1 2022

FINGRID

TRANSMISSION SYSTEM OPERATOR'S MAGAZINE / THEME: BUILDING THE GRID / *fingridlehti.fi*

More than 100 substation projects in two years

Heading for a harmonised European electricity market

Long-term maintenance ensures reliable transmission in the main grid

Frost scrubbers

Hoar frost sticks to the earth wires of transmission lines and presses them onto the phase conductors. The consequence is an earth fault, which de-energises the transmission line. If there is a very large amount of ice load, the tower structures or earth wires could break.

Ice load usually occurs between December and February in an area stretching from South Karelia to Lapland but especially in the regions of North Savo, North Karelia, and Kainuu.

Ice load is removed by scrubbing the earth wire with a specially-developed tool. This is generally done by helicopter, but the conventional "man and a rope" method is still used.

Every year, ice load is removed from an average of 100 spans, but there is significant year-to-year variation due to climate change. In the winter of 2018–2019, ice load was removed from a record 1,300 spans covering a total distance of approximately 390 kilometres. Despite this, ice load was the cause of four faults in the main grid. In some winters, it is not necessary to remove any ice load at all.

Fingrid has developed a special tower for ice loads that can withstand frost burdens in excess of the normal design criteria. These towers are used on new lines in areas where ice loads commonly occur. ◆

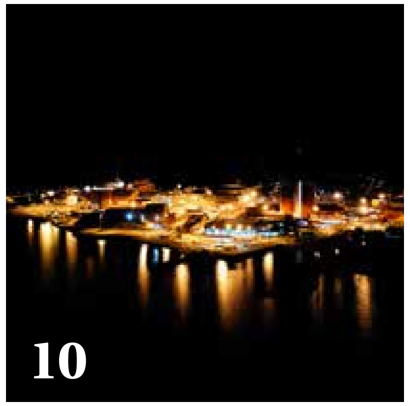
Frost is removed from an earth wire using a helicopter.

Watch the video! FingridOyj www.fingridlehti.fi/kuuran-kuuraajat/

CONTENTS

1 2022

THEME:
BUILDING
THE GRID



FOLLOW US ON SOCIAL MEDIA

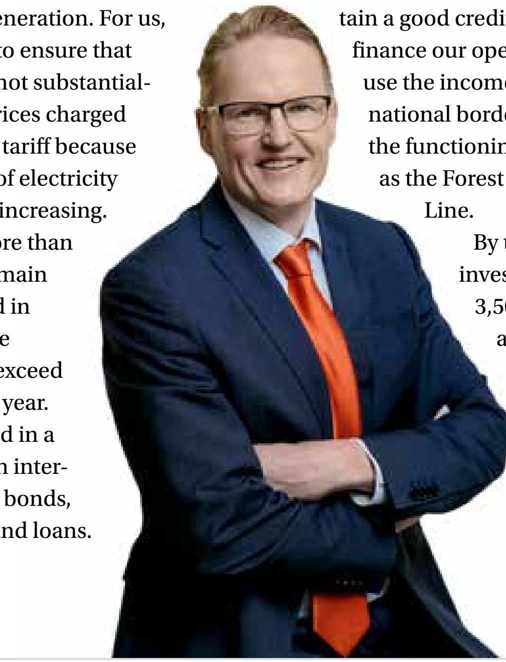
Read more at **fingridlehti.fi** and **fingrid.fi**

A historic wave of investment is underway – where does the money come from?

THE ELECTRICITY generation structure is expanding, decentralising, and becoming lower in emissions to meet the increasing demands of electrifying industries. The power system is in the midst of an unprecedented transition, which calls for major investments in the main grid.

Fingrid constantly has more than 100 projects in progress. We aim to ensure that Finland retains sufficient transmission capacity and remains a single bidding area for electricity trading. A strong main grid is also a competitive advantage for the region, attracting investments in consumption and generation. For us, the starting point is to ensure that our investments do not substantially change the unit prices charged under the main grid tariff because the billable volume of electricity transmission is also increasing.

We will invest more than EUR 2 billion in the main grid this decade, and in the coming years, the investment pot will exceed EUR 300 million per year. Financing is obtained in a decentralised way on international markets for bonds, commercial paper, and loans.



The Nordic Investment Bank recently granted a green loan of EUR 70 million, and the interest rate on a EUR 300 million revolving credit facility is tied to our company's sustainability targets. The more we succeed in connecting renewable energy to the main grid and upholding occupational safety, the cheaper the loan will be for us – a genuine win-win situation.

Our goal is to increase the share of green financing. High-quality operations throughout the supply chain – material suppliers, service providers, and Fingrid employees – help us maintain a good credit rating and attract investors to finance our operations in the future. We also use the income generated from bottlenecks at national borders for investments to improve the functioning of the electricity market, such as the Forest Line, Lake Line II, and Aurora Line.

By the end of this decade of intense investment, we will have an extra 3,500 kilometres of main grid lines and dozens of new substations, as well as a growing and satisfied base of customers.

Timo Kiiveri
Senior Vice President
Asset Management
Fingrid

FINGRID

FINGRID Fingrid Oyj's magazine, 25th volume **PUBLISHER** Fingrid Oyj, fingrid.fi **EDITOR-IN-CHIEF** Marjaana Kivioja, marjaana.kivioja@fingrid.fi **MANAGING EDITOR** Marjut Määttänen, marjut.maattanen@fingrid.fi **EDITORIAL TEAM** Marjaana Kivioja, Niko Korhonen, Minna Laasonen, Marjut Määttänen, Risto Ryynänen, Katariina Saarinen, Jarno Sederlund and Tiina Seppänen **EDITORIAL OFFICE** tel. 030 395 5267, fax 030 395 5196, postal address PO Box 530, 00101 Helsinki, street address Läkkisepäntie 21, 00620 Helsinki **AD** Laura Ylikahri **PRODUCER** Susanna Haanpää **CONTENT PRODUCTION** Legendium **COVER PHOTO** Susanna Kekkonen **CHANGES OF ADDRESS** assistentit@fingrid.fi **SUBSCRIPTIONS AND CANCELLATIONS** fingrid.fi/tilauslomake **PRINTING** Punamusta ISSN-L 14557517 ISSN 14557517 (printed) ISSN 22425977 (online publication)

Printed matter 4041-0619

Looking to the future

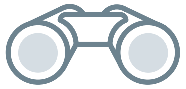
The power system vision clarifies Finland's status in the energy revolution.

What will carbon neutrality demand from the power system, and what technical challenges will the changes in the structure of electricity generation and consumption pose for it? What changes will the energy revolution demand from the electricity market? How can we tackle these challenges while enhancing Finland's competitiveness? These questions will be covered in the power system vision, a continuation of Fingrid's network vision, which was published last year. The power system vision will be completed in the autumn.

The power system vision is a continuation of Fingrid's network vision, which was published at the start of last year. The network vision's scenarios for the future foresee dramatic changes in the current power system. Whereas the network vision focused on analysing the needs for reinforcement, the power system vision aims to clarify the energy sector's overall status in the energy revolution while also considering the development of the electricity market.

"Working on the vision is one way of engaging in dialogue with customers and stakeholders. We hope the vision attracts plenty of interest and constructive discourse on Finland's electric future," says **Eveliina Seppälä**, Project Manager in charge of the vision work at Fingrid.

In March, Fingrid is asking its stakeholders for their views on the scenarios used for the vision work and the future structure of the electricity market and power system. ◆

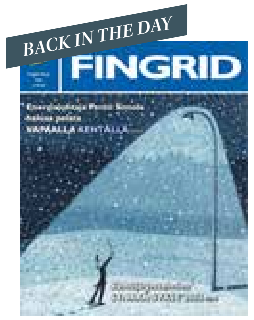


Take a look at main grid connection possibilities using the "network binoculars"

FINGRID receives a lot of enquiries about connecting to the main grid. We compiled this information about future connection possibilities and generation projects that are already underway in our "network binoculars".

The aim of the network binoculars is to provide customers and stakeholders with an open overview of grid planning and support the realisation of regional visions.

fingrid.fi/verkkokiikari



From one magazine to another

FINGRID magazine issue 1/2004 covered the exceptionally large electricity outages that had occurred the previous autumn in various parts of the world. The Energy Director advocated for diverse electricity generation capacity in this magazine.

What do you think about the current content and revamped look of the Fingrid magazine?

Send your feedback: **viestinta@fingrid.fi**

PROFILE

Network connection almost complete

Minna Laasonen's work is independent, interesting, and probably never dull.

TEXT MINNA SAANO | PHOTO SAMPO KORHONEN

I have worked at Fingrid since its inception in 1997. Previously, I worked in expert and managerial positions, but then I felt the urge to get back into an engineering role. Since 2010, I have been working in Power System Operations.

At the moment, I am preparing the synchronization of the Olkiluoto 3 power plant and the execution of the test production phase from the perspectives of the transmission system operator and power system. I also serve as secretary to the steering group on System operations, which is one of our internal processes.

The best thing about my job is the independence I have. When the targets are clear, I plan for myself how I will achieve them. Keeping the overall picture under control is an interesting but demanding aspect for me.

There are many challenging things in my work, but they are hardly ever unpleasant or boring. The good thing about my job is that we have experts and specialists in various fields at Fingrid, and I can always approach them for advice if I need it.

There have been many memorable moments throughout my career. One such experience was when I contributed to the Nordic analysis group from 2013 to 2018. Among other things, we conducted several studies on how renewable wind power would affect the behaviour of the power system and how in system operations should we prepare for the changes related to it. I have fond memories of working with my Nordic colleagues; we were a good, tight-knit bunch.

This year, I hope the commissioning of Olkiluoto 3 will be completed and everything will go as planned." ◆

WHO?
Minna Laasonen

WORK
Senior Expert

FAMILY
Spouse and four children

FREE TIME
Finishing an eMBA degree, music, handicrafts, gardening, hiking and skiing

Substantial EU funding for the Aurora Line

The EU has granted EUR 127 million for the Aurora Line electricity transmission connection under the Connecting Europe Facility.

The new AC connection between Finland and Sweden is scheduled for completion in 2025, and it is the most important main grid investment of the decade.

The Aurora Line will increase the electricity transmission capacity from Sweden to Finland and lower the price of electricity in Finland. It will also enable the additional construction of renewable energy and promote the achievement of climate goals. The connection will also improve the security of the energy supply in Finland and the Baltic Sea region more widely. ◆

Datahub online!

DATAHUB, the centralised information exchange system for the electricity retail market, went live in February. All the data on approximately 3.8 million electricity accounting points in Finland is now stored in a shared system, which accelerates customer service and the exchange of information in the electricity retail market. The system is used by Finland's electricity retailers and distribution system operators. Datahub is being further developed to meet the evolving needs of energy markets.

Wind power connection agreements 2021

1,500 MW

Appointments in Fingrid's management

Jukka Metsälä, MSc (Tech.), MBA, has been appointed as CFO and as a member of the Executive Management Group from 5 May 2022.

Tuomas Rauhala, DSc (Tech.), has been appointed as Senior Vice President, Power System Operation and as a member of the Executive Management Group from 1 June 2022.

PRACTICAL QUESTION

Olkiluoto 3 is coming – we are ready

The Olkiluoto 3 nuclear power plant unit will soon begin contributing to Finland's electricity generation. What does the commissioning of the new nuclear power plant mean for the security and self-sufficiency of the power system? Minna Laasonen, Senior Expert at Fingrid, answers our questions.

1 How has Fingrid prepared for regular electricity generation at the new plant?
Fingrid has been active in preparing for this moment over several years. Our personnel possess specialist expertise in the operation of the main grid, and this will also see us through the start-up of the new nuclear power plant.

2 How will the electricity generation capacity of Olkiluoto 3 be reflected in the main grid?
It will be particularly evident in the form of an increase in Finnish electricity generation and better self-sufficiency, so it may also affect the need for electricity imports. However, OL3 will also slightly decrease the electricity import capacity from Sweden.

3 What contingencies are in place if OL3 is suddenly unable to supply electricity to the main grid?
Fingrid has worked with the plant's owner and builder, Teollisuuden Voima, to implement system protection that limits OL3's impact on the grid in the event of a sudden fault. Furthermore, the Nordic transmission system operators maintain reserves in case of such failures.

Our personnel possess specialist expertise in the operation of the main grid.

4 Will Finland be more vulnerable with respect to electricity in the future? Is it not true that the impacts of a potential disturbance are greater than for smaller units?
Fingrid has contingencies in place if OL3 suffers a disturbance and trips off the grid, so it will not make us vulnerable, even though the effects on the grid are larger than in the event of a failure in a small power plant. In addition, Finnish nuclear power plants generally have excellent reliability rates.

Finnish nuclear power plants generally have excellent reliability rates.

5 Will Olkiluoto 3 make Finland more self-sufficient in terms of electricity?
Yes, Finland will be more self-sufficient in the future. Electricity will be imported if it is cheaper in the neighbouring region. So far, the market has functioned, and Finland has also obtained electricity during its winter peaks. If the winter proved just as cold in our neighbouring countries as it is here, and if a significant generation problem arose, there could be a shortage of electricity. The completion of OL3 will alleviate this situation. ◆

CROSS-BORDER CONNECTIONS GROWING IN IMPORTANCE

A uniform European electricity market based on clean electricity generation requires cross-border connections between countries. In Finland, Fingrid is responsible for developing and maintaining such connections.

TEXT VESA VILLE MATTILA / PHOTOS FINGRID AND TVO

The European Union aims to create a harmonised European electricity market. **Jussi Jyrinsalo**, Senior Vice President at Fingrid, summarises the benefits of this objective in three points.

"Competition and the free movement of electricity across borders will reduce the price of electricity. In the future, no country will be able to constantly generate cheap electricity alone."

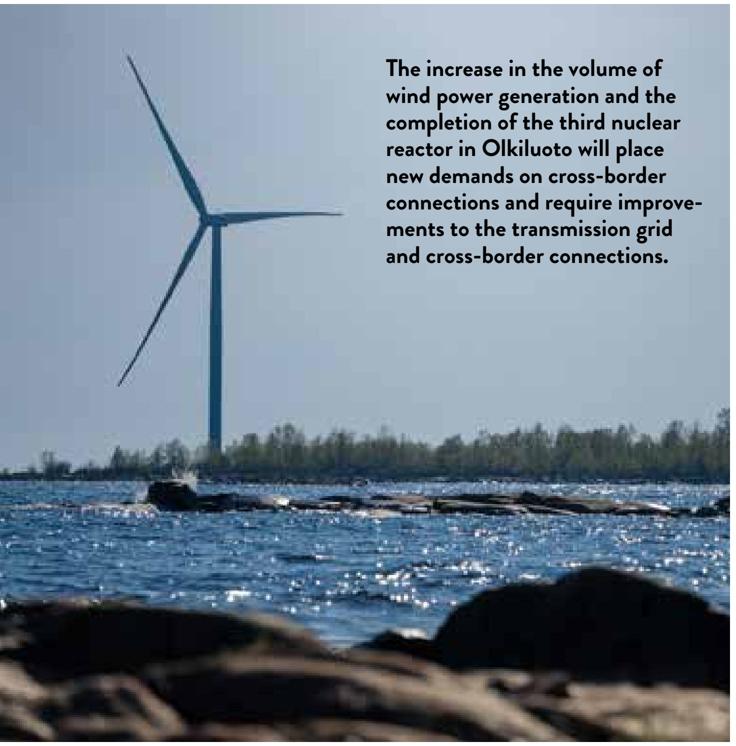
Harmonisation will also help in preparations against disturbances and in recovering from disturbances.

"In addition, a large network will promote the transition to the renewable electricity generation required for a clean electricity system. For example, the fluctuations in wind power generation need to be balanced out."

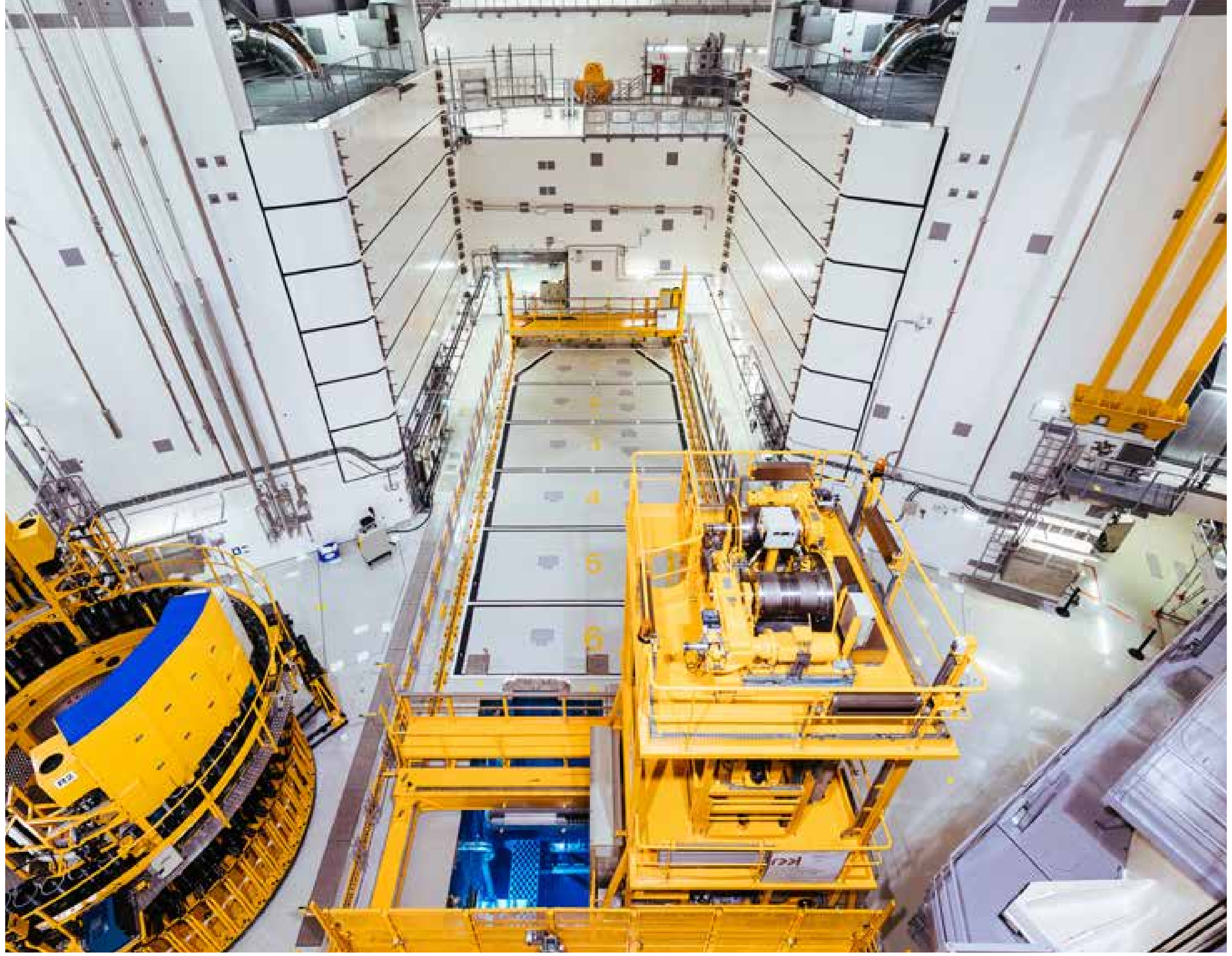
SEVERAL HIGH-VOLTAGE AC AND DC TRANSMISSION LINKS

Finland's main grid is part of the Nordic power system and the electricity market area formed by the countries on the Baltic Sea. The efficient operation of both of these requires good electricity transmission links.

"In the future, no country will be able to continuously generate cheap electricity on its own," says Jussi Jyrinsalo, Senior Vice President at Fingrid.



The increase in the volume of wind power generation and the completion of the third nuclear reactor in Olkiluoto will place new demands on cross-border connections and require improvements to the transmission grid and cross-border connections.



Finland's main grid is directly connected to the main grids in Sweden and Norway. As the Nordic networks operate at the same frequency, AC connections can be built between Northern Finland and Northern Sweden.

Finland's main grid is connected to the Russian and Estonian grids via high-voltage DC connections. DC means that the alternating voltage networks remain separate. For technical reasons, the submarine connection between Finland and Sweden also uses direct current.

According to Jyrinsalo, Fingrid will develop cross-border connections with Sweden and Estonia in the future. The potential for connections to Norway is limited by the geographical distance, while connections with Russia are hindered by the EU's forthcoming carbon duties.

CROSS-BORDER CONNECTIONS PROVIDE A BUFFER

Potential bottlenecks in cross-border connections are caused by geographical factors, political decisions, and technical and economic aspects. A bottleneck can be considered structural when the grid cannot meet the transmission requirement.

The main grid works well within Finland. It has enabled the country to remain a single price area in the electricity wholesale market.

"Within Finland, there are no bottlenecks in the transmission grid that restrict the transmission of electricity and cause price differentiation in the electricity wholesale market," Jyrinsalo explains.

However, changes in the nature of electricity generation and consumption require further development of the internal transmission grid and cross-border connections. For example, the cross-border capacity between Finland and Sweden is often insufficient, which means that the price of imported electricity rises in Finland.

The dramatic increase in the volume of weather-dependent wind power generation and the completion of the third nuclear reactor in Olkiluoto will place new demands on cross-border connections.

The buffer enabled by cross-border connections will become larger in 2025 with the commissioning of the new Aurora Line connection between Finland and Sweden.

"We need larger buffers to even out fluctuations in electricity generation and compensate for any disruptions at Olkiluoto 3," says Jyrinsalo.

The buffer enabled by cross-border connections will become larger in 2025 with the commissioning of the new Aurora Line connection between Finland and Sweden.

MAINTENANCE AND FORECASTING JUST IN CASE

Outages cannot be avoided on cross-border connections, but substantial efforts are made to minimise and manage such outages.

Fingrid is responsible for the Finnish sections of two HVDC connections between Finland and Sweden and two between Finland and Estonia. Fingrid has boosted its efficiency by initiating a continuous internal on-call system to reduce the number and duration of outages in the HVDC connections. The on-call system speeds up the process of gaining situational awareness and starting repairs.

Last year, Fingrid distributed its maintenance activities among its partners in a new way. It reinforced its own organisation at the same time.

"As there are several projects in the pipeline for maintenance and extending the life cycles of HVDC connections, we transferred the maintenance of automation systems to Fingrid. We use outsourced service providers and device manufacturers in the maintenance of high-voltage equipment," says Unit Manager **Kimmo Nepola**.

"Thanks to these changes, the availability and reliability of the HVDC connections remained good, and our ability to prepare for and react to faults improved further. We also cut costs."

MANAGED OUTAGES HANDLED IN COOPERATION

In order to safeguard operations and manage transmission outages, the operation of cross-border connections is planned for the long term. The aim is to minimise harm to the electricity market due to maintenance work.

Fingrid is developing and harmonising the equipment maintenance programmes required for cross-border connections, both in-house and with its partners. Cooperation and communication between Fingrid and the other parties to the cross-border connections is an essential element.

"We try to schedule, coordinate, and organise transmission outages so they occur at the most appropriate time of year or during the most suitable operating conditions. We consider these things in collaboration with the transmission system operators in our neighbouring countries," says **Jussi Huttunen**, Expert at Fingrid.

Transmission outages normally last between one and five days. ◆

Construction begins on the Aurora Line

The Aurora Line – a new AC connection between Finland and Sweden – will be completed in 2025. At the same time, Fingrid is strengthening Finland's internal electricity grid by building a line from north to south.

TEXT VESA VILLE MATTILA / PHOTO SHUTTERSTOCK

FINGRID AND the Swedish transmission system operator, Svenska kraftnät, are building a new 400-kilovolt transmission line. The Aurora Line, due for completion in three years' time, will go from Pyhänselkä, which is at the same latitude as Oulu, to Messaure in Jokkmokk, Sweden.

The Aurora Line will increase the electricity transmission capacity from Finland to Sweden by 900 megawatts and from Sweden to Finland by 800 megawatts.

"We will receive more balancing electricity from Northern Sweden, especially hydro power. The Aurora Line will also support industrial activity that will promote the energy revolution in the region," says **Jussi Jyrinsalo**, Senior Vice President at Fingrid.

As the project will benefit Finland first and foremost, Fingrid will bear the majority of the overall costs of the project. The Aurora Line is expected to cost approximately EUR 270 million.

The European Union has stated that the Aurora Line is a Project of Common Interest that will benefit several EU member states in the Baltic Sea region. As such, it granted funding for the planning of the project, and it has just granted EUR 127 million for the construction of the Aurora Line.

EFFECTIVE COOPERATION DESPITE DIFFERENT PERMIT PROCEDURES

Per Eckemark, Head of Grid Division at Svenska kraftnät, emphasises the regional importance of the Aurora Line.

"Many new electricity producers and consumers will be able to connect to the power grids in the northern parts of Sweden and Finland. Several large wind power projects are planned for Northern Sweden and, among other things, steel industrial plants that do not emit carbon dioxide."

Eckemark praises the collaboration with Fingrid:

"Working with Fingrid, we have learned to utilise key performance indicators."

According to Eckemark, the permit procedures for building transmission lines are smoother and faster in Finland than in Sweden. This is partly explained by the fact that in Finland, the new transmission line can be built next to an old line.

THE FOREST LINE WILL REINFORCE THE INTERNAL GRID

Large-scale construction will begin on the Aurora Line in autumn 2022.

The execution of the project also requires Finland's internal grid to be strengthened, as more electricity needs to be taken from the north to the south. This is the rationale behind the Forest Line from the Oulu region to Central Finland.

"The Forest Line will serve Finland's needs by enabling renewable energy from the north to be transmitted to consumption facilities in the south," Jyrinsalo points out.

Construction work is already underway on the Forest Line. In addition to transmission lines, the project involves building new substations and series capacitor stations, as well as expanding old ones. ◆

The European Union has stated that the Aurora Line is a Project of Common Interest that will benefit several EU member states in the Baltic Sea region.

Demand-side management for specific buildings

A startup named Kapacity.io is conducting an EU project in collaboration with Fingrid.

TEXT KATARIINA KRABBE
PHOTO SAMPO KORHONEN

"The smart grid will enable heating and ventilation to be optimised according to the electricity production capacity," says Jaakko Rauhala, CEO of Kapacity.io.

Functioning flexibility markets for electricity are vital to ensure the resource-efficient use of the power system. Local distribution system operators would also participate in flexible markets.

INTERRFACE is an EU-funded project under the Horizon 2020 programme to study the potential architecture of flexibility markets in Europe. The project involves 42 companies from 16 countries.

In the four-year project, Fingrid is focusing on developing and testing an information system to ensure smooth coordination between distribution system operators and transmission system operators.

Kapacity.io, a startup established by a group of people with doctorates and master's degrees in engineering from Aalto University, was involved in the open funding round for the project.

"We are focusing on what happens in individual buildings," says **Jaakko Rauhala**, the CEO and one of the three founders of Kapacity.io.

HEAT PUMPS CONTROL THE SMART GRID

Kapacity's customers are buildings that use heat pumps, and Kapacity offers them the chance of saving money on their electricity bills.

"We are developing a smart grid that enables the heating and ventilation in a building to be optimised according to the electricity production capacity. Kapacity provides flexibility markets with information on the flexible capacity of each building, and Fingrid activates the flexible load based on the information obtained and its own requirements."

Now, a system is under development to enable individual buildings to offer a demand-side response – not just large industrial facilities.

"When we get up to speed, we will be able to control even thousands of buildings, from detached houses to shopping centres."

The EU project is an important step for Kapacity.

"It is effective to work with Fingrid. There is enormous potential in the energy market transition and the development of data networks. Experiments help us to understand how to design services that make it easy for customers to get involved." ◆

IN GOOD CONDITION AT ALL AGES

The main grid was built over several decades. The equipment in use consists of very different devices and structures of various ages, and every item needs to be kept in working order throughout its life cycle. Long-term maintenance will help to ensure a high transmission reliability rate from one generation to the next.

COMPILED BY MIKKO JALONEN / INFOGRAPHIC BY LAURA YLIKAHRI

In 2021, maintenance work involved 34,200 work orders, and

28,600

site visits. The outcome of these visits included:

3,900
actions at substations in accordance with the maintenance programme.

1,000
tested, set or repaired relays and bay units.

18,700
inspected transmission line towers.

5,700 hectares
of rights-of-way cleared.

60,000 m³
of timber felled in border zones.

In 2021, main grid maintenance cost
EUR 26 million

Fingrid personnel and service providers spent
240
person-years carrying out maintenance.

Reserve power plant maintenance cost
EUR 12 million

4,600
work orders

The transmission reliability rate in 2021 was
99,99992 %
which translates to an average outage of 54 seconds per connection point.

RECORD-BREAKING WAVE OF

INVESTMENT IN SUBSTATIONS

Fingrid has more than a hundred substation projects in progress over two years, and the portfolio of projects underway is worth more than EUR 430 million. One key factor behind this boom is the green transition, which is taking Finland towards a carbon-neutral economy.

TEXT SAMI LAAKSO / PHOTOS SUSANNA KEKKONEN AND FINGRID

The substation in Länsisalmi, Vantaa, has been expanded from a single transformer bay to a four-bay switchgear plant.

Electricity networks are in a state of whirlwind development. This programme of significant investments in the main grid is necessitated mainly by Finland's shift towards carbon-neutrality and its focus on renewable energy generation.

"At this stage in our grid investment programme, we are mostly connecting our customers' generation and consumption facilities to substations. Construction is focusing first on substations, but it will then shift to transmission line construction," says **Daniel Kuosa**, Construction Manager at Fingrid.

Fingrid has budgeted EUR 200 million for substation investments this year. The project portfolio extends several years into the future and involves EUR 430 million of investment. Last year, there were approximately 50 substation projects. This year, the number will approach 70.

The work to expand the Jylkkä substation, which will be completed this spring, exemplifies the new needs. The 1,250 megawatts of wind power capacity in the Kalajoki and Pyhäjoki region requires three large transformers to bring this renewable electricity to the national grid. To put this scale into context, the new Olkiluoto 3 nuclear power plant will output 1,600 megawatts.

In addition, investment needs are increasingly arising due to electricity consumption. Investments are being made in areas such as battery factories, data centres, power to X plants that produce renewable fuels, heat pumps, and electric boilers.

SWITCHGEAR AND TRANSFORMER SUBSTATIONS

"Substations are like the electricity grid's synapses – they are hubs that connect the network's transmission line," Kuosa says.

Substations can be divided into two types: switchgear and transformer substations.

Last year, there were approximately 50 substation projects. This year, the number will approach 70.

"The environmental impacts of substations are under closer scrutiny," says Daniel Kuosa, Construction Manager at Fingrid.

Switchgear connects different parts of the network together. For example, in the event of a fault, the switchgear can switch off a certain part of the network automatically and switch it back on automatically.

Air-insulated switchgear, which is out in the open, surrounded by a wire mesh fence, is a familiar sight to many of us. Nowadays, gas-insulated indoor switchgear is increasingly built as an alternative, as it looks like an ordinary building from the outside.

The protective relays and automation systems at substations constantly measure the network's status, regulate the voltage, search for faults, and detect if there is too much current. In the event of a fault, they trip the faulty network component off the grid in a matter of milliseconds.

Transformer substations alter the voltage of the network. The voltage is lowered in steps as electricity comes nearer to the point of consumption.

Fingrid operates at the 400 kV, 220 kV, and 110 kV voltage levels. Large transformers – the size of a house – reduce the voltage from 400 kV to 110 kV and connect to customers such as distribution networks, production plants, and industrial facilities.

The largest generators and consumers of electricity connect directly to the 400 kV network at substations.

"The power transformers in the main grid are very heavy units, weighing up to 300 tonnes. Simply transporting them to their final location places major demands on the infrastructure," Kuosa says. In the past, power transformers have been brought to Finland all the way from South Korea.

The other high-voltage equipment in substations includes circuit breakers, disconnectors, and instrument transformers, although, to the uninitiated, they may all look like the same kinds of insulators.

EVOLUTION NOT REVOLUTION

The technical service life of a substation is calculated at approximately 40 years, but large system transformers can be used for up to 80 years with effective maintenance.

Daniel Kuosa describes how safety is at the heart of development work. Digital technologies have been adopted step by step over time.

"The greatest benefit of digitalisation is in condition management, where sensors monitor and measure components to help keep them in good condition."

The environmental impacts of substations are also taken into account in increasing depth. For example, SF6 gas has been widely used in gas-insulated switchgear thanks to its favourable properties. The downside is that SF6 is a potent greenhouse gas, so efforts are now being made to find substitutes.

Fingrid built its first substation without SF6 gas in Virkkala.

"Our targets are ambitious: after 2025, all our new gas-insulated apparatus will be free of SF6 whenever it is technically possible," Kuosa says.

In addition, studies are underway to examine the use of biodegradable ester oil instead of mineral oil as an insulator in transformers. ◆

"I have always firmly believed that everyone needs to get home healthy after a day's work on Fingrid's worksites."

WHO?
Antti Puuska

WORK
Expert, Grid Operation

LONG CAREER
Began working for Fingrid's predecessor, Imatran Voima, in 1976. Retiring in summer 2022.

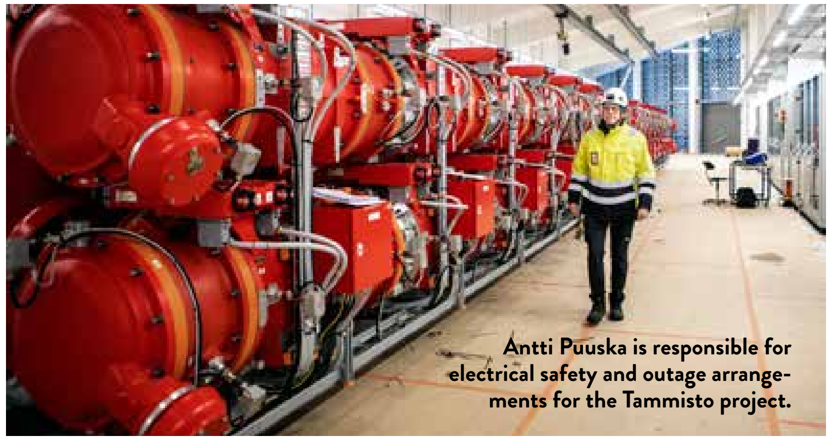
TEXT SAMI LAAKSO / PHOTOS SUSANNA KEKKONEN

Save the most challenging worksite for last

Antti Puuska, who began working at Fingrid's predecessor, Imatran Voima, in 1976, discusses how substation construction has changed over the last decades.

"**IMATRAN VOIMA** used to do everything itself with its own personnel. When competitive tendering came into the frame in the 1980s, other uniforms began to appear at our substations. That is when we began wondering whether other people could do these jobs," **Antti Puuska** smiles as he recalls the early years of his career.

Over the years, the operating models and solutions for substation construction have become more and more standardised. This has sped up projects, improved quality, and made the costs more manageable.


Antti Puuska is responsible for electrical safety and outage arrangements for the Tammisto project.

In the past, maintenance followed a predetermined schedule. Today, equipment is increasingly maintained according to genuine needs based on real-time data from sensors.

"The introduction of remote control systems in the 1970s was a major change. They made it possible to centralise substation monitoring and control the substation equipment from different control centres."

One of the biggest changes has been the attitude to occupational safety. Puuska describes the dizzying pace of development in personal protective equipment.

At the moment, the largest project in Antti Puuska's area of responsibility is in Tammisto, Vantaa, where a 40-year-old 110-kilovolt open-air switchgear plant is being replaced by equivalent indoor switchgear.

As a specialist in grid operation, Puuska is responsible for electrical safety and outage arrangements. The work also includes project supervision.

"Monitoring and attending worksite meetings have meant weekly visits to worksites. I contribute to ensuring that the work is done safely and according to the regulations. I have always firmly believed that everyone needs to get home healthy after a day's work on Fingrid's worksites."

Puuska says that the Tammisto project, which began in summer 2020, is one of the most demanding projects of his career due to its scope, location, and related electrical and occupational safety challenges. As Tammisto acts as one of the transformer substations supplying the Helsinki metropolitan area, transmission network reliability has needed to be as high as possible.

Antti Puuska will not be involved in commissioning the Tammisto substation. His long career, spanning six decades, is drawing to a close, and he will retire at the start of summer.

"My successors have busy times ahead of them. Just over 20 years ago, almost everyone in the company knew what stage the project was at, but today it is hard even to keep track of the number of projects. However, despite the mass of projects, we should not forget about maintenance," Puuska emphasises. ◆

Biodegradable ester oil for transformers?

A high-voltage transformer in the main grid may contain as much as 100 tonnes of mineral oil, which is used as an electrical insulator and cooling medium. The environmental risks associated with transformer oils are very unlikely to be realised, but it is still necessary to make contingencies for them.

TEXT SAMI LAAKSO / PHOTO SHUTTERSTOCK

FINGRID'S ENVIRONMENTAL specialist, **Jenni-Julia Saikkonen**, knows how non-toxic, biodegradable ester oils could be used instead of mineral oil to affect the management of the environmental risks associated with high-voltage transformers.

"The biggest risk associated with transformers is the risk of fire. If there were a fire, the heat, smoke, and any oil leaking from the transformer, along with the oily fire extinguishing water, would constitute a risk to the environment, safety, and electricity transmission," Saikkonen says.

However, she points out that transformer fires are extremely rare; the last one to occur in Finland was in the 1980s.

Saikkonen appreciates the many favourable properties of ester oils. One of the most important is that the flash point of ester oil is higher than that of mineral oil.

"In practice, ester oil is non-combustible."

Consequently, when ester oils are used in transformers, the clearances required for fire safety can be much smaller, and there is no need to implement protective walls or fire extinguishing systems in case of a transformer fire. The shielding pool, which is necessary to contain leaking oil and fire extinguishing water, could also be smaller.

Ester oil may also extend the transformer's service life, and it would be possible to place loads on the transformer at a higher power level.

There are also challenges to tackle: Natural ester oils made from renewable raw materials are at least nearly carbon neutral.

Natural ester oil solidifies in cold air, limiting its usefulness. Synthetic esters manufactured from petrochemical by-products do not suffer from the same solidification problem.

Ester oils are also somewhat more expensive than conventional transformer oils, but the price difference has levelled off in recent years.

"Ester oil has been used in equipment operating at a lower voltage level, but around the world, it has seen little use in high-voltage equipment. Pioneering work is needed in this field, and Fingrid is ordering the first device insulated with ester oil for a substation located in a groundwater area." ◆

Popularising information is also a professional skill

A key aspect of professionalism is maintaining a precise relationship with terminology. This relationship begins in the early stages of one's career and deepens gradually.

Professional terminology plays many roles. It provides a precise way of communicating things and helps to establish a connection with other experts in the field. However, being able to talk to laypeople about the field is also a professional skill. For example, the coronavirus pandemic has demonstrated that experts in infectious diseases cannot just talk to each other all the time. Professionals have been required to tell us what is happening and what to expect.

This is one of the key tasks of specialists in society: they interpret world events for the rest of us. Popularising information ensures that people can act in their own interests and for the good of society.

It is by no means easy to popularise technical or scientific information. Firstly, there is no such thing as a single, uniform audience. People have different amounts of background knowledge and interest. Some read foreign newspapers; others delve into the depths of the internet. Secondly, translating specialist terminology into the vernacular is an endless slog. There are usually no equivalents in the Finnish language, but a translation is not enough. Instead, we need to learn a new, more illuminating way of talking about things.

Specialists do not always understand the importance of popularising information. They may perceive the more accessible way of talking about things as imprecise, and media appearances take time away from more important jobs.

These are outmoded ideas that we should let go of. The pandemic showed that we need experts in the public eye as much as possible. If there is no accurate and accessible information available, people will seek answers elsewhere. There is plenty of disinformation around.

The world currently feels highly unpredictable. So many things are in a state of flux, from the energy system to health care and the media. Those who seek to destabilise society could just as easily target the main grid as people's health data.

The antidote to this is a good, shared understanding and experts who are used to talking to people who are uninformed, unsure, and afraid. ◆

Popularising information ensures that people can act in their own interests and for the good of society.

Tiina Raevaara
is an author and freelance science journalist who has taught the popularisation of science at the University of Turku as a professor of practice.

HAS THE DAY COME FOR INDUSTRIAL-SCALE SOLAR POWER?

Experts believe that technological advances and a strong electricity grid will pave the way for new solar power projects in Finland.

TEXT ARI RYTSY / PHOTOS SHUTTERSTOCK

The possibilities of using solar power on an industrial scale in Finland focus on large enterprises generating electricity for their own consumption. At present, Finland's largest solar power plants are fairly small by international comparison, mainly consisting of projects constructed to meet the needs of specific properties or companies.

A project to expand Finland's largest solar park in Nurmo has sparked interest in industrial-scale solar power as part of the national energy debate, as Atria, a company in the meat and food sector, is a pioneer in the industrial deployment of solar power.

The solar power plant near the company's factory in Nurmo was commissioned in 2018 and consists of about 22,000 solar panels installed on the ground and on rooftops. The panels generate approximately 5,000 megawatt hours of power annually, and the new expansion, which will be commissioned in 2022, will increase Atria's annual solar power output to over 9,000 megawatt hours.

MODELLING PROVIDES PREDICTABILITY

Herman Böök considers the modelling of solar power generation and the related applications under Finnish conditions in his doctoral dissertation, *Photovoltaic Output Modeling: Monitoring, Forecasting, and Applications.*

The generation of electricity is dependent on the weather, so weather parameters are at the heart of the model, with the most important being the amount of solar radiation and the air temperature.

“The daily and seasonal variation in solar power imposes certain constraints and, in the long term, somewhat complicates the large-scale exploitation of solar power for electricity generation in Finland,” he states in his dissertation.

Böök’s dissertation studies topics such as the use of modelling in building automation, profitability calculations for small-scale solar power generation, and virtual power plant trials using demand-side management in future electricity markets.

The generation of electricity is dependent on the weather, so weather parameters are at the heart of the model, with the most important being the amount of solar radiation and the air temperature. If necessary, it is possible to use ground-level observations, satellite data, or numerical weather forecasts as weather inputs.

“Satellite data is most suitable for producing forecasts for the coming few hours, after which numerical weather forecasting models step in. The general generation potential of solar power can be mapped, for example, using long series of ground-level or satellite observations,” Böök says.

Marja Kaitaniemi, Director of IBV Suomi, the Finnish office of the German group of companies Ib vogt, also says that forecasts focus on satellite data during the development phase of solar power projects. Modelling based on weather forecasts is becoming increasingly important as growth continues.

“I do not see any obstacles to the growth of solar power in Finland. For example, IBV Suomi is currently preparing a new solar energy generation area in Uusikaupunki. This will be a 200-megawatt project to the east of Kalanti, where there is a strong electricity network and a good amount of solar radiation,” Kaitaniemi says.

COMPETITIVENESS IN ORDER

Fortum began operating in India in 2012 and has focused on solar energy there from the outset. The first solar power plant project was in the five-megawatt region. Pavagada 2 and Jaisalmer, which were completed in 2019 and 2021, are much bigger power plants, outputting more than 300 megawatts.

“To date, Fortum has had five solar power projects in India with a total output of about a thousand megawatts. Growth is underpinned by the good solar conditions and favourable trends in generation costs in the Indian market throughout the plants’ life cycles,” says **Mikko Iso-Tryykäri**, Vice President of Wind and Solar Development at Fortum.

Fortum’s experiences with industrial-scale solar power are based on the latest technology and the management of large supply chains. For example, when solar panels are bought in large batches, the price is much lower.

The lessons learned internationally can also be applied in Finland, but the key is to ensure that solar power is competitive.

“It is hard to predict how solar power will develop, as technologies sometimes advance more quickly than expected. In Finland, the peak load operation hours of solar power consumption are just a third of the peak load operation hours of wind power, but the two forms could be mutually complementary in electricity networks,” Iso-Tryykäri says.

Marja Kaitaniemi emphasises that the companies already working on solar power projects are well-positioned to drive the developing market forward.

“In our experience, Finnish landowners are interested in solar power projects, and municipalities and authorities take a positive approach. It has also been easy and efficient to work with Fingrid.” ◆

“Forecasts focus on satellite data during the development phase of solar power projects,” says Marja Kaitaniemi, Director of IBV Suomi.

EVEN RELIABLE ELECTRICITY GRIDS MAKE PREPARATIONS **FOR CRISES**

Regular system testing and practical exercises with various parties ensure that Fingrid is ready to respond to a crisis. For example, communication is paramount in the event of a major operational disturbance.

TEXT TUIJA HOLTTINEN
PHOTO FINGRID

Normally, the Main Grid Control Centre's voice communications, such as transmission, outage, and disturbance situations, is based on a VoIP system," says **Arto Pahkin**, Manager in charge of Fingrid's network operations and disturbances.

However, in the event of an emergency, Fingrid communicates effectively and securely with the authorities and other security-critical parties via the Krivat cooperation platform or the Virve network.

From the standpoint of the transmission system operator, the authorities' networks are clearly backup phone systems that are used in the rare event of a major disturbance.

"In simple terms, Virve would be used in a crisis to send group messages and provide situation overviews to other parties. Krivat is a wider-ranging situational awareness system for critical actors, and it would be very useful for holding webinars with critical actors or showing map templates if the situation required it," Pahkin explains.

PLANS TESTED IN PRACTICE

A major disturbance in the main grid would mean power cuts all over Finland – in other words, a total blackout.

"We have procedures even for such an extreme situation. One is to restore power using imports from Sweden, and there is also a national method for restoring power. A lot of work has been done to make these arrangements: we have practised and tested them and found them functional."

There have been no major disturbances in Finland for decades. The most typical threats to the main grid are winter storms, but the power system also made it through Storm Valtteri at the start of the year without any major difficulties.

Jörgen Dahlqvist, Caruna's Director of Network Operations, says that making contingencies for emergencies is one of the core duties of individual electricity companies.

He points out that the legislation requires electricity companies to have functional and tested contingency and readiness plans.

"Although we have avoided large-scale catastrophes, there have been storms in recent times that have caused customers to suffer long outages."

FORECASTING REDUCES RISKS

Both Arto Pahkin and Jörgen Dahlqvist emphasise the importance of advance preparation. Good plans and practices also need to be rehearsed.

Procedures modelled on a computer need to be put to the test in joint practical exercises for crisis situations. Only then can all the relevant parties make tangible observations, rectify shortcomings, work out the nuances, and refine their activities.

NC ER – a network code in the event of an emergency

- Network Code for Emergency and Restoration (NC ER)
- The European Commission's network code, which covers emergencies and operational recovery in the electricity grid
- Aims to prevent disturbances from escalating into major disturbances and ensure the system can be restored to normal operation quickly
- The network code obliges the transmission system operator to designate the system-critical parties whose plants, systems, and guidelines must meet the requirements of the network code
- The energy companies designated as significant must take action in accordance with the network code by 18 December 2022

"Although artificial intelligence and systems offer good support and a basis for our activities, people are still in charge of operations. That is why they need active and continuous exercises and training," Pahkin says.

Finland's main grid has tens of thousands of kilometres of transmission lines and almost 120 substations.

"The main grid is in excellent condition," Pahkin says. He believes that a total blackout of the kind shown in the movies is very unlikely to happen in Finland.

"However, people do not always understand how important electricity is to every aspect of modern society. This is partly because the system security of our main grid is among the best in the world at 99.99992 per cent."

Pahkin points out that the main grid has been planned systematically and built in a timely manner.

"The consumption and generation needs have been forecast for years, and the grid is maintained constantly." ◆

Backlog in environmental impact assessment projects

The route of a planned transmission line may change if the environmental impact assessment (EIA) reveals significant natural assets. There is currently a backlog in EIA projects.

TEXT SUSANNA CYGNEL / PHOTO FINGRID

The purpose of the environmental impact assessment procedure is to reduce or entirely prevent large landscaping projects from harming the environment. Assessments often uncover matters that alter the location or route of a project – in Fingrid's case, a transmission line.

Environmental impact assessments are usually carried out for 400-kilovolt transmission line projects.

The environmental impact assessment is a systematic process carried out by a multidisciplinary working group of experts in fields such as environmental, natural, scenic, and social impacts.

Nature inventories provide information about the habitats and species of animals and plants of interest in the project area.

"We typically encounter one of the directive species or its habitat when we conduct a nature inventory, so we have to think about alternative routes," says **Lauri Erävuori**, Senior Consultant at Sitowise, which is one of the consultancies that carry out environmental impact assessments.

Fingrid commissions environmental impact assessments for its transmission line projects, and the assessments and reporting are carried out by an external consultant to guarantee an independent evaluation.

Assessments are conducted by Finland's largest multidisciplinary and environmental consultancies, among other entities.

WIND POWER, A SHORTAGE OF WORKERS, AND WINTER BACKLOGS

The entire environmental impact assessment sector is experiencing backlogs at the moment. This has been sparked by a boom in wind power all over Finland, with dozens of projects that are in the embryonic stage, undergoing planning, or already in progress.

The average environmental impact assessment takes over a year, but it can take even longer. This is further held back by the fact that the nature inventories included in the environmental impact assessment require a substantial amount of work that cannot be done in the winter when Finland's nature is covered by snow and ice.

However, the environmental impact assessment backlog has not delayed any of Fingrid's projects. Good advance planning is the key to ensuring that the assessment is carried out on schedule.

"We have prepared main grid development and investment plans extending to 2030, so we will also be able to carry out the environmental impact assessments on time. Various projects may be prioritised if necessary, so some things can be postponed and others done right away," says **Mika Penttilä**, Head of the Land Use and Environment Unit at Fingrid.

A shortage of experienced EIA practitioners is adding to the bottleneck because the process requires quite specialised expertise. New project managers and project secretaries are obtained through on-the-job learning.

The congestion is also putting pressure on the authorities. The Centre for Economic Development, Transport and the Environment supervises environmental impact assessments.

"Other authorities may also experience a high demand for the services, so there can sometimes be a long wait for permits," Penttilä notes.

DIALOGUE BETWEEN ALL PARTIES

Any person affected by a project may participate in the EIA, so information must be shared with all stakeholders, and everyone must have the opportunity to participate. Conversations continue throughout the EIA – the parties react to the results while the procedure is still ongoing, not after it. It is often possible to alter the planned transmission line route or examine alternative routes if there are serious grounds for this.

Fingrid's project group participates actively in EIA procedures for transmission line projects and acts as the face of the project towards stakeholders. An independent consultant is responsible for assessing the impacts, but Fingrid's experts participate in matters such as public events and negotiations with the authorities during the process.

"We are the contact party for the authorities and local businesses and residents in power line projects. We are responsible for ensuring that the EIA work is high in quality, and we discuss this with local residents. For example, we have just sent out 1,500 letters to landowners on various project themes," Penttilä says.

Interaction is a key part of the procedure. Everyone can make their views known, although it is not always possible to take all of them into consideration.

"Landowners may point out that natural assets are avoided but their land is not. We always debate these matters on a case-by-case basis, and it is part of the process," Erävuori says. ◆

Environmental impact assessments are usually carried out for 400-kilovolt transmission lines.

Environmental impact assessment (EIA)

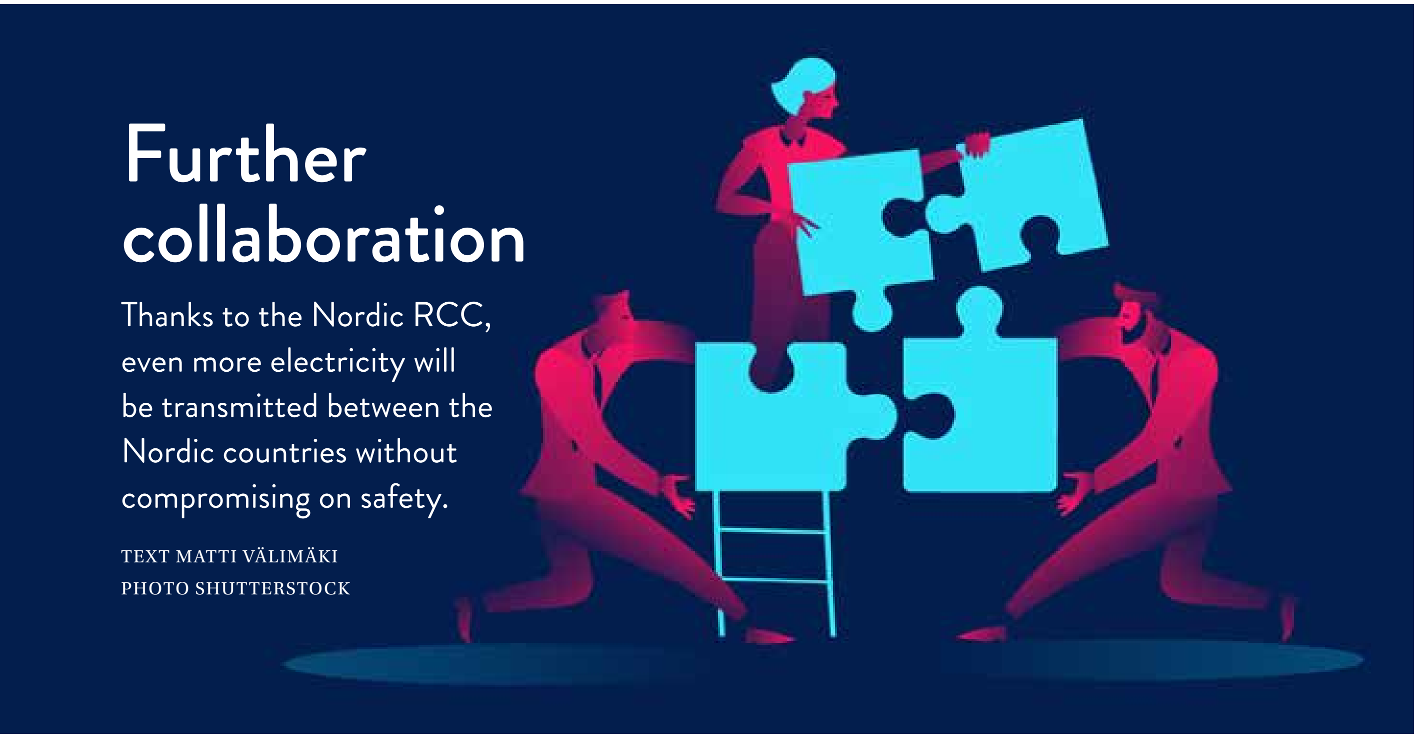
THE procedure seeks to reduce or prevent the harmful environmental impact of major projects.

IT is usually required for transmission line, motorway, mining, waste treatment, and wind power projects, for example.

Further collaboration

Thanks to the Nordic RCC, even more electricity will be transmitted between the Nordic countries without compromising on safety.

TEXT MATTI VÄLIMÄKI
PHOTO SHUTTERSTOCK



The Nordic transmission system operators jointly own the Nordic Regional Coordinator Centre (RCC), which will begin operating on 1 July 2022. The company will replace the previous operational planning office known as the Nordic Regional Security Coordinator (RSC) and expand the scope of its activities.

One new area where RCC will operate is in analysing faults in the Nordic electricity grid and reporting on them. In the future – the current estimate is 2024 – it will also begin calculating how much the transmission system operators will need to have in reserves to enable electricity to be generated in the event of a disruption in the power system. The RCC will also determine how much each transmission system operator can use power plants in its neighbouring countries to address the needs of the balancing capacity market.

The RCC will carry on from the RSC as the Nordic grid coordinator, an essential job if, for example, a cross-border transmission line is unavailable due to refurbishment. The RCC also checks the generation and consumption forecasts it receives from the transmission system operators and verifies the sufficiency of electricity based on the transmission capacity. In addition, it uses a new real-time model to calculate the safe electricity transmission capacity for cross-border lines, and the electricity market uses this information to set the electricity price. The RCC also analyses the system security of the Nordic grid.

RCC Specialist **Tuukka Huikari** says that the RCC will strengthen Nordic collaboration. One incentive for the change is the green transition in the energy sector – above all, the increase in weather-dependent wind power generation is increasing, which imposes new requirements for electricity transmission.

"The key idea is that Nordic collaboration and coordination can enable the existing infrastructure to be used as efficiently as possible." Collaboration can help to avoid unnecessary investments, such as the construction of new lines. "When we have better information on the situation at any given moment and a clearer picture of the future, it will no longer be necessary to leave any surplus capacity on power lines. More electricity can be transmitted without compromising on safety," Huikari emphasises. ◆

TEXT KATARIINA KRABBE / PHOTO SHUTTERSTOCK

Prepared to handle disturbances

The disturbance in the electricity grid in Continental Europe last year showed how well pan-European collaboration can work.

On 8 January 2021, the Orthodox Christian countries in Southeast Europe enjoyed their Christmas festivities, and electricity consumption was low. Elsewhere in Europe, it was cold, and consumption peaked, so a lot of electricity was imported from Southeast Europe. Suddenly, the grid was divided in two."A Croatian substation became overloaded and disconnected from the grid. The overload spread along several power lines, and one substation after another went offline. The situation continued until all the connections between Southeast Europe and Northwest Europe were broken. The system just opened up like a zip," says Frank Reyer, who chaired the panel of experts that investigated the disturbance.

Everything happened in a matter of seconds, and the system worked as intended.

"If network elements are excessively overloaded, they are supposed to trip and go offline. Otherwise, they would break," Reyer explains.

In one moment, Southeast Europe had too much energy, and Northwest Europe did not have enough.

"The frequency in the southeast increased, and operations accelerated in the network elements there. At the same time, the frequency in the northwestern parts of Europe decreased, and the system slowed down."

The deviations from the normal frequencies were 600 millihertz in Southeast Europe and 200 millihertz in Northwest Europe.

"Southeast Europe is a smaller area, and it was a real emergency. The larger grid in Northwest Europe was better able to withstand the disturbance."

The situation was brought under control within half a minute. The amount of electricity generated in the southeastern part was reduced, and consumption was reduced on the other side of the separation by disconnecting some large industrial facilities with demand-side management commitments in France and Italy.

"In addition, almost 500 megawatts of energy was obtained from the Nordic countries."

One hour later, the system was back to normal.

"Disturbances cannot always be avoided. The most important lesson to learn from this is that the pan-European integrated system works well. Support was available within seconds and TSO cooperation went well."

Although the system proved resilient, Reyer says the continent cannot rest on its laurels.

"We must take even better care to ensure resilience by the future system design, as the electricity system will change fundamentally as we use more and more renewable energy sources." ◆

The situation was brought under control within **30 seconds.**

Fingrid Current

Wednesday, 4 May 2022
1 pm–4:30 pm, Helsinki

THE THEME of the event will be the future of the electricity market. The event is invitation-only, but a virtual broadcast will be made available to everyone. We look forward to welcoming you!

Further details:
www.fingrid.fi/tapahtumat

@fingrid_oyj Fingrid Oyj Fingrid Oyj @fingridfi @Fingridoyj

FINGRID

DELIVERS. RESPONSIBLY.

Läkkisepäntie 21, 00620 Helsinki / P.O. Box 530, 00101 Helsinki / tel. 030 395 5000 / fax 030 395 5196 (all offices) / fingrid.fi / fingridlehti.fi