor failure on our side of EstLink 1 last November, the experiences Fingrid had in a similar incident a few years earlier were very useful for the repair work. They helped us to shorten the forced outage time. It is great that as partners we quickly support each other. The HVDC connections are like a car: they only work if all the elements work together. If one tyre is flat, we need to fix it fast," says Haug.

EstLink 3 is estimated to be completed in the 2030s.

"There is a common understanding between our countries that we need EstLink 3 to increase the possibilities of electricity transmission between the Nordic and Baltic countries. The amount of transferred electricity has grown steadily over the past few years. We are conducting feasibility studies and making preliminary plans for connection points and the best cost-effective routes. An investment decision on construction will probably be made within the next few years," says Haug." ◆

INDEPENDENTLY IN ÅLAND

Finland has two transmission system operators: Fingrid and Kraftnät Åland, the latter of which manages the power grid in the Åland Islands. Electricity is produced in Åland and imported, mainly from Sweden.

TEXT SUSANNA CYGNEL / PHOTOS SHUTTERSTOCK

Last winter was mild in Åland, so electricity consumption was lower than usual. High temperatures and high electricity prices kept consumption down.

"We were prepared to respond to any power outages, but there was no need for special measures because we had enough electricity all winter," says **Conny Rosenberg**, CEO of Kraftnät Åland.

Kraftnät Åland is a completely independent transmission system operator that maintains the electricity network and offers electricity transmission services in Åland, just as Fingrid does in mainland Finland.

Åland's power grid comprises a total of approximately 300 kilometres of lines, along with substations, cross-border connections, and IT systems. There are also connections to the mainland: one submarine cable to Sweden and two to mainland Finland.

WIND POWER AND IMPORTED ELECTRICITY FROM SWEDEN

Wind power produced in Åland covers about 65 per cent of the region's annual electricity consumption. When it is very windy, there is even a surplus of wind power, which can be sold to Sweden.

Solar power and a small amount of bioelectricity are also available. In a pinch, Åland can start up two gas turbines fuelled by diesel oil.

In addition to its own production, Åland buys electricity from Sweden, as it is closer to Åland than mainland Finland.

A 58-kilometre-long submarine AC cable stretches between the substations in Senneby, Sweden and Tellholm, Åland, connecting Kraftnät Åland to the Swedish electricity network operated by Vattenfall Regionnät.

A high-voltage DC cable stretches 152 kilometres from Åland to Naantali in mainland Finland. This connection is activated automatically within a few seconds if the connection to Sweden is lost.

"Åland has mainly bought electricity from Sweden ever since the first submarine cable was laid to Sweden in 1973," Rosenberg says.

RESERVE CONNECTION TO FINLAND

Kraftnät Åland is also connected to Finland by a high-voltage DC cable stretching the 152 kilometres from Ytterby in Åland to Naantali in mainland Finland. This connection is activated automatically within a few seconds if the connection to Sweden is lost.

This is a reserve connection that is only used in the event of disturbances. The same connection has occasionally supplied mainland Finland with power if Åland has had a surplus.

"For example, there was an outage in northern Finland last winter, so Kraftnät Åland transmitted electricity to mainland Finland via the Naantali connection," Rosenberg says.

The same need could arise in the event of an electricity shortage in mainland Finland. Rosenberg says that under certain conditions, Åland could effectively help mainland Finland.

He says that the Ytterby–Naantali cable could be used even more.

"It would be good to allow the market to access all the available capacity," Rosenberg contemplates.

There is a second connection from Åland to Finland, joining the grid in mainland Finland via the archipelago. The connection has a low capacity, and it only enables electricity to be supplied to the archipelago and a small part of eastern Åland. It is mainly used in the winter to reduce the load on the cable to Sweden.

DESTINATION: SWEDEN, VIA ÅLAND?

Åland's electricity connections to Sweden and Finland are independent of each other. If the need arises, each has enough capacity to supply all the electricity Åland needs.

Consideration has also been paid to whether mainland Finland could receive electricity from Sweden via Åland.

"Yes, it is technically possible. However, the existing connections have such limited capacity that the connection would not offer much power," states Rosenberg.

If offshore wind power is developed in Åland's waters, Rosenberg says that cables could be built to Sweden and Finland at the same time to enable electricity to be transmitted between the countries.

"No plans have been made for this, but the idea has been floated," he confirms.

INTERNATIONAL COOPERATION ALONGSIDE FINGRID

As mentioned above, the practical cooperation between Fingrid and Kraftnät Åland is mostly related to disturbances such as temporary electricity supply outages. The transmission system operators also work together by exchanging information and learning about each other's operations.

Kraftnät Åland Ab is an officially registered transmission system operator in the European Union, so it is subject to all the same EU laws and regulations as Fingrid. It is involved in the European Network of Transmission System Operators for Electricity (ENTSO-E), which coordinates international cooperation.

"Our organisation is small – we only have 14 employees – so we cannot attend every international meeting or event. In many cases, Fingrid's representative also represents Kraftnät Åland," Rosenberg says.

In addition, Kraftnät Åland has an observer's seat in the Nordic Regional Coordination Centre (RCC) for Nordic transmission system operators.

"Above all, Nordic cooperation provides us with plenty of information about matters such as the development of the electricity market." ◆

TEXT MATTI VÄLIMÄKI / PHOTOS SHUTTERSTOCK

ACCURATE INFORMATION **ABOUT FAULTS**

My Fingrid is a central point of access for customers looking for detailed information on power outages and estimates of the locations of faults.

My Fingrid now provides more detailed information on faults and disturbances in the main grid.

"The service shows information on specific transmission lines and provides accurate calculated estimates of fault locations using sources such as the Finnish Meteorological Institute's data on lightning strikes. This information could previously be found from several sources, but now it is all available in the same place, My Fingrid," says **Mika Pajuoja**, Expert at Fingrid.

My Fingrid is a digital service that customers can access by logging in to their accounts. It provides information such as electricity transmission metering, invoicing, and reactive power data.

"The service will continue to develop in response to customers' wishes and feedback," says Pajuoja.

Fingrid will continue to notify its customers of severe faults by text message or email as before.

"The text message and email service has also been improved. Messages are now sent nearly instantly, even at weekends."

My Fingrid will allow organisations to specify which people should receive text message or email notifications.

"In the future, customers will be able to modify their information, but for now, the updates must be handled via Fingrid," Pajuoja says.

HELP WITH REPORTING AND REPAIRS

Information is sent directly from Fingrid's supervisory control and data acquisition (SCADA) system to customers' SCADA systems. This also includes information about disturbances.

My Fingrid also provides information on electricity transmission metering, invoicing and reactive power.

"In the future, we want to provide more direct data like this to our customers so that they can see the status of the main grid on their own systems. However, we cannot publish electricity market data," Pajuoja notes.

Teemu Suvela, Operations Manager at Elenia, a distribution system operator, is satisfied with the update.

"It is helpful to have all the data to hand in My Fingrid when we report electricity distribution outages to our customers and the authorities. We will have quicker and easier access to the facts we need, and we can compare them with our own information."

Suvela says it is important to have information documented in one place, where it is easy to find in the future.

"For example, the information is useful when we analyse the condition of our network and the need for repairs," he notes.

FAULT REPAIR CREWS SENT TO THE RIGHT PLACE

When disturbances are investigated, it may become apparent that, for example, several autoreclosures have occurred in quick succession on one transmission line and that the estimated fault locations are approximately correct.

"When we have access to the most accurate fault location data possible, it is easier for us to dispatch repair crews to the places where faults are likely to be," Suvela says.

In a "right-of-use bay", the bay, switchgear, and protective devices belong to Fingrid, but the 110-kilovolt line out of the substation belongs to the distribution system operator, who is also responsible for repairing it if necessary. The length of the 110-kilovolt line may range from a few kilometres to more than one hundred kilometres.

If a fault occurs in a 110-kilovolt radially feeded power line, it is immediately apparent to customers connected to the medium- and low-voltage networks.

"The resulting power outage could affect a large area. Although we can almost always restore the power supply to customers using reserve connections in the medium-voltage network, the 110-kilovolt line must be repaired quickly," Suvela points out.

PLANNED OUTAGES

Mika Pajuoja says that approximately 300 faults arise in Fingrid's main grid or installations every year.

"In around two hundred of these cases, the outage only lasts about a second – the lights may flicker momentarily – before the network reconnects automatically. The most common cause of outages are lightning strikes and bird droppings soiling the insulator chains. In the winter, snow can accumulate on the lines and cause problems."

The most common causes of outages are lightning strikes and and birds soiling the insulator chains.

In addition, there are approximately 1,200 planned outages in the main grid every year. These allow for maintenance work or the connection of new parts of the network, for example.

The grid has expanded dramatically in recent years, as dozens of new wind farms have been connected.

"This has also caused the number of planned outages to rise. End users barely notice planned outages because replacement connections are arranged to prevent interruptions in the power supply." ◆

Local information about power outages (in Finnish): fingrid.fi/siirtokeskeytykset

TEXT MARJO TIIRIKKA / PHOTO HARRI NURMINEN

Planning is the most important aspect of transmission outages

Transmission outages are a necessary part of the construction and maintenance of the electricity network. Outages should be planned with care to ensure the security of the energy supply.

Repairs, maintenance, and investments in the branch lines connected to the main grid can also cause transmission outages in the main grid. Every year, more than 1,000 planned electricity transmission outages take place in the main grid, so there is always an outage happening somewhere in Finland.

"These are busy times. Transmission lines and substations are being maintained, serviced, and built all over Finland. These cause transmission outages. If the transmission outages are long, it is important to calculate system security," says **Jouko Loikala**, Fingrid's Regional Manager for Southern Finland.

The timing of electricity transmission outages is also important, and the aim is to carry out most of the work in the spring–autumn season. Some work requiring transmission outages is also done in the winter. For example, frozen ground is more conducive to transmission line construction and maintenance because it is easier to move heavy-duty equipment on harder terrain.

Work is sometimes scheduled for weekends or at night to reduce the impact on the market.

When work is carried out on the connection lines for major power plants and large-scale industry, the outages are planned to coincide with annual maintenance.

Jouko Loikala began working as Fingrid's Regional Manager for Southern Finland at the start of February. He previously worked as a Transmission Line Specialist in Southwest Finland region for nearly 16 years.

GETTING GOING WELL IN ADVANCE

Fingrid is responsible for the main grid, and electricity companies are responsible for planning outages and switching in the distribution network.

The plans are coordinated and integrated into Fingrid's plans.

Outages should be planned well in advance to minimise their adverse impact on the electricity market and the security of the energy supply.

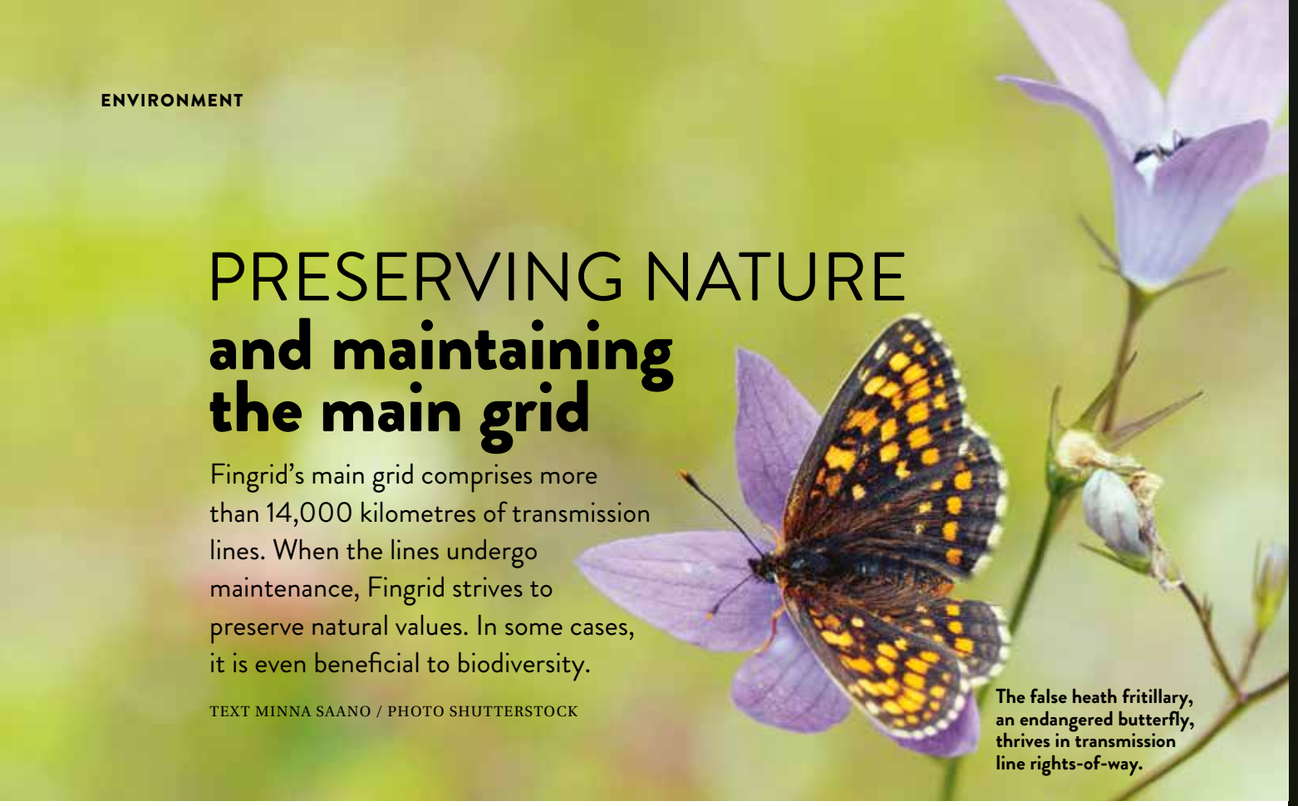
In broad outline, the process proceeds as follows: Fingrid's Grid Maintenance unit analyses the transmission and outage needs for the following year by the end of November. This information is used to coordinate work and prepare preliminary timetables for the next year. These are presented to the customer by the end of the following January.

"We try to include every party's maintenance needs in our outage plan to minimise the impact on customers and the electricity market. Coordination leads to the minimum possible disruption, good system security, and occupational safety," Jouko Loikala says. ◆

PRESERVING NATURE **and maintaining the main grid**

Fingrid's main grid comprises more than 14,000 kilometres of transmission lines. When the lines undergo maintenance, Fingrid strives to preserve natural values. In some cases, it is even beneficial to biodiversity.

TEXT MINNA SAANO / PHOTO SHUTTERSTOCK



The false heath fritillary, an endangered butterfly, thrives in transmission line rights-of-way.

Long transmission line routes often pass through valuable natural sites. We carry out maintenance on the principle of causing the minimum possible disruption to nature," says **Mikko Jalonen**, Manager, Maintenance Management at Fingrid.

For example, during nesting season, Fingrid does not clear vegetation from sites that are valuable to birdlife. In some places, maintenance work requiring heavy machinery is postponed until winter because it results in less damage to the soil and vegetation than when the ground is soft.

Before clearing or treating the trees in the border zone, official sources are consulted to verify whether the area contains any protected plants or nature areas.

"Specific instructions are issued for places like these, and the most sensitive areas are marked on the terrain so that they can be avoided."

One aspect of preserving biodiversity is preventing the spread of invasive species.

"It is our aim that the employees working in the field are able to identify invasive species and do their work without spreading them," Jalonen says.

Transmission line maintenance work also promotes the living conditions of species and increases biodiversity.

"When we fell trees in border zones, we can leave logs behind at the landowner's request to provide more rotten wood to help various organisms grow and thrive in the area and serve as nesting trees for birds."

Meadows and pastures, the natural environments of many butterfly species, are becoming rarer, but transmission line rights-of-way can offer suitable open habitats for them.

"Regular clearing work has preserved the habitats of endangered butterflies. One species to benefit from this is the false heath fritillary, along with the elder-leaved valerian, a food source for this butterfly," Jalonen says.

Fingrid is currently conducting a study to monitor the effects of more frequent clearing on the reproduction of plants and other living organisms in traditional landscapes and sunny, dry habitats.

"We are receptive to new ways of maintaining and promoting biodiversity as part of our operations."

Fingrid contributes to biodiversity by developing the main grid to achieve the green transition and climate goals, so our climate will change as little as possible and have the minimum possible impact on nature. ◆

TEXT TUIJA HOLTTINEN / PHOTO SHUTTERSTOCK

Testing 24-hour performance

The Network Code for Emergency and Restoration (NC ER) was prepared by the European Commission to prevent disturbances from spreading and causing blackouts and ensure that the system can be swiftly restored to normal operation.

The network code obliges the transmission system operator to designate the system-critical parties whose installations, systems, and internal instructions must meet the requirements of the network code.

The five-year transition period following the adoption of the network code expired at the end of last year.

Jari Siltala, Senior Expert in charge of implementing the NC ER at Fingrid, says the designated parties have succeeded in implementing the required 24-hour capability.

"In practice, the parties have ensured that even in the event of a 24-hour power cut, the control centre will remain operational, the electricity will stay on, and the most critical tools will work. It is also important to maintain communication capabilities: it must be possible to exchange information in real time and provide situational awareness by phone."

The control centre's operating capacity is tested by cutting off the electricity. At the same time, the electricity consumption is metered and calculations are performed to check that there is enough power for the capacity of the batteries and fuel.

The 24-hour resilience of voice communications is tested annually by making test calls in both directions. This year, the relevant parties will decide how to handle testing in practice.

"The idea is that the voice communication tool is, to the extent possible, in everyday use. That would enable us to utilize the call logs to minimize the need for additional test calls. In other words, the phone system would be the normal channel the parties use to communicate," Siltala explains.

The 24-hour capability applies to control centres and designated power plants and substations.

"The implementation was quite a big project for us. It affects more than 100 substations in Fingrid's main grid. In addition, there are another 100 substations in distribution networks."

Siltala says the work has progressed well.

"In the current circumstances, it is also easier to understand the importance of these things. We are seeking to ensure that electricity production remains as stable, reliable, and secure as possible under all conditions." ◆

Make the most of our map service!

FINGRID'S MAP SERVICE is a convenient channel for checking Finland's main grid. You can see where the main grid is located in Finland, which main grid projects are underway, and where it is currently possible to connect to the grid. In addition, you can find out about upcoming clearing operations near transmission lines and submit your feedback or questions.

THE MAP SERVICE shows operational disturbances arising in Fingrid's electricity network. For example, grid construction and maintenance may occasionally require transmission outages, and the map service shows where and when these will occur.

Discover Fingrid's map service (in Finnish) and submit feedback on our transmission line projects: www.fingrid.fi/karttapalvelut

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