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FINGRID

TRANSMISSION GRID AND SYSTEM SECURITY

In this issue

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Cover photograph: Fingrid's head office will move close to the Käpylä railway station on 7 December 2012. The new office building is a prominent landmark beside the Tuusulanväylä road.
Photograph by Juhani Eskelinen

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EDITORIAL

POWER SYSTEM in a new situation

Electricity is generated at the same time as it is consumed. In the traditional setup, generation adapts to fluctuations in consumption while there is very little elasticity in consumption even if the price was to rise. The Nordic power system contains an abundance of rapidly regulating hydropower, and thermal power which can provide regulation at a slightly slower rate. This regulating capacity is needed to balance changes in consumption between summer and winter, between day and night, as well as at the level of minutes. In sudden disturbances, hydropower in particular represents great regulating power to restore the power balance.

The future power system will have more and more energy produced from wind and solar power. Electricity is obtained when the wind blows or when it shines, not when electricity is consumed. On the other hand, some of the conventional condensing power capacity is leaving the market. There will be more nuclear power, and it is usually produced at full capacity.

These changes in the energy production architecture are reflected in the operation of the power system. Wind power and solar power will increase the need for regulating energy. More and more of the power regulation for the needs of Finland must actually be carried out by power plants in other countries, primarily hydropower plants in Sweden and Norway. This requires strong transmission connections between Finland and its neighbouring countries.

The volume of wind and solar power in Continental Europe has grown very quickly due to subsidy mechanisms. Power system operation has faced new challenges when the electricity flows change rapidly and travel through different countries. However, there will be a limit to the growth of renewable energy when the system security of the power system is compromised. A power system only containing wind and solar power simply does not work.

In the future, too, there will be a need for regulating generation capacity and for the rotating mass of conventional power plants. These ensure system security in acute disturbances. The situation with regard to renewable energy is good in Finland, as the Nordic power system dominated by hydropower can take much wind power and potentially solar power into the system.

Another challenge in the operation of the power system is the growth in the size of electricity generating units. A power plant which is too large cannot be connected to the system, even if the transmission lines could accommodate its electricity. The sudden tripping of the largest generating unit from the system constitutes a dimensioning fault, for which the power system must be prepared at all times. It must be possible to withstand the tripping and to restore the power balance quickly by means of automatic reserves.

The new nuclear power plants in Finland will be the largest units in the Nordic system. According to present calculations, the Nordic power system can withstand an individual fault of a maximum of 1,650 megawatts without a wide-spread blackout. Due to the laws of physics, the unit size of the largest nuclear power plant unit must be limited to this value in the new terms of connection to the grid. In line with the growth of renewable energy, the volume of rotating mass in the power system will reduce, which makes the situation all the more challenging.

One way to offset the fluctuations in electricity production and consumption is greater demand response based on when production is available. In other words, what is needed is more thorough involvement of consumption in the market, plus procedures suited to this end. In Finland, we must also bear in mind that there must be sufficient electricity also when it is cold, dark, and maybe no wind. It is then that electricity consumption is at its peak.

Reima Päivinen
Reima Päivinen is Fingrid's Senior Vice President responsible for power system operation.

SYSTEM SECURITY – goal shared by all

Changes in the energy production architecture impose new kinds of challenges on system security and call for more advanced co-operation between high-voltage transmission systems, distribution networks, electricity producers, and electricity consumers. The European network code for the connection of power plants to the transmission system is being prepared, and Fingrid is also updating its own grid connection terms. There are requirements for smaller and smaller power plants, but on the other hand the power produced by large power plants is also capped.

Text by Jussi Jyrinsalo | **Photographs by** Plugi, iStockphoto

In the future, an increasing portion of new power plants will utilise renewable energy sources. As the power system changes, its inherent resistance to disturbances declines and varies constantly. However, power plants continue to serve as the foremost support points of the voltage and frequency of the transmission system, and the entire system relies heavily on them. One certainly impossible solution is a setup where certain power plants would be constructed in the power system to maintain system security so that other plants would be able to generate electricity without an obligation to also support the system.

European requirements for disturbance resistance

Changes in the power system will undermine the ability of the transmission system to respond to various types of disturbances, such as tripping of transmission connections or large power plants. This will call for new measures to ensure system security. One key measure is to ensure the operation of various types of generators when they are subjected to a variety of disturbances.

ENTSO-E, the European Network of Transmission System Operators for Electricity, has been preparing the network code Requirements for Generators (RfG), which set standards for power plants to be connected to the transmission system. RfG is currently being finalised and will likely take effect during 2014. Some of the requirements are the same for plants to be connected in different parts of Europe while others can be applied to local conditions. In the Nordic countries, for example, the fault ride-through requirements of large generators are more stringent than in other parts of Europe. This is due to the fact that the voltage dips spread to a wide area up here, and a few large plants account for quite a high proportion of the total output. The tripping of several plants from the grid cannot be permitted during a single grid fault. This is why the generators must remain connected to the grid even if the duration of the voltage dip extends from normal.

Worth noting in RfG is that certain requirements are applied to smaller and smaller power plants, even the size category of under 1 MW. This is a consequence of factors such as the observation made in Germany a couple of years ago that solar panels no longer remain connected to the grid when the frequency rises to 50.2 Hz. It has been estimated that the volume of electricity production capacity which may trip suddenly is well in excess of 10,000 MW in Germany alone and more than 20,000 MW in the whole of Europe. Since the system in Continental Europe is prepared for the tripping of only 3,000 MW, which corresponds to two large power plant units, the protection of small-scale production has been co-ordinated in order to decrease the volume of electricity production which may trip at the same time. In other words, small-scale electricity production connected to the distribution network level can also have significant system impacts if the volume of such production is high enough.

Maximum output for power plant units

Fingrid is also updating its general grid connection terms and the specifications for the operational performance of power plants. One of the objectives is to anticipate compatibility with the future European network code. Fingrid's own requirements are also being extended from units of 0.5 MW up to large nuclear power plants.

One new issue is that the maximum permitted stepwise power change is set to 1,650 MW, which in practice limits the maximum power produced by the largest power plant unit. Analyses have indicated that a power change higher than this cannot be managed without the frequency of the Nordic grid dropping too much and without consumers being disconnected from the grid across the Nordic countries. The limiting factor is the mass rotating in the synchronous generators in the Nordic system. The small volume of this mass, especially during the summer season, results in a very fast frequency drop if a large unit trips from the grid. In this case, the reserves used for frequency control do not have time to activate properly, and this cannot be helped even by increasing the volume of reserves.

The power limit set will be updated whenever necessary if the resistance of the Nordic system to disturbances changes. The goal is to enhance the monitoring and forecasting of inertia, in other words of the energy stored in rotating synchronous machines, in the Nordic countries so that the power of the largest units could be restricted only when necessary. Another relevant factor is the availability of reserves which respond to frequency changes quickly, and in particular load elasticity. It may be that at some point in the future, for example refrigeration machines can automatically reduce their electricity consumption when the frequency of the system goes down. This would facilitate the control of the system frequency.

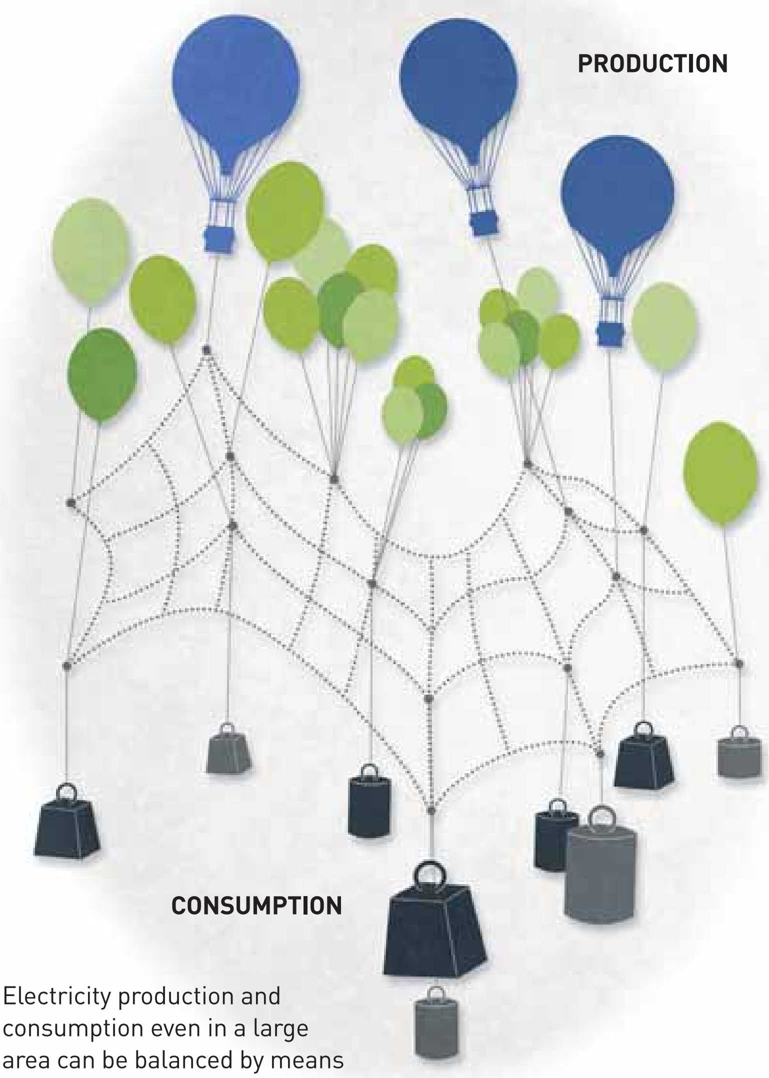
> Ensuring the system security of the shared system requires more collaboration from the network operators.

The updated terms of grid connection also specify further the documents required in conjunction with connection as well as their delivery schedule and acceptance procedure. The contents, acceptance procedure and documentation of the commissioning tests carried out to verify the requirements have also been specified in more detail. The goal is to give the connection process a more specified format than before, which will make it easier to manage compliance with the requirements. As small-scale production connected to a distribution network becomes increasingly common, the distribution network operators will also have a responsibility to ensure that the requirements imposed are met, and they obtain an opportunity to set their own additional requirements. Ensuring the system security of the shared system therefore requires more collaboration from the network operators. →

Reserves both in the grid and at power plants

As the majority of the new power plants to be connected to the Finnish grid utilise either nuclear power or renewable energy, the control properties of the total power produced deteriorate from the current situation. This means that even though Finland achieves self-sufficiency in terms of the annual energy produced, there is considerable variation in electricity generation at different times, and Finland is even more dependent on cross-border interconnectors, which serve as a buffer against changes and disturbances. The wind and solar conditions can be forecasted, but there is no way of telling in advance when there is a failure in a large nuclear power plant. This is why some transmission capacity must be reserved for eventual failures in large plant units. And since the replacing power in the Nordic power system comes to a large extent from hydropower generators in Sweden and Norway, that capacity must be reserved specifically on the northern alternating current interconnectors from Sweden.

The market-based power flow variations, large unit sizes, and the constant variation of wind power generation will also increase the need for reserves activated by frequency changes in the system. These reserves are traditionally reserved in rotating power plants, but there is already shortage of reserves, at least judging by the ever-rising market prices of reserves. If the opportunities to control loads on the basis of frequency do not improve substantially, there may become a situation where it is sensible to store reserve power even in batteries. As battery prices are constantly coming down globally, there are now various types of battery applications also for power system management purposes. Fingrid is one of the companies examining the use of batteries for frequency control, but batteries cannot provide an overall solution to this problem. The energy volumes to be stored in major frequency deviations are so large that the most cost-effective way to maintain a balance between electricity production and consumption is to adjust them to match each other. ■



Electricity production and consumption even in a large area can be balanced by means of the transmission grid.

The grid does not work without power plants, and power plants do not work without the grid

Power plants provide the electricity transmission system with power and also with its voltage and frequency, which enable flexible electricity transmission from power production to consumption along an extensive grid. Traditionally, electricity has been produced by means of synchronous generators, which, while rotating synchronously via the grid, support each other also during various disturbances. By connecting networks together into larger and larger interconnected systems, it has been possible to increase the synchronously rotating mass and to take advantage of the control capability of power plants over larger areas. This, in turn, has enabled the construction of ever larger power plant units.

In the future, an increasing proportion of the new power plants will utilise renewable energy. This means that they have either no rotating generator or the power which rotates the generator changes constantly. The plants will consequently be connected to the grid through an electronic power converter, and the plants will no longer rotate synchronously with other generators. A similar situation is one where electricity production is replaced by importing it via direct current connections from outside the interconnected grid. When the number of natural points of support decreases, the ability of the grid to withstand a variety of disorders deteriorates.

Customer needs
into closer consideration in power system development

The rapidly changing power system introduces new challenges to transmission system development. In the future, the system will be developed in even closer co-operation with our customers, says **Jussi Jyrinsalo,** who will start as Fingrid's Senior Vice President responsible for customers and system development at the beginning of 2013.

Text by Suvi Artti | **Photograph by** Valtteri Kantanen

Jussi Jyrinsalo has been closely involved in enhancing European co-operation in ENTSO-E's System Development Committee. "It is also important for the customers to bear in mind that the Finnish electricity transmission system is part of a bigger system, and the Finnish grid cannot be developed completely in isolation from the European system."

Fingrid's organisation will be revised at the beginning of 2013: as an example, some units will be transferred from the grid services function to the system development function. In this way, the services offered to the network customers and the entire system planning process including the permitting process can be brought together. "In the same context, we took a closer look at the location of the various duties within the organisation," says Jussi Jyrinsalo, Fingrid's Senior Vice President for system development.

According to him, customers will not see the change at first. The same familiar customership managers will continue as the contact persons, and **Pertti Kuronen,** who used to be responsible for grid service, will continue in expert duties at the customer interface.

"The first step is to make the system planning resources give better support to the work carried out at the customer interface," says Jussi Jyrinsalo. "During the spring, customer service will be enhanced throughout the company so that the customer voice can be heard even better through various channels. After all, we do have many other contact persons vis-à-vis the customers alongside the customership managers who take care of the grid connections and transmission service."

System planning in unison

For Jussi Jyrinsalo, the new job description means going "back to roots". His career at Fingrid commenced 15 years ago in the role of a customership man- →

ager, from which position he transferred to become the head of the system engineering unit just before the new millennium, and later to his current position as the Senior Vice President responsible for system development.

Now he looks forward to meeting the customers again and to having an insight of their needs. "Major changes have taken place in the power system and among Fingrid's customer base, especially in recent times. Fifteen years ago, the customers constituted a relatively stable group, and much of the work was about renewing the agreements and negotiations concerning the tariff structure," says Jussi Jyrinsalo in reflecting on his earlier work as a customership manager. "Now we have a large number of new potential production units to be connected to the grid, such as wind turbines, which are very different from the traditional power plants. At the same time, there are plans for larger and larger nuclear power units."

What is new in the challenging situation is the fact that now a large volume of new small-scale electricity production capacity is also being connected directly to distribution networks. This makes it more difficult to manage the big picture. As a result, according to Jussi Jyrinsalo, more co-operation between all parties is required in system planning. He considers that the integration of grid service with system development is a logical solution in the new situation.

"In this way, we get more planners to the customer interface to think of the best possible solutions. We have hundreds of new potential customers, who do not necessarily have any experience of how the transmission system works. Fingrid, on the other hand, does not have much experience in wind power technology, so there is a lot to be learned on both sides."

Learning is already well under way: Many wind power producers have visited Fingrid recently to present their projects. "All of the plans may not necessarily materialise, but we have already learned much about wind power, and those presenting their projects have hopefully had an understanding of how the transmission system works."

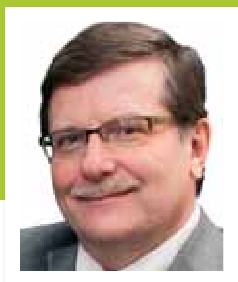
From code language to plain language

As the customer base is becoming more diversified, Fingrid's values – especially impartiality and transparency – are in a key role. "The equal treatment of all customers, including the numerous potential customers, is highlighted," says Jussi Jyrinsalo. According to him, this also involves communicative challenges.

"We are accustomed to speaking our own code language with the customers, but now we have to start talking in a plainer language. We cannot assume that customers who have not previously been involved in the process of connection to the grid would immediately understand all terms." ■


Jyrki Havukainen


Raimo Härmä


Tapio Salonen

CUSTOMERS' WISHES

We asked a few customers of Fingrid what kind of a message they would like to send to Jussi Jyrinsalo.

Jyrki Havukainen
Operations Manager, Neste Oyj /
Managing Director,
Porvoon Alueverkko Oy

"I hope that Fingrid pursues its customer-oriented approach. The high system security of the Finnish electricity transmission system is a critical factor for the process industry facilities which operate in Porvoo. The transmission tariff increases are understandable so as to finance the capital investments, but I am concerned about the rate of the tariff increases."

Raimo Härmä, Managing Director,
Kymenlaakson Sähköverkko Oy

"I hope that the constructive and co-operative procedures continue. You must be able to speak directly about difficult things, too. We look forward to regular, natural, and open communications."

Tapio Salonen, Managing Director,
Tampereen Sähköverkko Oy

"We hope for continued transparent, equal and open-minded exchange of information and discussion of common issues, as well as innovation. We have had a regular and good rapport, which aims to find mutually beneficial overall solutions to present and future system challenges."

Jaakko Tuomisto, Office Manager of Power Issues, TVO

"Our co-operation with Fingrid has always been good, and even difficult issues have been dealt with directly and openly. I have worked with Jussi Jyrinsalo long enough to be able to say that the co-operation will continue on the same foundation and that we can come up with solutions in the future, too."

Fingrid's website revised

Fingrid launched its new internet pages on 17 September. The pages have been updated in terms of layout, visual appearance and underlying information systems.

The objective of the reform was to add to the amount of information found on the pages and to improve readability. A whole new section on the website is the section Customers, and there are now also a number of new subsections, such as Responsibility, Safety, and under the Company section Personnel and recruitment as well as President's message.

There is more to come, because Fingrid's extranet site is also being revamped. The extranet will experience a similar reform in terms of readability and data systems. The ultimate goal is to improve both usability and data security.

The new extranet will be launched towards the end of 2012. The revised public website is available at the familiar address **www.fingrid.fi/en**. Feedback on the pages can be given through the link Feedback.

Unit prices of balance service in 2013

The new unit prices of Fingrid's balance service as of 1 January 2013 are as follows:

Fixed monthly fee	200 €/month
Actual production	0.158 €/MWh
Actual consumption	0.266 €/MWh
Volume fee for imbalance power in the consumption balance	0.5 €/MWh

The energy fees for imbalance power in each balance are in accordance with an agreed model.

Capital investments in the transmission system raising the tariffs – transmission prices up by 15 per cent

Fingrid will raise the grid transmission tariffs at the beginning of 2013 by an average of 15 per cent. The raises are based on the increase in the cost level of the electricity transmission business and on the company's sizeable capital investment programme. However, Fingrid's transmission tariffs continue to be affordable on a European scale.

Fingrid is investing 1.7 billion euros in the high-voltage transmission system in this decade to ensure reliable transmission of electricity in Finland well into the future. In all, Fingrid is planning to construct almost 3,000 kilometres of transmission lines and 30 substations. In addition to the new transmission connections, a number of substations and transmission lines originally constructed in the 1960s and 1970s will be modernised.

"The electricity market and power production patterns are changing. We are building the transmission system to conform to the needs of our customers and the Finnish society. Our customers' new generation capacity must be connected to the grid, while at the same time it is of paramount importance to safeguard secure electricity supply and well-functioning electricity market mechanisms," says Fingrid's CEO **Jukka Ruusunen**. The capital investment programme is financed by means of additional borrowing and income financing.

The grid service fees are adjusted annually. The Energy Market Authority supervises the reasonableness of electricity transmission pricing. The Authority determines the maximum permitted level of return on network operation and monitors it during specified supervision periods. The length of the present period is four years.

Joint efforts against cyber threats

CONTINGENCY PLANNING IS THE KEY

Denial of service attacks, malware, compromised passwords. Our increasingly online world is also increasingly vulnerable.

Text by Ursula Aaltonen | **Photograph by** Communications Regulatory Authority

"The threats and risks pertaining to information networks have clearly become more common and severe in recent years. The cyber threats are primarily related to the seriousness of the phenomenon – to situations where the effects are wide-ranging and reflected in the functioning of society as a whole," says **Timo Lehtimäki**, Director of the Finnish Communications Regulatory Authority.

Timo Lehtimäki heads that unit of the Communications Regulatory Authority which is responsible for information networks and their security. In this capacity, he has had a vanguard position to follow the changes in data security threats over the past decade. "Today's society is highly dependent on the internet, and its impacts are felt more widely than we often even come to think of. As an example, closed networks are mostly an illusion today, when virtually all data passes through the internet at some point. This is why preparations for data security threats are an increasingly critical component of the efforts of all communities."

According to Timo Lehtimäki, the role of the Communica-

"Finnish data networks have long been – and still are – among the cleanest in the world", Timo Lehtimäki says.

tions Regulatory Authority is clear in this respect. “We maintain a constant overall view of what is going on out in the world, and our priority is to assess and forward this information. This primarily takes place through the cert.fi website, where we compile all relevant data on the data vulnerabilities, data security threats and related violations. However, it is up to each organisation to react to the essential information,” Lehtimäki points out.

All is powered by electricity

Since 2007, the Communications Regulatory Authority has been responsible for providing data security services to parties which are critical in terms of security of supply in Finland. These parties include the energy industry and electricity networks. “Information networks and electricity are of course closely dependent on each other. So that data could travel, electricity must also flow – and to a great degree also the other way around.”

According to Timo Lehtimäki, the data security threats facing electricity networks have also become more aggravated in recent years. “The same threats concern electricity networks and any other networks – after all, the control centres also rely on data systems. It is of primary importance here, too, to stay up-to-date so that we can be prepared for the worst case scenario.”

Timo Lehtimäki says that an attack against electricity networks can also take place as if by accident. “You may be subject to a data security attack also indirectly. As an example, there could be a situation where the electricity network and its management systems are in order, but communications to and from the control centre of the network are overloaded as a result of an attack on some other place. Communications in a congested network are more difficult and may even become completely prevented. The situation could be compared to a traffic jam – the driver, car and road are all in the prime condition, but the traffic just does not work,” Lehtimäki explains.

> Closed networks are mostly an illusion today.

Communications networks make preparations for disturbances for instance by means of a variety of backup power systems. Timo Lehtimäki says that these can only provide a temporary solution, and in many cases for quite a short period of time at that. “The functioning of society is based largely on fixed networks powered by electricity. Mobile networks can be a local and temporary solution in a disturbance, but they do not replace fixed networks. Mobile networks also need electricity to function, and you cannot rely just on emergency power arrangements, such as battery banks.”

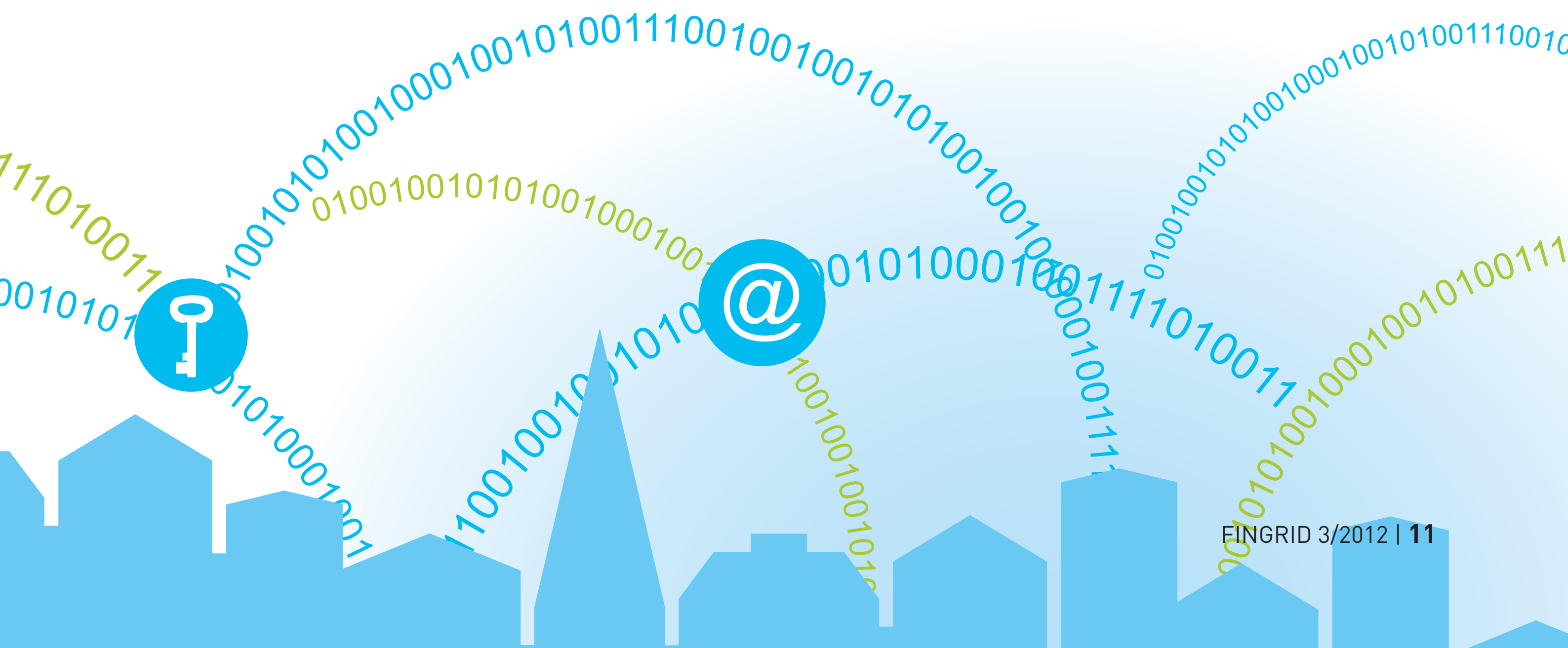
When information travels, co-operation works

According to Timo Lehtimäki, as far as cyber threats are concerned, Finland can still feel relatively tranquil. “We Finns are notoriously bad at praising ourselves, but we have a good situation here. Finnish data networks have long been – and still are – among the cleanest in the world.”

He adds that one of the factors contributing greatly to this is that we have nationally well-functioning networks. The Finnish Communications Regulatory Authority works closely with for example domestic telecommunications operators. “The fluent flow of information and our domestic networks have even caused envy in some international colleagues of ours. Of course, it also makes everybody’s efforts easier when we can work together and in agreement with those wrestling with the same problems.”

There are dozens of authorities focusing on data security issues in the European countries, and Timo Lehtimäki says that their mutual co-operations works well. “We conduct close co-operation especially between CERT authorities in different countries.”

One of the “gems” in the international contexts, according to Timo Lehtimäki, are the relations with Russia. “We have →



reasonably good co-operation relationships with Russia, through which many of the internet attacks take place. This is a clear advantage for us in the international arena."

Also a political question

Timo Lehtimäki says that emerging nations in Africa and Asia are a big question mark – and also potential sources of problems. He adds that data security issues in these countries are at an infancy at best. "The only authority in data security matters on the entire African continent exists in Tunisia. Moreover, for example the distribution of pirated software represents business protected by the government in some African countries. The operating environment is therefore quite different from the one to which we have become accustomed, so finding common ground for discussion about problems could be challenging to say the least," Timo Lehtimäki argues.

He says that the international operating environment in data security is changing in other respects, too. "So far, the co-operation has focused largely on technical matters. But now that the events are becoming more serious, it is only natural that a political aspect is also involved. My prediction is that in the future we will work more closely on the basis of formal agreements to be signed between countries."

Cyber – the word of tomorrow

Issues pertaining to cyber threats and security have also been on the agenda within the framework of the national cyber security strategy which is being prepared in Finland. **Mikko Kosonen**, President of Sitra and head of the working group which is preparing the strategy, recently suggested the establishment of a separate cyber centre in conjunction with the Communications Regulatory Authority.

"An expansion in the sphere of activities and centralisation of expertise will benefit all parties. The better we are aware of the threats in the world, the better we can anticipate and prepare ourselves and consequently respond at the level of the entire society," is how Timo Lehtimäki, who works as an expert member in the working group headed by Mikko Kosonen, sums up the advantages of the cyber security strategy and the proposed cyber centre. No official decision about the establishment of the centre has been made yet. "Decisions about the establishment and its schedule are likely to be made this year."

According to Timo Lehtimäki, the future not only holds threats but also opportunities. "We have already accumulated much knowledge and expertise in the field, and Finland being a small country, we are fast and agile. The present strategy work can open exciting opportunities in the international arena – when you cannot go back to the 'good old days', you just have to adapt. The importance of data security will not certainly decrease in the future," Timo Lehtimäki sums up. ■

The better we are aware of the threats in the world, the better we can anticipate and prepare ourselves.

Sufficient electricity in the cold winter weather

Text by Timo Kaukonen

As the winter is approaching, an estimate of the trend in electricity consumption and production as compared to the previous winter has again been drawn up. The past winter 2012 was not very cold in Finland, but there was a period of very cold weather in early February. The hourly electricity consumption went up to 14,300 megawatts on 3 February. The all-time-high peak consumption, almost 15,000 megawatts in the winter of 2011, was still far, because there was not an exceptionally cold period.

The electricity consumption forecast for the coming winter would seem to be fairly close to last winter's forecast of 15,000 megawatts in a cold winter day which occurs once every ten years. Industrial consumption of electricity in Finland has decreased slightly, but other consumption has risen correspondingly, which is why the total peak consumption is approximately at the same level as in the previous winter.

The electricity generation capacity available to the market during peak consumption has remained nearly the same, at 13,300 megawatts. The largest single new power plant in Finland is Fingrid's Forssa 300 megawatt reserve power plant, which is not, however, included in the normal generation capacity in a winter situation, because the plant is only operated during disturbances. A few relatively small thermal power plants and power upgrades in some hydropower plants are completed, but at the same time some of the older generation capacity has been decommissioned. About 100 megawatts of wind power have been completed or are about to be completed, but the forecast presumes that this production is very small in a cold and calm winter day. The situation with peat harvesting has been poor, and it has been suggested that the peat power plants would not quite reach their maximum production capacity in the winter season.

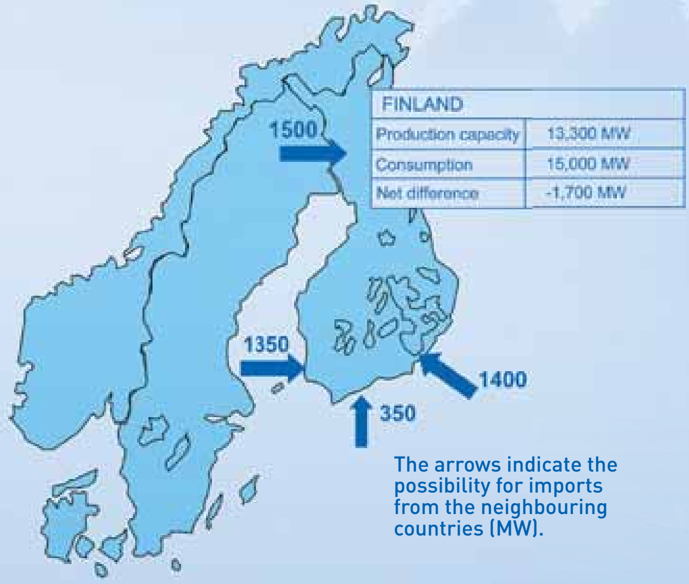
Finland is dependent on electricity imports during peak consumption situations when the weather is cold. The import capacity from the neighbouring countries is at the same level as in the previous winter with the exception of the Fenno-Skan 1 connection between Sweden and Finland. It will be out of use for the rest of 2012 due to fire damage repairs. There is also uncertainty as to how much imports from Russia are available during peak consumption hours. This is due to the Russian market price, where one of the price components is a capacity fee. However, it would seem that there is sufficient import capacity to transmit the necessary imports of electricity, provided that no other faults emerge.

All in all, it can be stated that although Finland is dependent on imports of electricity, there is enough electricity in Finland also during very cold days in the coming winter. The forecast suggests that in the Nordic countries, too, there is sufficient electricity to cover peak consumption in the entire area.

The power situation in Continental Europe deteriorated last winter as a consequence of the closure of German nuclear power plants. According to forecasts, the situation in the coming winter would seem to remain roughly unchanged, in other words there are some concerns over security of supply and sufficiency of transmission capacity. ■

Power balance 2012/2013

The power balance forecast concerns the power situation in a very cold winter day, which is likely to occur in Finland once in ten years.



The arrows indicate the possibility for imports from the neighbouring countries (MW).

GOOD BUILDING, better service

In early December, Fingrid's head office will move approximately seven kilometres north, to Läkkisepäntie road adjacent to the Käpylä railway station in Helsinki. The brand new red building not only provides modern working facilities but also technically secure systems for power system control.

Text by Tiina Miettinen | **Photographs by** Eija Eskelinen

Fingrid launched the head office project four years ago, initially aiming to examine technical security and development of control centre operations in the existing facilities. It became apparent in the early stages of the project that the technical and operational security of the control centre as well as improving of system security would succeed best in new facilities. The company consequently decided to look for new rented premises.

The search for the new premises in the Helsinki region began in 2009. The company aspired to find a property which would be suited to versatile expert work. The facilities had to be applicable to both team work and independent design work. At the same time, they had to meet stringent technical criteria so that the company's main duty – securing the system security of the power system – would be enabled even better than earlier.

The contract on the new rented facilities was signed with YIT Rakennus Oy in the autumn of 2010. The construction of the business park named Triotto began in January 2011 and was completed in 2012. The first part, the DNA building, was completed in the summer, and Fingrid's building in late autumn 2012.

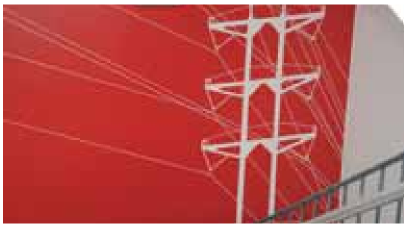
Fingrid has access to about 7,400 square metres of space, of which workspace accounts for over 5,100 square metres and the rest are technical facilities and meeting rooms. The meeting and conference rooms are located on the first floor and the actual office facilities are located on floors 2 to 5. The office floors contain a variety of facilities: team rooms, project rooms, open space, individual rooms, and ad hoc meeting rooms.

Energy-efficient building within easy reach

Environmental concerns have also received attention. The premises were built applying YIT's "energy genius" concept, according to which the energy efficiency of the structures and solutions is taken into account in the design. The selection of proper technical building systems and equipment, in turn, allows savings in future maintenance costs. An international LEED environmental rating will be applied for the building. Fingrid's office floors also have energy-saving LED lights.

Triotto is easy to reach. It is located along good transport links, right on the border of the Käpylä and Oulunkylä residential areas in Helsinki. The exact address is Läkkisepäntie 21. Two major transport routes run past the building:

The lamps in the lobby welcome everyone to Fingrid's new office.



The Tuusula motorway and the railway line to the north. The distance to the Käpylä railway station is about 100 metres. Ring Road I, Hämeenlinna motorway and Lahti motorway are only a short drive away, and it takes about 15 minutes to drive to the airport. The area houses many other offices, such as YIT's head office.

Driven by the integration of control centres

The need for the new facilities was created primarily by the decision to integrate Fingrid's Power System Control Centre in Helsinki and the Network Control Centre in Hämeenlinna. The amalgamation of the control centres aims at enhanced efficiency and improved customer service, especially in the event of disturbances.

"The benefits of the integration materialise in particular during disturbances, when we will be able to quickly establish an overall view of the situation and to launch the right measures. Customers will benefit from the fact that they have a single point of contact. I believe that the quality of service will also improve," says **Reima Päivinen**, Fingrid's Senior Vice President responsible for power system operation.

The merger of the previously separate control centres into the Main Grid Control Centre will intensify performance. However, the goal is not to reduce workforce but to renew the procedures. The first priority continues to be high system security and good service to the customers at all times.

Possibility for change

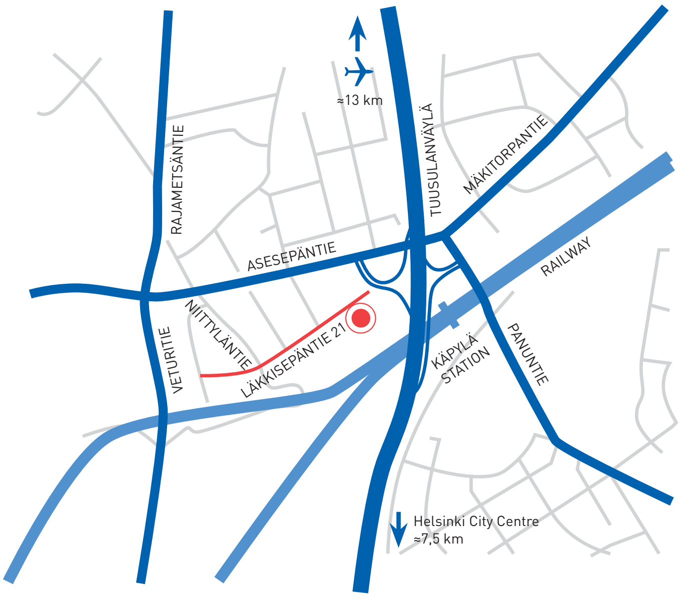
A facility team was established within Fingrid for the head office project, with the various functions being represented in the team: power system operation, human resources, information technology, administration, and security. Necessary construction and design consulting expertise has been procured externally. The facility team has been headed by Fingrid's General Counsel **Tarmo Rantalankila**, and the project manager during the construction phase was **Erkki Turu**.

"This project has concerned all us Fingrid people, a little differently at the different stages. Everyone has been given an opportunity to have their say – and the opinions have also been listened to, even though it was not possible to put everything into practice. About 30 Fingrid employees have participated actively in the design and construction processes," Erkki Turu says.

When this article is being written in late October, he is very busy, as are the employees in Fingrid's ICT unit. The building is undergoing operational testing, and the finishing work is starting. Fingrid's move is far from being just an ordinary office removal. The Finnish electricity system must be monitored, the data systems must stay in operation, and the lights must be kept on in Finland even if the control centre moves to a new place.

"Mind you, this is no new thing for me. I was there when Fingrid moved from Myyrmäki to Arkadiankatu in the late 1990s. The pattern is basically the same now, too," Erkki Turu says.

The project is soon behind, and the lights will come on in Triotto. "This has been tremendously challenging, because our goal throughout the project has been to obtain first-rate technical solutions to safeguard system security. On the other hand, it is great that at the same time we have had a possibility to change. The office technology has been completely re-thought, which also makes it possible to change the working practices. Everything has gone pretty well according to the plans and the master schedule," Erkki Turu says with a sigh and knocks on wood. ■



Fingrid's new head office is easy to reach by car or train, and it is not far from the airport, either.

System control will focus in Helsinki

As Fingrid's new office building will be complete, the company will no longer have two control centres. The Network Control Centre in Hämeenlinna and the Power System Control Centre which used to be located in conjunction with the company's head office in Helsinki will be merged into the new Main Grid Control Centre.

Text by Ursula Aaltonen | **Photographs by** Valtteri Kantanen and Fingrid

The previous major change in the control room operations dates back to 2001, when the regional control centres were concentrated in the Network Control Centre in Hämeenlinna.

"This is the last step in the transition to a model of a single control centre. The change will enhance our internal communications and expedite the action taken, especially in the event of disturbances, and therefore it will also benefit our customers. The co-operation between the formerly separate control centres will improve, and customers will receive information and services from a single source," says **Arto Pahkin**, head of the Hämeenlinna Network Control Centre.

Together with **Jari Siltala**, Manager of the Power System Control Centre, he will be responsible for Fingrid's new Main Grid Control Centre. They have also jointly headed the working group which has been planning the new control centre. "The integration of the control centres has required huge amounts of preparatory and ground work. The planning process has also involved many outside parties – architect office, consulting firm and interior designer, to name a few," says Jari Siltala.

Launch in January

The Main Grid Control Centre will be launched in Fingrid's new premises in Helsinki at the turn of January and February 2013. The Power System Control Centre, which used to be located in Arkadiankatu in Helsinki, will move to the new premises in the first stage in conjunction with the move of the head office. The moving of the Hämeenlinna Network Control Centre is scheduled for the end of January, after which the Main Grid Control Centre is ready for full-scale operations.

"All the functions will naturally be tested thoroughly before the control centre is commissioned. The move is a huge effort for our personnel – and especially so for the ICT people, who have worked really hard to have everything ready on time," Jari Siltala says.

According to Jari Siltala and Arto Pahkin, the functionalities of the new control centre represent top notch level. "Much of the credit for this goes to the project group and the control room staff, whose feedback and input in the design work have played a vital role," they commend.

Security first

The design of the new control centre has paid attention to many functionalities, such as acoustics and ventilation. "Acoustics design is an important consideration when the same room is shared by many people who need to be able to concentrate on the matter at hand and, if necessary, talk on the telephone," says Arto Pahkin.

Security has been number one priority in the planning process. "A security audit was carried out in our control centres a few years ago, and we have taken heed of the results of the audit in many respects. The new control centre will have at least two operators present at all times," says Arto Pahkin.

Abandoning the model of two control centres also means that the Helsinki and Hämeenlinna control centres can no longer serve as each other's backup. "This is something to which we have to prepare ourselves. Backup arrangements are an integral part of the functionalities, and we have now enhanced the backup control centre system further as a result of the changes made," Arto Pahkin states.

New model into use

The work of the Main Grid Control Centre, which employs approximately 20 Fingrid people, is based on three main duties: power system management, balance management, and transmission system management. Roughly speaking, the first two duties have previously belonged to the Power System Control →

PRIMARY RESPONSIBILITIES OF MAIN GRID CONTROL CENTRE

Power system management

- 400, 220 and 110 kV network and device control
- Power system management in normal and disturbance situations

Transmission system management

- Clearing of disturbance and fault situations, restoration of operation
- Outage planning and management

Balance management

- Power balance management
- Management of reserves
- Purchase of loss energy

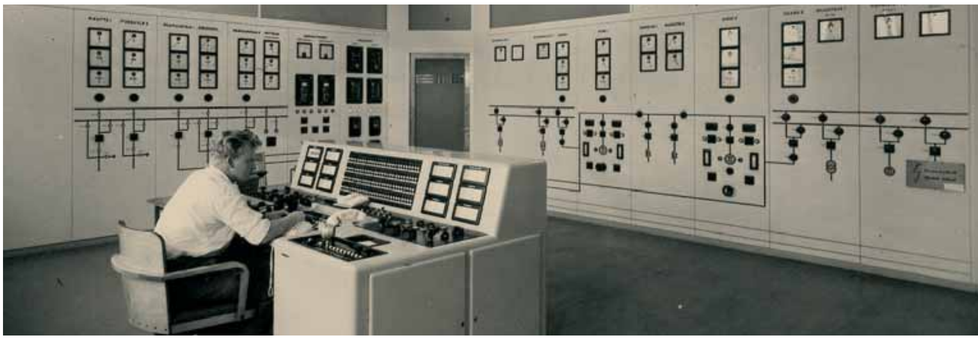
Centre in Helsinki and the latter to the Network Control Centre in Hämeenlinna. Both the division of responsibilities and the duties have been adapted in the new approach. "The operating model applied to the Main Grid Control Centre enables the employees to have increasingly diversified job descriptions. We can make better use of the personnel resources, and for most of the operators, this means new duties," Jari Siltala says.

Another major change to the former is that those taking care of transmission system management will be working in shifts of 24 hours. The other control centre personnel will continue to work in normal three-shift work. The new shift arrangements will reduce travel by the employees, so it facilitates the commuting of especially those living outside the Helsinki area," Arto Pahkin states.

During the day, the new control centre will be manned by three to five people depending on the day of the week and situation at hand, and by two people at night. Some of the personnel are on standby for eventual disturbances to complement the control centre staff whenever necessary. During disturbances and other extraordinary situations, they will assist in communications and other duties.

Both Jari Siltala and Arto Pahkin are visibly happy with the new control centre. "The Main Grid Control Centre makes it possible for us to maintain system security at the present good level also when the electricity market conditions change and as the generation capacities will increase," Arto Pahkin says. ■

Turku transformer substation in the early 20th century.



In the 1950s, all transformer substations worked in three shifts. The photograph shows the Petäjävesi substation in 1959.

In the 1960s, the transformer substations shifted to a day shift and stand-by duty. A main control centre was established in Tammisto. The Tammisto main control centre in its renovated appearance in 1969.

In the 1970s and 1980s, control was gradually shifted to seven regional control centres. The main control centre moved to Myyrmäki in Vantaa. In the 1990s, control operations concentrated in the four regional centres and in the Power System Control Centre set up in Helsinki. The photograph is of the Myyrmäki main control centre in 1991.

The Main Grid Control Centre to be commissioned in January/February 2013 will be responsible for the control of the entire transmission grid in Finland. Jari Siltala (on the left) and Arto Pahkin at their new workplace.

Reserve power plant ready to serve

The commissioning of the Forssa reserve power plant to be inaugurated in the spring of 2013, and especially the arrangement of the fault ride-through test, was a challenging task. The test was carried out flexibly thanks to careful advance planning. The fault ride-through test showed that the reserve power plant can withstand voltage disturbances in the grid and that it will also work during them as specified in the relevant documentation.

Text by Antti-Juhani Nikkilä and Minna Laasonen | **Photograph by** Manjamedia

Commissioning tests are conducted in conjunction with the commissioning of a power plant, used for verifying that the plant conforms to the specifications for the operational performance of power plants (VJV). The commissioning programme of the Forssa reserve power plant consisted of a number of tests performed during the summer and autumn of 2012.

The operation of the power plant during voltage disturbances is verified against the plant documentation and a fault ride-through test carried out in the network. A fault ride-through test ensures that the power plant with its auxiliary systems and processes works during voltage disturbances in the grid so that the plant does not trip from the grid.

A fault ride-through test requires careful planning, because the impacts of a voltage disturbance caused by the test in the meshed high-voltage grid could be reflected in a large area. It is not even possible to arrange the test at just any time due to the disadvantage inflicted on the other users of the grid. The arrangement of the test switching necessitated by a fault ride-through test may require many switching operations in the electricity network, and these operations have further effects on the properties of a regional electricity network during the test switching.

The test switching must enable a sufficiently deep voltage dip in terms of the power plant tested in a way that does not cause disadvantage to the users of the network or overload the components in the network. The protection of the network must also work during the test switching, and it must be possible to isolate the fault made in the network from the rest of the power system quickly and reliably.

The planning process must take into account the necessary measurements so that the behaviour of the network and of the tested power plant can also be examined after the test. Since the transmission situation in Fingrid's grid varies between the different days of the week and seasons of the year, the timing of the test with respect to the other switching operations in the grid must be planned with care.

The operation of the Forssa reserve power plant during a voltage disturbance was verified successfully by means of a fault ride-through test in September 2012. In the test, a three-phase short circuit lasting for 100 milliseconds was performed in a part of the 110 kilovolt transmission network. During the test, both units of the reserve power plant were connected to the grid at a total power of 240 megawatts, and both units were provided with separate measuring instruments to record the behaviour of the plant during the voltage disturbance.

The fault for the test was made in an isolated 110 kilovolt branch line about 15 kilometres from the power plant and from the nearest power transformers. So as to minimise the impacts on the other users of the network, the reserve power plant and the fault location had been transferred electrically as far away from the other users as possible. The effects on the other users were limited effectively by means of switching arrangements: the voltage in the 110 kilovolt busbar of the transformers at the reserve power plant during the test fault was approx. 49 kilovolts, while even the lowest voltage for the other users of the network was as high as about 108 kilovolts.

A voltage dip lasting for 100 milliseconds, like the one in the test, is not fully as challenging as a deep voltage dip lasting for 250 milliseconds, which is specified in the specifications for the operational performance of power plants. However, causing a voltage dip as long as that would have resulted in major impacts on the other users of the network and inflicted a considerably greater burden on the components in both the electricity network and at the power plant. ■

The Forssa reserve power plant will constitute an important part of Fingrid's own fast disturbance reserve. The reserve power plant consists of two gas turbines with a total output of 300 megawatts. The fuel used by the plant is light fuel oil. The reserve power plant can be started directly from Fingrid's Main Grid Control Centre, and the plant can reach full capacity in less than 15 minutes.

Guaranteeing access to INFORMATION

Information on the power system travels to the control centres along the operation control system, SCADA. Seppo Lehto, Fingrid's Special Adviser in ICT matters, and his colleagues make sure that the system works properly.

Text by Suvi Artti | **Photograph** from Seppo Lehto´s personal album and by Valtteri Kantanen

Seppo Lehto disengages from the busy work schedule by taking exercise in many ways. He has spent both summer and winter holidays in many years in the Alps cycling, hiking and skiing.

The operation control system collects data on the state of the power system and on electricity consumption and production.

"Our most important task is to keep the lights on in the whole of Finland," is how Seppo Lehto summarises the fundamental purpose of his work. In his case, this means taking care of the trouble-free operation of the operation control system or SCADA (Supervisory Control and Data Acquisition).

In recent months, Fingrid's ICT people have been kept busy, alongside their normal duties, by the moving of the company's headquarters and by the integration of the Network Control Centre and Power System Control Centre into the new Main Grid Control Centre.

"As early as the planning and construction stage, we have done a lot of work to enable the move. Everything has been planned so that there will be no interruption in the electrical systems of the building at any point. I have not really taken part in the implementation of the facilities themselves, but my role is highlighted when the move actually takes place," says Seppo Lehto.

Increasingly important data security

The operation control system collects data on the state of the power system and on electricity consumption and production. The information is utilised for example when planning the operation of the transmission system as well as when forecasting the balance between electricity consumption and production.

In recent years, the data compiled by the system has been exploited to an increasing degree for several purposes. At the same time, data security has become a main concern. "When I started working in Fingrid 15 years ago, there were hardly any data security risks. Nowadays, ensuring data security constitutes an important part of our work," Seppo Lehto says. He has noticed that history data is of interest to more and more people within the company. "There are queries from different units – and it is of course good if the information contained in the system can be brought to use."

Problem resolution with joint forces

Seppo Lehto describes his work as problem solving which calls for logical reasoning and an ability to combine pieces of information in the right order. "Something needs to be carried out or a fault needs to be fixed, and you must use certain facts to determine how to take care of the matter. If you do not know something yourself, the information is always available from some source: a colleague, internet or a phone call."

Unlike many of his colleagues, Seppo Lehto does not have an engineering degree, but his background is from information technology. "It is sometimes annoying not to have a greater insight into electrical engineering. Fortunately, you do not need to know everything yourself, but there is always someone to ask from. Our people do not keep information to themselves," Seppo Lehto commends the atmosphere in the ICT department and in the entire company. This is also the reason why he has been in Fingrid for 15 years.

"We have a pretty good crew and a good spirit, and there is nothing wrong with the company itself, either. The work offers sufficient challenges, sometimes almost too much so. There is no risk of boredom," he says with a grin.

One of the things that keeps up the team spirit are the annual athletics games between Fingrid's ICT department and the control room personnel, with the games consisting of the heptathlon for women. Most of the participants have usually been men, but a few brave women have also ventured.

In addition to the athletics field, Seppo Lehto can be found in his spare time at the gym or snooker hall, on a mountain hike, or in the biathlon grandstand. He has toured the World Cup in biathlon as a spectator and learned to know both fans and athletes from various countries. "When **Kaisa Mäkäräinen** won the World Cup, we all celebrated the victory with her. That almost makes me a part of the Finnish team, doesn't it?" Seppo says with a smile. ■


ELTEL

Fault repair tower
erected in a day

Fingrid's service providers were able to show their performance in an imaginary situation within a major fault exercise in October.

Text by Suvi Artti | **Photographs by** Valtteri Kantanen

A powerful storm has swept across Southern and Central Finland, and a new storm is approaching. Electricity supply has been lost in a significant part of Southern and Central Finland. Voltage has been restored to the high-voltage grid, but most of the end users in the area still have no electricity. The mobile telephone network is down, so telephone communications do not work. This was the initial situation in the three-day major fault exercise which Fingrid arranged for the representatives of its customers and partners in Tuusula in early October.

A major disturbance in the high-voltage grid is something that has not been experienced since the 1970s. At that time, the grid was very different and could not manage disturbances equally as well as the present grid. In other words, there are no routines for major faults, which is why regular exercises focusing on serious disruptions need to be arranged.

The Boxing Day storm in Finland in 2011 showed that society is increasingly dependent on electricity. That storm did not cause disturbances in Fingrid's grid, but the blackouts in regional and distribution networks lasted for several days at worst. "The storm which came close to the Helsinki region indicated that there is room for improvement in the co-operation between various parties. There were also signs of political pressure to improve contingency planning. A major failure calls for co-operation between all parties: regional network companies, Fingrid, emergency services, and other authorities," said **Reima Päivinen**, Fingrid's Senior Vice President responsible for power system operation, who spoke in the exercise.

Tower erected through joint efforts

Erecting a fault repair tower had been practised earlier on a training field both by means of winch and using a helicopter, but this was the first time that the large-scale exercise took place in the terrain. The exercise involved people from three different companies: Fingrid, and its present maintenance management service providers Eltel Networks and Empower. "People from different companies would have to work together also in a real situation, which is why it is important to learn how to play together safely," is how Fingrid's Project Manager **Kari Lindholm** summarised the objective of the exercise.

The installers were to erect a new tower to replace a collapsed one. First, the erection work had to be planned jointly, taking into account all safety aspects, such as necessary earthing. The initial situation corresponded to a stage where one crew would have already cleared the accident site, and now another crew would come in to erect the tower.

The briefing for the situation was given on Monday, and the installers got to work on Tuesday morning. The erection work actually went faster than what the organisers of the exercise had anticipated: the tower was standing at 1 o'clock in the afternoon, and completion was only short of some finishing touches.

"Everything has worked without glitches, and we have progressed according to plan," said Eltel Network's Power Line Installer **Raimo Janhunen** when the erection of the tower was nearing its end. He added that the co-operation between the workers of various companies had been very good. "All are experienced installers and done a lot of this kind of work." Raimo Janhunen himself has plenty of experience: he has worked for more than 40 years in transmission line installation.

Agreements on the use of fault repair towers

When the installers were erecting the tower, the other participants of the exercise worked indoors in workshops thinking of issues such as how to develop the fault repair tower further, and the division of work in a major disturbance. **Jukka Pentikäinen** of Turku Energia Sähköverkot Oy participated for the first time in the exercise arranged by Fingrid. He thought that the exercise was useful. "Fingrid and regional network companies must work together in extraordinary circumstances, so it is good that there are relevant exercises. A year ago, we signed an agreement with Fingrid on the use of fault repair towers. →

This exercise provided an opportunity to see how it all works in practice."

The erection of the tower was recorded on video, so those working indoors in the workshops were also able to see how the field exercise progressed. "It was interesting to see how the erection work was actually carried out," Jukka Pentikäinen stated. "Another good point was the presentation of the VIRVE telephone and satellite phone, and we also got to practise their use. The exercise as a whole made us all think whether there is some room for improvement in the procedures of our own companies."

Fingrid has agreements on the use of fault repair towers with six regional network companies. The fault repair towers are warehoused in Heinola, and service providers also have supply storages in different parts of Finland.

Expensive minutes

A major disturbance in Fingrid's transmission system would have sizeable effects on national economy: the economic impact of a power failure in the whole of Finland would rise to 100 million euros per hour. In the exercise arranged in Tuusula, it was assumed that one tenth of Finland would be without electricity. The economic impact of this would be 10 million euros per hour, in other words 167,000 euros per minute.

You consequently need nerves of steel in a disturbance, plus a contingency plan drawn up in advance, also containing important telephone numbers. Kari Lindholm gave practical instructions on what to do in such a situation. "The first thing is to contact Fingrid's regional transmission line expert, and clearing work experts. It is difficult to find the fault location especially when it is dark, and it requires a lot of human resources. The entire co-operation network must be available from the outset. It is also worthwhile using as much assistance as possible in data compilation, such as in retrieving the basic information on the failed line. Moreover, it is a good idea to agree on where to meet just in case telephones do not work." ■

The erection of the fault repair tower went according to plan, said Raimo Janhunen (on the left) and Ahti Rautsiala, who work at Eltel Network's Varkaus unit. Factors such as the unavailability of telephone services did not complicate the situation.

KNOW THE TERMS

This column presents and defines terminology in the electricity transmission business and related fields.

System frequency

Text by Minna Laasonen

Frequency refers to the number of recurrences of a recurrent phenomenon in a given period of time. Frequency can be calculated when the time interval between the recurrence of the phenomena is known. This time interval is called the time period *T*, and frequency *f* is the inverse $f=1/T$ of the time period.

In an electricity network, frequency is related to alternating current, and it indicates the time period over which the current and voltage range. If the frequency of the electricity network is 50 hertz (Hz), the time period of the voltage and current is 20 milliseconds; in other words, there are 50 cycles in a second.

Finland is part of the Nordic power system, where the nominal frequency is 50.0 hertz. This area with the same frequency at all times is also known as a synchronous area.

The frequency of an electricity network describes how well the instantaneous electricity generation and electricity consumption in the network are in balance. If the volume of electricity generated in the network and imported into it from outside is precisely the same as the volume of electricity consumption and electricity exported from the network, the frequency is exactly 50.0 hertz. If the total consumption and exports grow bigger than the combined production and imports, the frequency decreases. On the other hand, if the sum of production and imports is greater than the sum of consumption and exports, the frequency increases.

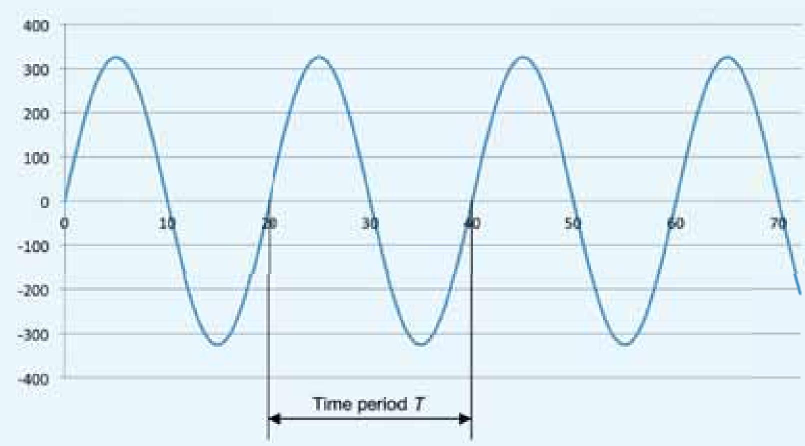
Since electricity generation and consumption vary all the time, the frequency varies continuously, too. The magnitude of the frequency change depends on the magnitude of the change in the consumption power or generation power. The magnitude of the frequency change also depends on the operating situation and on the volume of generators and motors which rotate synchronously with the network. The greater this rotating mass connected to the network, the smaller the impact of a power change of a given volume on the frequency.

The frequency in the Finnish power system varies between 49.9 and 50.1 hertz in a normal situation. We need reserves to balance consumption and generation and to maintain the frequency within the normal range. The Nordic countries have so-called frequency controlled normal operation reserve, which intends to keep the frequency within the normal range during normal operating conditions. The total volume of this reserve is 600 megawatts, and Finland's share of it is about 140 megawatts. The normal operation reserve consists of electricity generation or imports, which change on the basis of frequency.

Since the variation in frequency in a normal situation has grown over the past 10 years, a new reserve type, automatic frequency restoration reserve, which activates slightly more slowly than the normal operation reserve, will likely be introduced in the Nordic countries next year. The Nordic balancing power market is also available for balancing electricity production and consumption.

The frequency may go outside the normal range if there is a sudden major power change in the power system. If a large power plant fails and trips from the grid, the frequency falls below the normal frequency range. This activates frequency controlled disturbance reserve. This reserve in the Nordic countries totals 200 megawatts less than what the power change caused by the largest single fault is. At the moment, generator 3 at the Oskarshamn nuclear power plant in Sweden has the highest power, 1,400 megawatts, in the Nordic countries. When it is connected to the system and delivers full power, the total Nordic frequency controlled disturbance reserve must be 1,200 megawatts.

The largest loads tripping as a consequence of a single fault are usually not so great as to cause considerable changes in the frequency. This is why it is quite rare that the frequency would rise above the normal frequency range as a result of a fault. However, the sudden failure of high-voltage direct current cables in a situation where they are taking much power out of the Nordic power system may cause the frequency to rise above 50.1 hertz. ■



The voltage varies sinusoidally, and its time period *T* is 20 milliseconds, in other words the voltage frequency is 50 hertz.

Network codes coming
– what will change in system operation?

ENTSO-E, the European Network of Transmission System Operators for Electricity, has been working on new network codes for transmission system operation. The goal is that all three relevant network codes would be ready within ENTSO-E at the latest by mid-2013.

Text by Timo Kaukonen

The **Operational Security** Network Code is one of the network codes which govern transmission system operation. This code which is being prepared right now defines the general principles and responsibilities as regards the maintained system security of the power system and relevant processes. The code aims to improve in particular co-ordination and co-operation between the transmission system operators (TSOs) in the management of cross-border transmissions and performance of cross-border interconnectors as well as in congestion management.

The Operational Security Network Code will set the high-level requirements for system operation as a whole. The code is based on the (N-1) principle which provides for the most severe single failure at any given moment. The following categories of requirements have been established in the most recent Operational Security Network Code published on 17 August:

- System states
- Frequency control management
- Voltage control and reactive power management
- Short-circuit current management
- Congestion and power flows management
- Contingency analysis and handling
- Protection
- Dynamic stability assessment
- Operational testing, monitoring and investigation
- Data exchange
- Operational training and certification

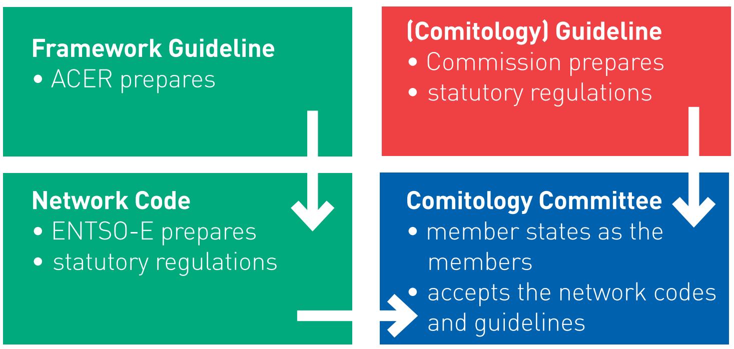
The drawing up of the network code on **Operational Planning and Scheduling** is also in progress. This code specifies the more detailed requirements for issues such as common grid models, operational security analyses and outage co-ordination, including their planning and scheduling. This network code will be in public consultation for two months from the beginning of November, during which time stakeholders can comment on it via ENTSO-E's website.

The third network code under preparation is called **Load Frequency Control and Reserves**. This network code has a direct impact on system operation, and it sets out in more detail the hierarchical structure of frequency control as well as the technical and volume requirements concerning the different types of reserves used in frequency control. The network code requires the TSOs to monitor frequency quality more accurately and to take necessary action if the frequency quality is not at a satisfactory level. The Load Frequency Control and Reserves network code also specifies the operational security conditions for the trade and distribution of reserves between TSOs and synchronous areas.

Increasingly closer exchange of information

In general, the network codes will call for more precise and better operational planning and real-time monitoring, which brings with it a need to increase the exchange of information between the TSOs, distribution network companies, and parties having a significant impact on the operation of cross-border transmission lines. In order to improve the real-time exchange of information between the TSOs, a shared data system, European Awareness System (EAS) is already underway. It will enable the control centres of other TSOs to obtain

PREPARATORY PROCESS FOR EUROPEAN NETWORK CODES



ACER Agency for the Cooperation of Energy Regulators
ENTSO-E European Network of Transmission System Operators for Electricity

The network codes will be drawn up in accordance with the EU's third legislative package on the electricity market by following the policies and framework guidelines specified by the European Commission and ACER, Agency for the Cooperation of Energy Regulators. Following the approval of the European Parliament and official release, the network codes will represent legislation binding all member states.

information swiftly on disturbances and other exceptional circumstances. This consequently provides a better overall view of the state of operational security in the entire power system.

The network codes require that the TSOs create a Common Grid Model (CGM) in Europe, enabling accurate results for transmission capacity calculation and operational reliability calculation for different time periods. This will require the necessary production and consumption data from distribution network companies and other major parties connected to the transmission system. In Finland, the exchange of information is already at a good level in many respects, so for those connected to the system, the necessary changes would appear to be further specifications rather than large-scale reforms. In the whole of Europe, the new network codes will lead to much more systematic information exchange practices, thus improving the accuracy of forecasts and real-time monitoring in the future.

From the TSOs, the network codes will require greater co-ordination and co-operation in the detection of congestions and in the management of measures which prevent congestions. The core of operational security, the (N-1) criterion, must be based to an increasing degree on an approach utilising probabilities: if the likelihood of a rarer fault case increases, its effects must be analysed and, where appropriate, taken into account. The seriousness of the impacts of fault cases must also be assessed and taken into account while performing the analysis and when selecting the calculation cases. Dynamic phenomena must be examined as close to real time as possible, if the phenomena are limiting factors, as is the case often in the Nordic countries.

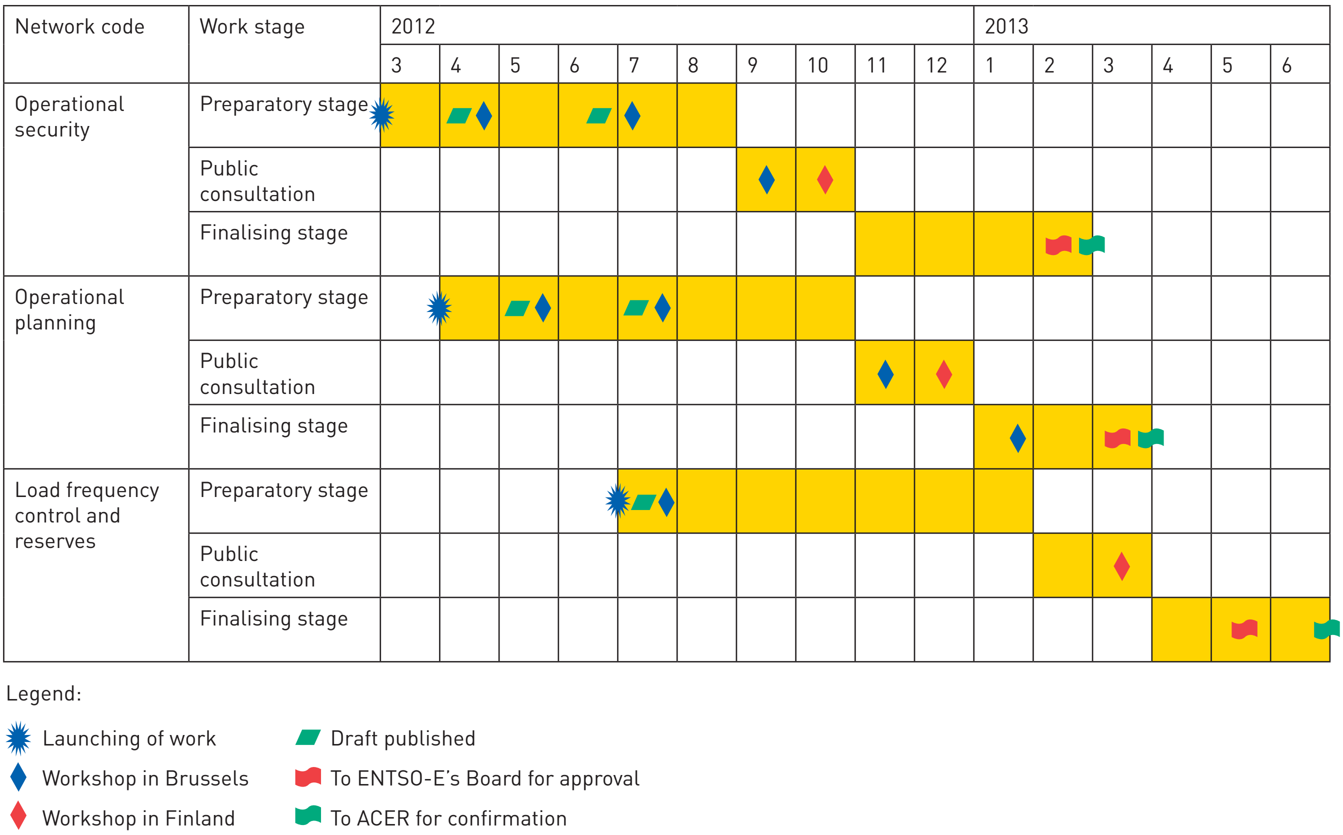
There will be shared European rules for commissioning tests and for the testing of equipment during operation, and the training and certification of the TSOs' operation personnel will become more formal.

Overall, the European network codes governing transmission system operation will harmonise the practices and principles and consequently improve the co-operation possibilities of TSOs, distribution network companies and parties connected to the transmission system. This may translate into schedule adjustments for example in outage planning. Excluding the specifications mentioned above, the new network codes would not seem to change the prevailing good operational practices in Finland very much. ■

The most recent draft versions of the network codes can be found on ENTSO-E's website at: www.entsoe.eu/resources/network-codes. ENTSO-E and Fingrid will arrange workshops and consultations on the network codes, with all parties concerned having an opportunity to influence the contents of the new network codes.

Schedule of preparation of network codes on transmission system operation

1. ACER's framework guideline 2 December 2011
2. Mandate of European Commission to ENTSO-E on 24 February 2012



Helping ospreys to move

Unobstructed view over a lake attracted an osprey couple to build its nest on a transmission line tower near Savonlinna. When the ospreys return from their overwintering area to Finland next spring, a new home awaits them.

Text by Ursula Aaltonen | **Photographs by** Pertti Koskimies and Ahti Rautsiala / Eltel Networks

The artificial nest built atop a tall spruce beside Lake Haapavesi is located about half a kilometre from the old nest of the ospreys. The osprey couple built the old nest – for the second time – on the upper structures of a transmission line tower last summer. However, their home amidst the power lines at a height of 43 metres was a security risk both to electricity transmission and the birds themselves, which is why the nest had to be dismantled at the end of the nesting season after the birds had left it.

"It is easy to understand that the birds could not resist building a nest on the transmission line tower: at an open, high and peaceful spot beside lakes with much fish. The nest offered the birds an unobstructed view in all directions, dozens of kilometres away," says **Pertti Koskimies,** biologist and ornithologist, who was responsible for the construction of the artificial nest.

The osprey, the only bird of prey in Finland which eats nothing but fish, tends to nest beside water. Man has, however, narrowed down the ospreys' living space, which is why the bird nowadays prefers to look for a peaceful nesting place further away from watercourses. "About 90 per cent of the ospreys in Southern Finland nest in man-made nests. Without them, the species would have disappeared completely from Finland," Pertti Koskimies says.

Drastic measures into play

So that the ospreys would not build yet another nest on the transmission line tower, drastic measures have been brought to play. "We have installed nesting obstacles made of steel wires on the nest tower and on two adjacent towers which might attract the birds. The nest twigs will simply not stay in place due to the obstacles installed between the overhead ground wire peaks. And that means that nesting on the tower is an impossibility," says Fingrid's **Jarmo Lahtoniemi**, who is responsible for transmission lines in the region.

Steel spikes had been installed in the crossarm structures earlier, primarily intending to prevent gulls from sitting on top of the towers and defecating on the insulators of the transmission line. The spikes have kept gulls away effectively, and it was thought that they would also prevent ospreys from building a nest – but that was not the case.

"The ospreys are clearly in a whole different category, because the spikes did not make any difference to them. On the contrary, they probably appreciated the handy spikes, which made it easier to assemble the twigs into a nest," Jarmo Lahtoniemi says with laughter.

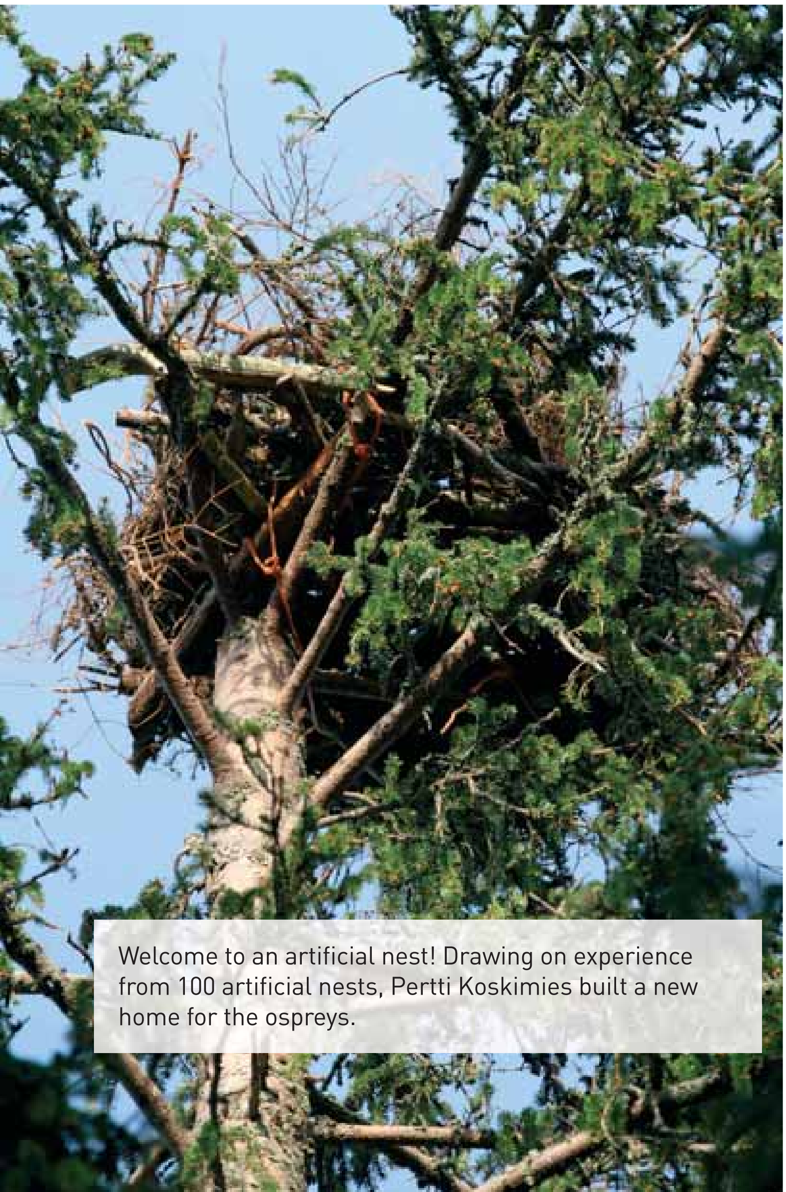
Bird of prey with a habitual place of residence

Like most birds of prey, the osprey tends to nest in the same place. "Once the bird finds a good spot, it returns to it for the rest of its life – even the offspring often come back to nest no more than 100 to 200 kilometres from their birth nest. Males are slightly more loyal in this respect than females," Pertti Koskimies says.

Whether the two ospreys will find their new nesting place will be revealed next spring when the birds, which typically spend the winter in West Africa, return to Finland. "In an average spring, they return to Finland between 20 and 25 April," says Pertti Koskimies.

The ornithologist who has built a total of about 100 artificial nests believes that the ospreys will accept their new home this time. "There is a direct view between the old nest and the artificial nest, which is located at a really good vantage point, too. Since nesting on the transmission line tower is no longer possible, the artificial nest is certainly the best available alternative for them." Let's keep our fingers crossed! ■

A bird's nest on a transmission line tower is a security risk both to electricity transmission and the birds themselves. Nesting obstacles made of steel wires are expected to keep the ospreys away from the towers.



Welcome to an artificial nest! Drawing on experience from 100 artificial nests, Pertti Koskimies built a new home for the ospreys.

MODERN JOINT CUSTODY

During the nesting period, the division of work between the male and female osprey is clear: the female hatches and takes care of the chicks while the male catches fish.

As there is shortage of good nesting locations, the ospreys have to fly longer distances to fish, and at best a bird may fly hundreds of kilometres in a day. In a single summer, an osprey male catches about 80 to 100 kilos of fish.

In August or so, the female is the first to leave the nest, a couple of weeks after the chicks have learned to fly. The male continues to take care of the offspring until September, when it also heads to West Africa. The younglings, which leave the nest last, use their inherent navigation ability to find their way to the wintering area on their own. The migration takes more than a month.

The young birds spend their second summer in the African heat and do not return to their birth places until the age of two. Then it is time to find a nesting place of one's own and also a spouse, which an osprey chooses for lifetime. Unlike for example swans, ospreys live with their partner during the nesting season only, while they spend the winters apart. An osprey can live with the same partner for up to 30 years.

Careful planning is the **foundation of system security**

Maintenance work and modifications in the transmission grid require planned transmission outages, which means that parts of the grid need to be disabled temporarily. Careful advance planning of outages ensures that the transmission grid can be operated in an as trouble-free and economically viable manner as possible. This benefits all parties of electricity trading.

Text by Arto Pahkin | **Photographs by** Valtteri Kantanen

Significant outages have been carried out in different parts of Fingrid's grid in 2012. The goal is to ensure system security during the outages by means of extraordinary switching arrangements or power plant arrangements. As a rule, system security has been retained, but there have also been exceptions, like the regional disturbance in Ostrobothnia in August. During the overhaul of the main transformer in Seinäjoki, there was a disturbance on the Kristiina–Tuovila 220 kilovolt transmission line. The disturbance caused a power failure of 9 minutes in the Vaasa region.

As the end of the year is approaching, planning for the next year is in full swing. In 2013, too, there will be maintenance and construction work in the transmission grid in many parts of Finland. Parts of the grid need to be deenergised temporarily because of this work. This poses challenges on securing electricity transmissions also on a regional level.

Outage needs to Fingrid by the end of January

In accordance with the main grid agreement, Fingrid must be informed of outage needs concerning Fingrid's grid by the end of January. The detailed schedule can become more precise later – the important thing is to get timely information on which part of the grid the outage concerns.

Outage planning is carried out in cooperation between the various parties so that the work can be performed safely. Moreover, system security analyses are used for ensuring the sufficient system security of the transmission grid. As far as Fingrid's grid is concerned, the outage needs are compiled well before the end of the year. When the customers communicate their outage needs by the end of January, the outage need plan encompassing the entire year is completed by the end of March. Customer-specific plans are then available from Fingrid's regional operation experts.

Fingrid has arranged regional meetings with network companies and electricity production companies in conjunction with the most challenging construction projects in the company's grid. These meetings will also be held in the future. ■

“It was worth the trouble!”

Comprehensive expansion work related to the EstLink 2 project is in progress at the Anttila substation in Porvoo. Thorough transmission outage planning has enabled uninterrupted electricity supply to the customers also during the critical steps in the work.

Text by Suvi Artti

The most critical stage at Anttila in terms of outage planning took place in October 2012, when the Tammisto–Kymi 400 kilovolt power line was rerouted to the substation. “The situation was particularly challenging, because the outage concerned so many parties. In addition to the 400 kilovolt line, all 110 kilovolt lines running under it also had to be de-energised,” says Fingrid’s Special Adviser **Antti Puuska**. The challenges were highlighted by the fact that one of the parties involved is the Kilpilahti industrial area, where interruptions in electricity supply would cause both significant economic losses and safety risks.

Saved by last-minute change

“The first proposal of how to rearrange the transmission lines came from the transmission line contractor in 2011. According to the proposal, Kilpilahti would have been left to rely on a single connection, between Porvoo and Pernoonkoski, for a few days. This proposal served as the basis of planning in the first meetings that we held with the representatives of Kilpilahti in early 2012 and in the summer,” Antti Puuska says. Then happened something that sometimes happens in transmission outage planning: as the h-hour was approaching, the parties stated that a different, more reliable solution had to be found.

“We had known from the outset that relying on a single connection is not a good option. The so-called (N-1) criterion is not met in such a case. This criterion means that if there is just a temporary disturbance in the only available connection, electricity supply is interrupted.” The original plan was finally found to be too risky. This was stated in the last meeting, just a week before the beginning of work. An alternative solution was found in co-operation with the transmission line contractor at the last moment: the work could be divided into two stages so that the Porvoo–Ruotsinkylä line could also be kept in use while the 110 kilovolt lines between Anttila and Kilpilahti were de-energised.

When the work had started on the morning of 1 October, Antti Puuska received a memorable telephone call. “**Arto Pahkin** from our Network Control Centre called and told me that there had been a disturbance on the Porvoo–Ahvenkoski line half an hour after the switching work had been carried out that morning. I was flabbergasted. It was really worth the trouble to re-prepare the outage plan. It was a small effort compared to the consequences that the likely tripping of Kilpilahti would have had.”

The reason of the transient disturbance has not been unveiled so far. One suspected reason was a flock of birds, which an inspector discovered on a tower adjacent to the assumed failure location. Disturbances are not commonplace: there have only been a few transient disturbances on the Porvoo–Ahvenkoski and Ahvenkoski–Pernoonkoski lines over the past 5 years.

Uninterrupted power supply is important

Jyrki Havukainen, Production Manager of Neste Oil, who represented the Kilpilahti industrial area in the outage planning process, commends Fingrid for keeping the customers up to date at the different stages of the planning process, starting from 2010 when the route of the line was being examined. “The positive thing was that after the first plan was found to be untenable, there was rapid response to the situation. The last-minute changes were really important.”

A total of 10 industrial companies work within the Kilpilahti area. Alongside Neste Oil, there are also other process industry enterprises that require uninterrupted electricity supply. “System security was kept at a good level all the time. As an example, the connection was restored at the end of the day’s work for the dark period. This minimised interruption risks,” Jyrki Havukainen says. ■

Antti Puuska (on the right) presenting to Neste Oil’s Jyrki Havukainen the expansion work conducted at the Anttila substation. This work is required to connect the EstLink 2 HVDC connection to the Finnish grid.

POWERED BY ELECTRICITY

In this column, writers share their experiences of appliances driven by an electric motor. **Kimmo Kyllönen** of Electricity Museum Elektra took Nissan Leaf electric car for a spin.

On a date with **an electric car**

Text by Kimmo Kyllönen | **Photographs by** Juhani Eskelinen

One of the upsides of working in a museum is that you get diverse assignments. I was offered an opportunity to get to know a fairly new all-electric car – Nissan Leaf. In fact, an electric car is not a new invention, since the first cars in the 19th century were driven by electricity. Even Grandma Duck drives a 1916 Detroit Electric.

Leaf is the first family-sized car with a price almost the same as that of a normal family car. The appearance of the car is not much different from the Japanese cars in the streets, and you would not know that Leaf is electric if it were not for the decals. The familiar control devices can be found inside the vehicle. Someone accustomed to automatic transmission is not much baffled by the lack of the clutch pedal or by the small gear stick with three positions. When Leaf starts from the on-off power button, however, what comes to life is a car from a whole new decade.

The displays behind the steering wheel and in the centre console indicate the charge level, remaining driving distance and a number of other details, too many to examine during a test drive of a couple of hours. The car does not have a single analogue meter, which is actually well in line with the image of a new-age full-electric car. The vehicle is equipped with modern and comprehensive accessories: rear view cameras, navigation apps and other basic goodies are there. In other words, money buys much more than just an electric motor and a huge battery set.

When the car starts, the charge level meter shows that the battery is full and that the estimated driving distance is 150 kilometres. The car slides smoothly from the parking facility at a full torque of 280 Nm. It does not matter that the car is silent; it actually feels pleasant.

Leaf is easy and agile in city driving. Thanks to massive torque, the car shoots from traffic lights with a slight depression of the accelerator pedal, and there is no fear of slowing down others at traffic lights. It is also nice to know that while the car is at a standstill, it does not consume any energy or emit emissions. More of these in the city and the air quality would improve anywhere!

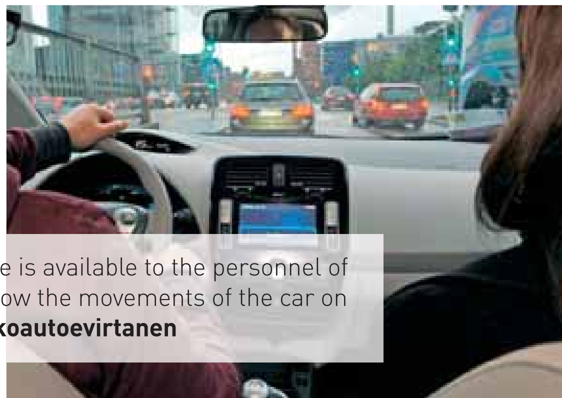
On access to a highway, it is also easy going, at the same speed as a robust Audi ahead. Acceleration is adequate and the feel of driving is more or less the same as in my own diesel car. In a rapid acceleration, the remaining driving distance plummets. 150 kilometres has changed to 120, and soon to less than 100. However, Leaf can recover the energy used in breaking, and the meter soon climbs up when driving at a small load.

One thing that disturbs a little is that the powered steering is overpowered. You can virtually spin the car around with your little finger, and you do not get any feel from the ground through the steering. This is alright in an urban setting, but at higher speeds I might long for some sort of touch to the road. On forest roads, the car would probably seem to steer the driver.

The distance travelled by me consisted of driving in Helsinki and on the ring roads with a speed limit of 100 km/h. The biggest problem was the range – doubling the driving distance to 300 kilometres would be sufficient for journeys a little farther. Battery technology is probably the biggest bottleneck in the development of electric cars these days.

It is very easy to recharge the car: just plug in the cord in the socket at home or in a charging device at a service station, and that's it. Moreover, the car is easy to control and pleasant to drive, so if you do not mind the numb yet sensitive steering, Leaf, with a longer battery life than now, could be a very interesting option. In its present configuration, it would be well suited as a second car in the family or for short driving mostly in urban areas.

For comparison, I made a small calculation: my own 1.6-litre diesel car consumes 3.6 litres per 100 kilometres if I drive really trying to save fuel, and about 4.5 litres per 100 kilometres in normal driving. The electric car performs the same distance with an electricity cost of around 2.50 euros, so at the current diesel prices, my Skoda Octavia is 2 to 2.5 times more expensive in terms of fuel cost. On an annual level, this would translate into a saving of approx. 1,000 to 1,500 euros if I drove 40,000 kilometres a year. The difference between the purchase prices of the cars would be covered in about 8 to 10 years at the present prices. In other words, an electric car would not be a lucrative purchase from an economic point of view. Of course, if the maintenance costs and car taxation were to come into play, the price difference would be levelled off sooner. ■



The electric car described in the article is available to the personnel of Finnish Energy Industries. You can follow the movements of the car on Facebook at **www.facebook.com/sahkoautoevirtanen**

Preparing for a major disturbance highlighted in the Power and District Heat Pool

The Power and District Heat Pool established between an agreement between Fingrid and the National Emergency Supply Agency heads the detailed preparations and contingency planning for energy production, transmission and distribution. In recent times, the pool work has highlighted the securing of the critical functions of society during long power cuts.

The Oil Pool and the Power and District Heat Pool have appointed a joint task force to examine how to improve preparations at service stations for long blackouts in the high-voltage grid and in distribution networks. The goal is that during a wide-spread power failure, specific service stations would take care of the refuelling of vehicles used by repair units in the relevant area and possibly also of provisioning services. Efforts would be made to distribute fuel from these stations to all customers.

The Power and District Heat Pool and the Water Pool have launched a project aiming at securing electricity supply to waterworks. The project will initially survey the situation in 2012. In conjunction with the meetings of the regional committees of the Power and District Heat Pool, there will be five co-operation meetings, with representatives of waterworks and electricity network companies summoned to the meetings. After this, the Water Pool will draw up guidelines and examples of best practices for securing electricity supply to waterworks.

GRID QUIZ

Competition to the readers of Fingrid Magazine

Answer the below questions and send your reply by fax (number +358 (0)30 395 5196) or mail to Fingrid no later than 31 January 2013. Address: Fingrid Oyj, PL 530, 00101 HELSINKI, FINLAND. Mark the envelope with "Verkkovisa". **You can also send your reply to Grid Quiz online. The link can be found on the home page of our website www.fingrid.fi.** Among all those who have given right answers, we will give five surprise gifts as prizes by drawing lots.

The answers to the questions can be found in the articles of this magazine.

1. What is the maximum output power of power plants as specified in the new specifications for the operational performance of power plants?
- 1,200 MW
- 1,650 MW
- 2,025 MW

2. The warehouse for Fingrid's fault repair towers is located in
- Lappeenranta
- Kouvola
- Heinola

3. The new Main Grid Control Centre will start full-scale operation at the beginning of
- December
- February
- April

4. Fingrid's new head office is located next to which railway station in Helsinki?
- Käpylä
- Oulunkylä
- Tapanila

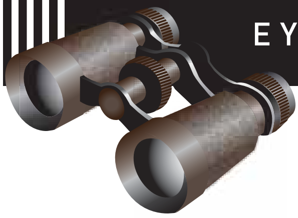
5. Of the network codes being prepared by ENTSO-E, which network codes are in the public consultation stage in November and December 2012?
- Operational Security Network Code
- Operational Planning and Scheduling
- Load Frequency Control and Reserves

6. After the osprey chicks have hatched, the first to leave the nest is the
- male
- female
- youngling

7. In accordance with the main grid agreement, Fingrid must be informed of outage needs concerning Fingrid's grid by the end of
- January
- February
- March

Winners of prizes of the Grid Quiz in the previous Fingrid magazine (2/2012): Esa Hagman, Helsinki; Harri Hakala, Helsinki; Kari-Juhani Kangasniemi, Hyvinkää; Mika Matikainen, Mikkeli; Arto Saari, Helsinki.

The late autumn is the time to calm down, but at the same time it represents the expectation of something new.



Autumn silence

November has already progressed far, and the house is quiet. Only the sand heaps near the walls give an indication of the inhabitants, which are sleeping in their nest under the house. I sit down in a corner. It was right here that I saw a badger – the present master of the abandoned house – a couple of months ago. It emerged on the mound in the evening twilight, stood there for a while and sniffed the scents of the early autumn. It retreated back to its cave, reappeared with a load of sand, and then went along its path into the darkness of the forest.

An entire clan of badgers inhabits the house and another nest located in the nearby forest. At best, a dozen or so badgers have been up and about: a large male, a couple of adult females, cubs born in the previous summer, and last summer's small cubs. There has been a lot of bustle in the evenings, and the paths leading to the cave have been trampled hard.

I push myself in through the door which is stuck ajar. The room is still furnished with a table and a couple of chairs, a few rag rugs on the floor, and other miscellaneous rummage. Everything is covered with dust, and sand, which the badgers have brought with them from under the floor. Especially the cubs used to move around indoors in the summer, but now they are in hibernation in their nest under the floorboards. They are in a deep sleep, their hearts beat at a sluggish pace, and their breathing is shallow. They have adjusted the flame of life to a minimum in order to save energy until spring.

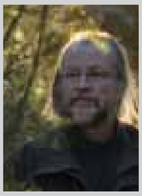
Perhaps their sleeping chamber is right beneath my feet. Maybe they are just a metre away from me. I like that thought, and I remain sitting on the chair. In my mind, I can see the whole clan, lying side by side on a bed padded with moss and hay. I can imagine the minute sounds and the subdued breathing that reveal that the animals are alive and breathe at their tranquil pace. The idea is so captivating that I would like to crawl under the house to watch them.

However, I confine myself to walking to the other nest, which is located a stone's throw away under some shrubs and large pine trees. A heap of dried brackens has been forgotten at the mouth of the nest. A winter bed has also been laid in this nest, and a part of the clan probably sleeps in the cave underground. The forest around the nest is like from a soothing painting. The autumn winds have ripped the brown leaves from the trees, and hoar frost which emerged in the hay at night has melted away. The colours are subtle, mainly conifer green and broken tones of brown. Further away, between the trees, is a red house.

Many hate November, the month of death. I like it, I like the idea that everything dies to be born again. The late autumn is the time to calm down, but at the same time it represents the expectation of something new. The grey days pass by slowly, the darkness comes earlier and earlier, until the two dark periods almost seem to touch each other, with only a brief glimpse of day between them. Then comes the first snow, which changes everything in one fell swoop. It illuminates and decorates the landscape, covers the traces of autumn, starts a new period in the great cycle.

For me, November is the time of silence and reflection. I think of the past year and ponder on the future. I make plans, most of which are forgotten or buried under new plans, but some idea always keeps on living and crystallises into action. The quiet days of the late autumn are made for this sort of contemplation. It is peaceful in the surroundings, and nothing much happens in the natural environment. You do not miss anything even if you just sit the whole day looking at the grey scenery.

I am fascinated by the gloom of the late autumn. The migratory birds have gone, the insects have disappeared into their hideaways. The plants have withered, and there are really no mushrooms any more, either. The crops ripened by summer have been harvested, but preparations for the new are already underway. The white-tailed deer spend their wedding, and a fertilised egg floats in the womb of female badgers. In the winter, while the female sleeps, the egg attaches to the uterine wall and continues to evolve, and soon after the female badger wakes up, she gives birth to new life. ■



Heikki Willamo, columnist of the Fingrid magazine, is a photographer, author and journalist from Karjalohja. He has published several nature books for both children and adults; most recently "Pyhät kuvat kalliossa" (together with Timo Miettinen, Otava 2007), "Huuhkajavuorella" (together with Leo Vuorinen, Maahenki 2008), "Viimeiset vieraat – elämää autiotaloissa" (together with Kai Fagerström and Risto Rasa, Maahenki 2010), and "Vuosi metsässä" (Maahenki 2012). Heikki Willamo's special objects of interest include forest nature in Southern Finland, Northern rock art, and myths related to animals.

Merry Christmas

and a Happy New Year

This year, we donate the sum reserved for Christmas greetings to the operations of Save the Children Finland.

NEW
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