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Fingrid Oyj 3/2011

# FINGRID

## TRANSMISSION GRID AND SYSTEM SECURITY

## In this issue




**FINGRID**
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Cover photograph: Touko 2011, the largest electricity disturbance exercise in Finland, tested the co-operation between electricity companies and society. Arto Pahkin, head of Fingrid's Network Control Centre, and Adviser Kati Koivunen studying the balancing of consumption and production during the restoration of the power system.
Photograph by Jonna Monola


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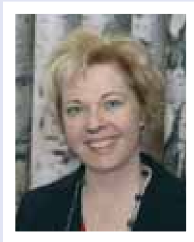


## ANTICIPATING COMMUNICATIONS

People are less tolerant of power cuts or at least more critical about them than before. There was a blackout of 10 minutes in the centre of Turku on a Saturday evening this autumn. Information on the disruption spread rapidly in online media. The teenage daughter of a friend of mine heard about the blackout immediately on Facebook.

Even though the fault was not in the nation-wide grid, Fingrid also received, due to incorrect initial news, inquiries from the media and feedback from the citizens concerning our website. The primary concern seemed to be how something like that can happen in this day and age, and why communications were not speedier.

Things like that may very well happen, and as regards the speed of communications, the information is on Facebook before the spokesperson of the energy company receives the message from the company's control centre.

In a society relying on electricity, even a short disruption quickly paralyses people's everyday activities. Even though our power system is very reliable and electricity companies aim to continuously improve their distribution systems, technical failures and human errors are possible, and electricity can be lost even in large areas.

People do understand that disturbances may occur, especially ones caused by weather conditions like storms, just as long as information about them is obtained swiftly. Social media has highlighted the demands for speedy communications. Energy companies face a challenge to keep abreast of the demands.

The basics of crisis communication hold true for power failures: information must be released transparently, quickly, and from the actual source. In a disturbance, there is an urgent need for information about the affected area, when power is restored, and about the cause of the blackout.

In a total blackout, communications would progress in stages. First, it would be vital to disseminate information on the blackout to the whole country. This would be followed by fulfilling the regional information needs, and when things are normal again, it would be time to find out what really happened and why, and how to prevent any similar events.

In a total blackout, the pressure from the media would be considerable. The telephones would be ringing around the clock. Even if there was no electricity in much of the country, news would still be made all the time. While information would be needed dearly, the modern communications channels would not work. How can you communicate when the Internet is down, radio and TV do not function fully, mobile phone services cease to operate when the batteries at the base stations become empty, e-mail is out etc.

However, you can make preparations for the worst case scenario in communications. We can draw up materials beforehand and prepare to communicate technical matters to the consumers understandably.

Above all, we must establish advance contacts with the media, authorities, and other key stakeholders. In a worst case scenario, we must know whom to inform quickly and which numbers to phone. We must have "hot lines" in place to the primary media such as the Finnish Broadcasting Company, which can inform citizens by radio. In all energy companies, we can make advance preparations by setting up information points for the media and consumers.

It is also important to caution people that a severe fault can happen, and how people can prepare themselves. This is the message that the energy industry was sending in the Touko 2011 exercise. Even though we cannot foresee accidents, it is possible to give advance information for some eventualities. We can warn people about the potential damage done by storms and communicate for instance difficult outages in advance.

Fortunately, long-term blackouts are rare, and most of them can be communicated on the websites of energy companies, by telephone, and through the media. And we should not forget social media: it is a good idea to communicate wherever people are present anyway. One reform is the disturbance site shared by all distribution companies, published on the website of the Finnish Energy Industries.

Electricity is a vital commodity for us all. This is why network companies must have a low threshold for communications about disturbances: the message will spread anyway.

Tiina Miettinen

Tiina Miettinen is Fingrid Oyj's Communications Manager.

# BACKGROUND OF TARIFF INCREASE

**Major investments and an increase in costs are reflected in the pricing of grid transmission.**

**Text by** Maria Hallila • **Photographs by** ManjaMedia and Juhani Eskelinen

The news about the 30 per cent increase in the grid tariffs, publicised in early September, did not come as a surprise to those who have been following Fingrid's messages earlier. For several years now, the company has been preparing its customers for a tariff increase "which will be a two-digit number". The underlying factors are Fingrid's capital investment programme, the biggest in its history, and an increase in market-based costs.

The price increase applied from the beginning of 2012 is the first step in a series of developments within which the grid fees will go up in stages in the coming years to a level of return allowed by the Energy Market Authority.

"The transmission fees levied by Fingrid in the past four years have been approx. 250 million euros less than the permitted level of return. However, the return not received earlier will not be levied retroactively in the new fees," says Fingrid's President **Jukka Ruusunen.**

### Financial matters at the core

Fingrid published the news about the tariff increases in its seminar on the transmission system, arranged for its customers in Helsinki on 7 September. This annual event has traditionally focused on presenting the construction and maintenance projects in the Finnish transmission system. Now the seminar concentrated on the financial conditions of the transmission business, with the tariff increases being based on these conditions.

Fingrid's capital expenditure in 2011 totals approx. 270 million euros.

**"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."**

There will also be considerable capital investments to strengthen the grid in the future: Fingrid is prepared to make capital investments of a total of 1,700 million euros in new transmission connections and reserve power plants in the next 10 years.

Ten years ago, at the beginning of the 21st century, the company's annual capital expenditure in the transmission grid was 40 to 50 million euros per year, so the capital investment

The reserve power plant constructed in Forssa is one of the foremost projects within Fingrid's capital expenditure programme. The construction costs of the plant due to be ready in August 2012 total over 110 million euros.

costs have roughly quadrupled on an annual level.

Fingrid's present construction programme encompasses almost 3,000 kilometres of transmission lines and 30 substations. The foremost projects comprise the submarine cable links to Sweden and Estonia, and the Forssa reserve power plant. In addition to the construction of new transmission connections, Fingrid will renew a number of old substations and transmission lines originally constructed as early as the 1920s.

"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. Customers' new electricity generation capacity must be connected to the grid. On the other hand, it is absolutely vital for society to ensure the secure supply of electricity and a well-functioning electricity market," Fingrid's President Jukka Ruusunen says in justifying the extensive construction programme.

### Costs on the increase

Alongside the sizeable capital investment programme, the market-based costs of the electricity transmission business are on the increase. Fingrid is responsible for maintaining a balance between electricity production and consumption, and this calls for a sufficient volume of reserves for both normal and disturbance situations.

"Fingrid's grid revenue in 2011 totals approx. 220 million euros. The annual reserve power costs and reserve costs are at present about 30 million euros, but they will go up to approx. 50 million euros. The costs resulting from the electricity transmission losses are increasing in the coming years by 10 million euros to around 70 million euros. In addition, the company's financial costs are expected to rise by about 20 million euros per year," Jukka Ruusunen lists the costs.

### Pricing structure retained

The new contract period for the grid service is four years like before, but the unit prices will be reviewed annually, with the prices for the following year to be published in the early autumn. Jukka Ruusunen says that the tariff increase programme focuses on the early years. The increase percentage in the first year is the highest, while smaller price increases can be applied in the subsequent years.


Tapani Liuhala (on the far right), Chairman of Fingrid's Advisory Committee, commented on the tariff increase news after the speech of Fingrid's President Jukka Ruusunen (on the left). Risto Harjanne, Managing Director of Helen Sähköverkko Oy, also discussed the theme of the day.

The structure of the grid tariff remains unchanged for the most part. Even though the payment portion of electricity production rises somewhat, the tariff is mostly based on consumption. There will not be essential changes to the mutual relationship of the fees for input into the grid and output from the grid as well as consumption fees during the four-year contract period.

According to Jukka Ruusunen, Fingrid's grid fees are low on a European scale even after the tariff increase, and Fingrid also intends to preserve price competitiveness by means of the cost efficiency of the operations.

"There are extensive ongoing grid construction projects by many other European transmission system operators, too; as an example, the grid tariffs were raised by dozens of per cents in the other Nordic countries a few years ago," Jukka Ruusunen states.

To back up his words, he presents a graph of the trend in Fingrid's grid tariff during the entire history of the company (1998 to 2012). According to the graph, the price increase to be introduced at the beginning of 2012 will actually bring the real tariff to the same level at which it was in Fingrid's early years.

When referring to the future trend of the tariff, Jukka Ruusunen stresses the importance of good risk management. "It brings predictability to the tariff. However, you cannot eliminate all uncertainty," he points out.

### More efficiency

The customers' perspective to the tariff increase was presented in the seminar by **Tapani Liuhala**, Chairman of Fingrid's Advisory Committee.

"The price change is huge. We can only accept it in the event that Fingrid's operational efficiency continues to improve. There is always room for improvement," Tapani Liuhala commented.

He also emphasised the importance of security of supply; it must meet the customers' requirements.

In commenting on Fingrid's decision to bring the financial return of its operations to the level permitted by the Energy Market Authority, Tapani Liuhala stated that the Finnish regulatory system provides a good example for the rest of Europe.

"It is acceptable to work within the framework of regulation also in terms of pricing, even though it seems a little bitter," he stated.

According to Tapani Liuhala, Finland is facing great challenges in the maintenance of the basic infrastructure.

"The decisions made last year concerning an increase in the baseload production capacity of electricity will also require capital investments in the electricity transmission system. The power system is to an increasing degree a pan-European system, which also necessitates the construction of physical connections."

According to a recent piece of news publicised in the day of the seminar, Finland came in the fourth place in the global competitiveness ranking. Still, Tapani Liuhala pointed out that Finland is in a tough competitive situation.

"The basic infrastructure related to energy is in a key role in terms of competitiveness. It must be in order," said the Chairman of Fingrid's Advisory Committee. ■

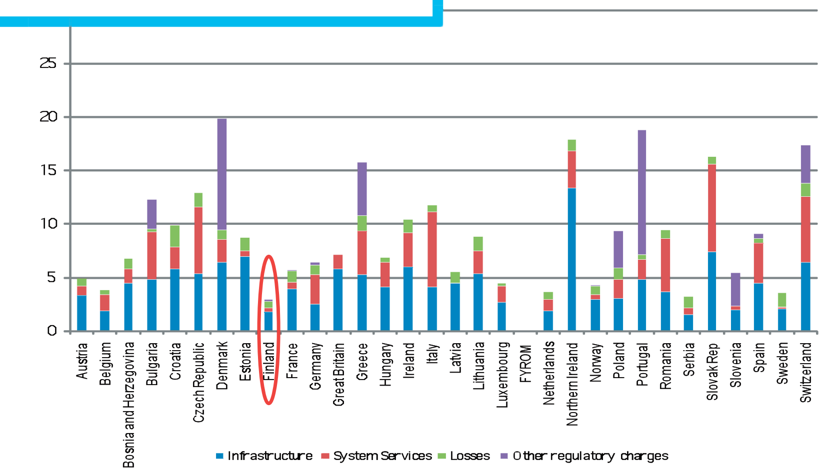
The news about the tariff increases did not come as a surprise to the audience of Fingrid's transmission seminar. The seminar was attended by about 150 guests representing Fingrid's customers and partners.

## Grid pricing in 2012

The average increase in grid pricing in 2012 is 30%

| Unit prices €/MWh | 2011 | 2012 |
|---|---|---|
| Consumption fee, winter period | 2.52 | 3.48 |
| Consumption fee, other times | 1.26 | 1.74 |
| Output from grid | 0.72 | 0.8 |
| Input into grid | 0.3 | 0.5 |

The connection point fee will be abolished from 2012




## Grid tariffs in the ENTSO area in 2011

# **Grid service** at increasingly unambiguous terms

**The new grid contract period commencing at the beginning of 2012 will bring tariff changes and also reforms to the terms of service. The reforms specify and simplify the service structure and the contract practices. The extent and definition of the main grid is also under contemplation.**

**Text by** Pertti Kuronen • **Photographs by** Juhani Eskelinen

The grid contract period of 2008 to 2011 is drawing to an end. When the previous grid contracts were being drawn up in 2007, not many could predict the recession which hit the world in the next year. However, the world recovered from the recession quicker than anticipated, and 2012 will show in what kind of an economic situation we are ending up this time.

Fingrid's grid contract for 2012 to 2015 will also cover the previously separate reactive power agreement, reserve agreement for reactive power, and the agreement for real-time information exchange. Moreover, the transmission service for the Russian interconnections will be separated into an agreement of its own.

The actual grid pricing continues to be based on the energy volume, and the fixed connection point fee (1,000 €/month) will be abandoned. One major change is that the unit prices will be confirmed annually in September. In this way, the outlook for the next year is clearer, and the amount of the tariff can be specified in more detail, avoiding forecasting risks and their impact on the pricing. The text of the contract has been specified in many places so as to improve clarity and comprehensibility.

The pricing structure of the transmission service on the Russian interconnections was clarified so that the pricing was divided into three components:

- ITC/perimeter fee
- costs of the transmission lines crossing the border between Finland and Russia; these are allocated directly to electricity transmission taking place across the border
- portion of cross-border transmission of the costs of the rest of the Finnish grid.

The ITC/perimeter fee is levied on electricity transmission on the external borders of the EU. The fee accepted by the Commission of the EU compensates costs caused by the transit transmission of electricity through countries. The fee charged on the connections between Russia and Finland is transferred directly to ENTSO-E's fund.

### Towards simplified connection procedure

The procedure for new connections to the main grid will be simplified so that after the payment of the connection fee, the connecting party is not subject to any annual fees. The new connection fee would cover the improvements and renewal of the connecting bay. In this sense, the procedure is quite similar to that in distribution networks. In other respects, the rights and obligations specified in the connection agreement remain unchanged.

The present agreements remain in force as far as the old connections are concerned. With these, the new procedure will be adopted as agreements are renewed with the customers.

## Continued co-operation

"Fingrid's co-operation with its customers continues to be close. The world around us is changing, which is why both the electricity transmission networks and the electricity market are being enhanced. In order to ensure the flow of information and hearing the customers' needs and views, Fingrid continues active and comprehensive interaction with its customers in many forums," says **Pertti Kuronen**, Fingrid's Senior Vice President responsible for grid service.

The company's Grid Committee, Operations Committee and Market Committee have attained an established status as significant development platforms. The company's Advisory Committee serves as a two-way information channel and consultation forum between Fingrid and all its customers.

The specification of the connection fee has been based on the customer's need. In other words, if the main grid needs to be provided with solutions heavier than what the customer needs, these are covered by the grid tariff. In the case of connection to a substation, this means smaller connection costs than at present, which encourages a connection to a substation. This method of connection provides the best system security both in terms of the customer and the main grid.

The pricing of transmission line connections caused most discussion and feedback in terms of the new connection fee approach. The price of transmission line connections would be considerably higher than earlier. In a transmission line connection, a transmission line of the nation-wide grid serves as part of a customer's connecting line, using some of the transmission capacity of the transmission line of the main grid.

A transmission line connection to the main grid is calculated on the basis of a power of 25 megavolt amperes (MVA), which is the highest power that can be connected to a transmission line. The goal of this connecting power step of 25 MVA is to first utilise the existing connections and new connections in full so that transmission line connections, which impair the availability of the relevant transmission line, could be minimised. Such connections are not allowed at all in many countries.

In accordance with the general terms of connection, an electricity production plant of a maximum of 5 MVA can be connected to a transmission line. However, wind power which does not feed a significant short-circuit current is paralleled with consumption, and in that case the maximum power connected to a transmission line is 25 MVA. This facilitates the connection of relatively small wind farms to the grid.

The handling of the new connection principle will continue with the Energy Market Authority. The objective is to introduce the new practice from the beginning of or early 2012.

### Specified scope of transmission grid

The new electricity market directive entered into force at the beginning of March 2011. The extent of the Finnish main grid and its expansion principles have also been discussed in conjunction with the preparation of the Finnish Electricity Market Act to be amended on the basis of the directive. The criteria that ultimately define the extent of the grid will be determined in line with the new Electricity Market Act in 2012.

Fingrid originally intended to carry out the potential definition verifications of the main grid, required by the changes that have taken place in the structure of the grid, prior to

the beginning of the new grid contract period. In accordance with the present schedule, the definition and extent of the main grid, the related negotiations, and the agreements on individual measures with the customers can be completed at the earliest by the end of next year, when the new Electricity Market Act will take effect. A specific task force, called SIMA, has prepared the introduction of the single electricity market directive in Finland. Its report suggests that there would not be significant changes to the present main grid.

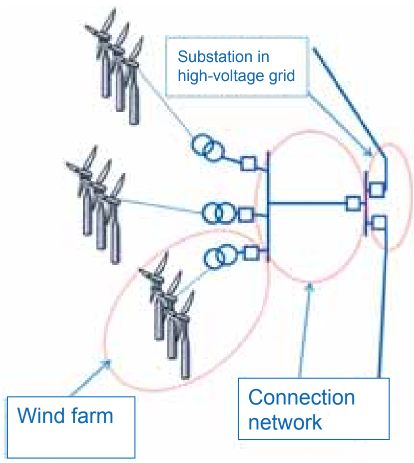
In line with the evolution of the grid, the intended use of some parts of the grid has changed or is changing. This primarily means that some transmission lines have shifted over to radial operation so that they no longer serve the purpose of the main grid, and their costs can hence no longer be covered through the grid tariff.

Such parts of the grid will primarily be offered to be acquired by the party or parties using them. If the acquisition is not possible for some reason, one temporary solution could be that the part of the grid in question is converted into a connection network. The parties connecting to such a network pay the network-specific costs as an annual fee. The costs consist of the capital, operation, maintenance and losses of the network. A connection network agreement is signed for the same period of time as the actual grid contract.

There can also be developments the other way around: if a part of a regional or distribution network meets the criteria of the nation-wide grid, Fingrid is ready to buy the relevant parts of the network on the same principles.

The Electricity Market Authority has pointed out that the network acquisitions must take place on a voluntary basis.■

## Connection network




## Pricing of transmission service for Russian interconnections

### Unit prices and pricing structure of transmission service for Russian interconnections in 2012

| 400 kV connections | | 110 kV private connections | |
|---|---|---|---|
| - Cross-border fee | **0.5 €/MWh** | - Cross-border fee | **-** |
| - Main grid service fee | **2.0 €/MWh** | - Main grid service fee | **2.0 €/MWh** |
| - ITC/perimeter fee | **0.8 €/MWh*** | - ITC/perimeter fee | **0.8 €/MWh*** |

* The price of the ITC/perimeter fee for 2012 has not been confirmed yet by ENTSO-E

KNOW THE TERMS

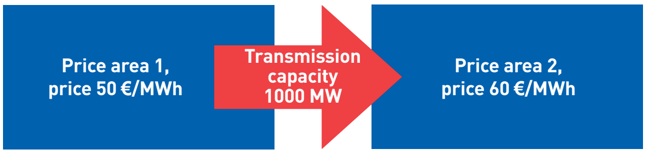
This column presents and defines terminology in the electricity transmission business.

# Congestions and congestion income

Electricity moves in the Nordic electricity market at market terms. For the sake of economic efficiency, it is sensible to produce electricity wherever it is cheapest, and transmit the electricity from there to areas of more expensive production. In this way, the goal is to cover consumption primarily by electricity with lower production costs.

**However, it is not always possible** to produce all electricity for a certain market area in a region with cheaper production. Congestions are created in an electricity transmission grid in places where the transmission capacity of the grid is not sufficient to respond to the needs of the market. As an example, there were quite a few situations between Finland and Sweden this autumn, where the price difference of electricity between the two countries was so great that the Finnish players would have liked to buy considerably more electricity from Sweden than what the cross-border transmission lines were able to transmit. This constitutes a congestion in the transmission grid. A congestion can naturally occur in any part of the grid, but on cross-border lines the impacts of a congestion are clearly reflected in the market as price differences.

**The Nordic electricity market** applies a mechanism, according to which congestion income is created in a congestion situation. In the situation depicted in the picture, there is transmission capacity between the two bidding areas, but the capacity has not been sufficient to level out the price differences, as a result of which the bidding areas have segregated into price areas of their own. In this case, a consumer in area 2 buys electricity at a price of 60 euros per megawatt hour (€/MWh), and a producer operating in that area sells electricity at that price. Correspondingly, a consumer and producer in area 1 apply a price of 50 €/MWh to the electricity. However, in the hour in question, 1,000 MWh of electricity has moved from area 1 to area 2, and the producer in area 1 has obtained a price of 50 €/MWh for the electricity, and the consumer in area 2 has paid 60 €/MWh for it. In such a situation, the difference (60 €/MWh – 50 €/MWh) x 1,000 MWh = 10,000 € remains with the electricity exchange, which pays it further to the owner(s) of the transmission connection between the areas.




**However, the transmission system operators** cannot use the accumulated congestion income as they please, but, according to European legislation, congestion income must primarily be used for increasing the transmission capacity, in other words in transmission system investments or counter trade, and secondarily, for a justified reason, for reducing the grid tariff.

The enclosed table shows how Fingrid's congestion income has accrued on an annual level, and what the income has been used for. The total costs of projects have been summed up for the year of completion of the project, which is why the costs of the Fenno-Skan 2 link between Finland and Sweden, to be completed this year, are not yet reflected in the table. The table can also be found at Fingrid's website at www.fingrid.fi/portal/in_english/electricity_market/market_integration/

**Text by** Katja Lipponen

| | Congestion income used for lowering the grid tariffs | Congestion income reserved for developing the grid | Investments in increasing the transmission capacity between Finland and Sweden | Congestion income "funds" reserved for developing the grid, cumulative |
|---|---|---|---|---|
| | **million €** | **million €** | **million €** | **million €** |
| 1998 | 0 | 1.1 | 0.1 | 1.0 |
| 1999 | 0 | 2.3 | | 3.3 |
| 2000 | 8.1 | 9.7 | | 13.0 |
| 2001 | 0 | 3.7 | 15.3 | 1.4 |
| 2002 | 2.9 | 13.7 | | 15.1 |
| 2003 | 0 | 14.6 | 1.5 | 28.2 |
| 2004 | 0 | 7.9 | 8.7 | 27.4 |
| 2005 | 0 | 15.4 | | 42.8 |
| 2006 | 0 | 13.1 | | 55.9 |
| 2007 | 0 | 21.3 | 3.3 | 73.9 |
| 2008 | 0 | 23.2 | 10.7 | 86.4 |
| 2009 | 0 | 4.9 | 37.9 | 53.4 |
| 2010 | 0 | 9.0 | | 62.4 |
| 2011 | | | | |
| **Total** | 11.0 | 139.9 | 77.5 | |

Riku Huttunen believes that the incentives devised by the Energy Market Authority will encourage electricity companies to modernise their distribution networks.

So that there would be sufficient electricity

# Energy Market Authority monitors, supervises and controls

**The Energy Market Authority together with the various parties involved in the energy sector follows the demand and supply of electricity in Finland. The Authority has an important role in matters pertaining to the supply security of electricity.**

**Text by** Maarit Kauniskangas • **Photograph by** Juhani Eskelinen

"One of our duties is to follow the electricity generation capacity so that there is sufficient electricity production at all times," says **Riku Huttunen**, who started as the Director General of the Energy Market Authority in August. His background in the energy industry consists of a career of several years at the Ministry of Employment and the Economy and prior to that at Finland's permanent representation to the EU in Brussels.

According to Riku Huttunen, the electricity supply situation in Finland is now stable. The demand for electricity has not increased much. The next significant change in electricity production will be the completion of the Olkiluoto 3 nuclear power unit within the next 3 years.

Peak load capacity will be needed for the peak demand situations of the winter. Fingrid has 600 megawatts of peak load capacity for these situations, and the competitive tendering of the relevant plants belongs to the domain of the Energy Market Authority.

## Supervisor of distribution networks

Another duty of the Energy Market Authority related to supply security and system security is to supervise the electricity network business. This means that the Authority determines the permitted level of return of network operators in relation to their equity and capital investments made. In other words, the Energy Market Authority supervises the reasonableness of the pricing of network operators.

Electricity transmission and distribution are natural monopolies, because there would be no sense in building parallel networks which would compete with each other.

The quality of electricity distribution involves a quality incentive used in the supervision model of the Energy Market Authority. This incentive is being expanded. Earlier, distribution network operators were subject to a maximum reduction of 10 per cent per year from the reasonable return calculated for a network operator if there were interruptions in electricity distribution. The maximum sanction will now be raised to 20 per cent for the period of 2012 to 2015. Correspondingly, the bonus for a good quality of supply security will rise to a maximum of 20 per cent from the earlier 10 per cent.

In addition to the quality incentive, the Energy Market Authority has also introduced an innovation incentive so that network operators would promote innovative technical and functional solutions. Another objective is to support the development of smarter electricity networks.

The incentive model has also been criticised in that it punishes network companies even in situations where they have been subject to the forces of nature. As an example, there were extraordinarily fierce storms in 2010, raising the interruption costs over 10 times as high as in an average year.

"The effect of the incentive will level out. When network operators replace their old networks, they receive an incentive bonus, which will help the operators to collect a reasonable return on their business," Riku Huttunen points out. In fact, the incentives should encourage the renewal of distribution networks, since many distribution networks are about 50 years of age and really in need of renewal.

## Regulators in Europe

While working at Finland's permanent representation to the EU in Brussels from 2000 to 2004, Riku Huttunen augmented his experience of the co-operation between the various players in the energy industry in Europe. Now he serves as the representative of Finland in the Board of Regulators of ACER, the Agency for the Cooperation of Energy Regulators in the EU.

"In ACER's decision-making process, each of the 27 member states of the European Union has one vote. In other words, the mighty Germany has a single vote just like the small Malta," Riku Huttunen explains.

The EU's third legislative package on the internal electricity market came into force in March. It is closely associated with the system security of electricity networks in Europe. All the issues covered by the package have not yet been transferred to national legislation in Finland.

"It is not the intention to create a supranational European regulator for a long time to come. The reason for this is that we have a different kind of a national regulator in each European country, especially if we talk about network supervision. Even the Swedish authority operates under a different logic than we in Finland," Riku Huttunen says.

ACER therefore focuses on cross-border projects. In the long term, it may also pay attention to the functioning and transparency of the network control models. After all, the parties to be supervised are also highly different from each other. For example, the transmission grid in France is in national ownership, while in Germany there are several high-voltage grids.

The third legislative package gave the Commission of the European Union authorities to re-align the norms. So, the Commission can take an initiative, on the basis of which ACER draws up framework guidelines for network codes. The codes, in turn, are drawn up by ENTSO-E, the European Network of Transmission System Operators for Electricity. The network codes created as a result of co-operation between ACER and ENTSO are returned for approval to the Commission of the EU. According to Riku Huttunen, the purpose is not to increase bureaucracy in the work of distribution networks, since the national regulators supervise their network operators directly.

"The more unified the opinions of us Finns are in ACER, ENTSO-E and in the committees of the Commission, the stronger the influence that we can make on the European rules. The Nordic countries have generally also had rather convergent positions, which explains the progress of the Nordic electricity market."

It has already been predicted that the following winter will be very cold. Riku Huttunen points out that in the winter, when there is not too much electricity, national self-interests come to the surface. The Nordic countries are very different from each other in terms of their electricity production architecture, which has also been an asset in the common electricity market. The single electricity market area is spreading to Western Continental Europe, and there will be more transmission connections. Congestions in electricity transmission will become a problem.

"This is a European problem. It may be particularly difficult to strengthen the connections between high-voltage transmission systems in different countries. Who will pay for the capital investments, if the companies or citizens in the country in question do not benefit from the strengthening of connections. There is real demand for European co-operation." ■

# Will there be sufficient electricity for all in the cold winter weather?

Before the coming winter, the sufficiency of electricity in peak demand situations has been contemplated again. The past winter was very cold, and the hourly electricity consumption went up to 14,900 megawatts on 18 February. In other words, electricity consumption had returned to the record figures of 2007 after the decline a couple of years ago.

As a result of the precarious economic situation, the increase in electricity consumption appears to have ceased again, and therefore the peak consumption in the coming winter is expected to remain at the same level as this year. The volume of domestic production capacity is also at the same level as last winter. The available domestic power plant capacity totals 13,300 megawatts.

**The shutdown of German** nuclear power plants as a result of the Fukushima nuclear accident reduced the electricity production capacity in Continental Europe. Despite this, there is enough electricity for the Germans, unless an exceptionally cold weather spreads over a wide area in Europe. However, the reduced nuclear power capacity causes many types of problems in the European high-voltage transmission system, since replacing electricity needs to be transmitted over longer distances. Diminished supply may have implications on the price of electricity, and in difficult system operation situations there may be less electricity available for exports to the Nordic countries.

**The completion of the Fenno-Skan** 2 submarine cable before the beginning of 2012 will increase the transmission capacity between Finland and Sweden by 800 megawatts. The division of Sweden into bidding areas, in turn, will change the situation so that the market price of electricity guides electricity more accurately to wherever it is needed the most. A procedure where the Swedes prevent exports of electricity from Southern Sweden in order to control transmissions within Sweden is no longer possible. It can be expected that in peak load situations, there is more electricity available from Southern Sweden to Finland via the Fenno-Skan submarine cables than in the past.

**Finland continues** to be dependent on electricity imports. Electricity is obtained from Sweden, Russia and Estonia to cover the deficit. A capacity of 600 megawatts, which secures the sufficiency of electricity in Finland by virtue of the new peak load capacity act, will be in a starting readiness of 12 hours from the beginning of December until the end of February. The relevant power plants (Inkoo, Vaskiluoto, Kristiina) will start either in situations prompted by the electricity exchange when the purchase and sales bids do not meet each other or in the event of a threat of power shortage at the request of Fingrid's Power System Control Centre.

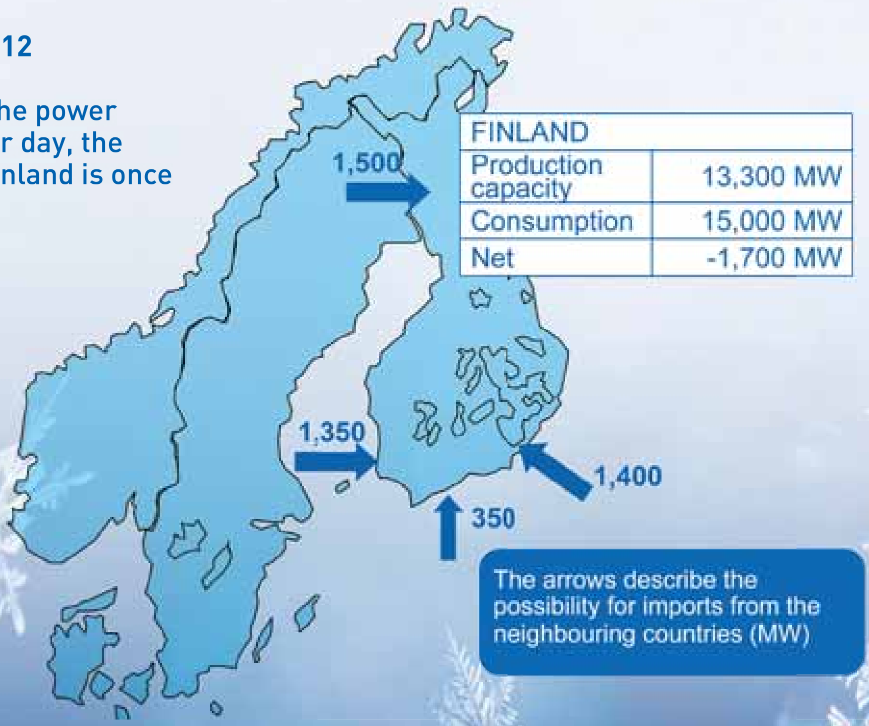
**If, despite the precautions,** it appears that Finland would run out of electricity, Fingrid will start its own and contracted reserve power plants, which provide a total of approximately 800 megawatts for serious disturbance situations.

Finland continues to be highly dependent on imported electricity, but the risk of electricity running out in the cold winter weather is very small.

**Text by** Reima Päivinen

**Power balance 2011/2012**

**The forecast indicates the power situation in a cold winter day, the likelihood of which in Finland is once in 10 years.**




| FINLAND | |
|---|---|
| Production capacity | 13,300 MW |
| Consumption | 15,000 MW |
| Net | -1,700 MW |

# The new balance service agreement will be valid until further notice

**The present one-year balance service agreements between Fingrid and the balance responsible parties draw to a close at the end of 2011. From 2012, the agreements will be valid until further notice.**

Fingrid launched the planning of the balance service agreement for 2012 in the first half of 2011. The agreement project has progressed so that the needs for changes were surveyed by August 2011, and the draft agreement with its appendices was sent to the balance responsible parties for comments at the end of August. The iteration stage of the agreement was launched on the basis of the feedback and comments thus received, after which the agreement with its appendices was sent to the Energy Market Authority for confirmation at the end of September.

The most significant change in the new contract as compared to the present one is that from the beginning of 2012, the agreement will be valid until further notice. The reason for the change is the project headed by the Nordic regulators concerning the inter-Nordic retail market for electricity, and the ongoing co-operation project between Fingrid, Statnett and Svenska Kraftnät on the harmonisation of their balance services. An agreement which is valid until further notice allows for better control of changes as the said harmonisation issues progress and become effective.

The new balance service agreement encompasses the actual agreement and its appendices: Application instruction (Appendix 1), Fee components and their determination, unit prices, terms of payment, and taxes (Appendix 2), and Guarantees (Appendix 3).

In November, Fingrid will begin the signing of the agreement with the balance responsible parties. The agreements and their guarantees must be completed by mid-December.

# New peak load capacity arrangement launched

**The new Finnish act on the peak load capacity which secures a balance between electricity production and consumption entered into force on 1 March 2011. The application of the act commenced at the beginning of October. Finextra has signed agreements with the owners of the power plants used for the peak load capacity arrangement.**

The Energy Market Authority has arranged competitive bidding and confirmed the power plants selected for the peak load capacity arrangement for the period of 1 October 2011 to 30 June 2013. The arrangement covers the following power plants: Inkoo 3 owned by Fortum Power and Heat Oy, Vaskiluoto 3 owned by PVO-Huippuvoima Oy and Kristiina 1 owned by PVO-Lämpövoima Oy. The total capacity of the power plants is 600 MW.

In accordance with the act on the peak load capacity, the power plants will be in a starting readiness of a maximum of 12 hours in the winter period of 1 December to 28 February, and in a starting readiness of a maximum of one month at other times.

The costs of the peak load capacity arrangement will be approx. 18 to 19 million euros per year in this period.

Fingrid has delegated the administration of the peak load capacity to its fully-owned subsidiary Finextra. The peak load capacity is funded by means of a fee based on electricity consumption, levied from the grid customers in retrospect in three-month periods. Finextra has signed the payment agreements for the peak load capacity with the grid customers.

Kristiina 1 power plant is one of the three peak load capacity plants.

# Customer:
# society as a whole

**Fingrid's unit attending to system operation planning takes care of a major responsibility in the Finnish society. "Much of our work is to secure the proper functioning of society," says Senior Adviser Minna Laasonen. Development projects providing contingencies for future system security challenges have a major role in her job description.**

**Text by** Maria Hallila • **Photograph by** Juhani Eskelinen

There is much to study and develop in the energy sector. The EU's climate and environmental objectives together with the energy savings and efficiency requirements which have increased in line with these objectives give rise to a continuous array of innovation projects, whose results are also reflected in the way the Finnish electricity transmission system is operated.

Fingrid wishes to be actively and comprehensively involved in the related development work and in building the future. Minna Laasonen's present duties involve three R&D projects.

## Security above all

About a year ago, an interest in technical challenges made Minna Laasonen change her previous mainly administrative duties of a technology manager in Fingrid's R&D Unit to the career of a senior adviser involved in the operation of the Finnish transmission system.

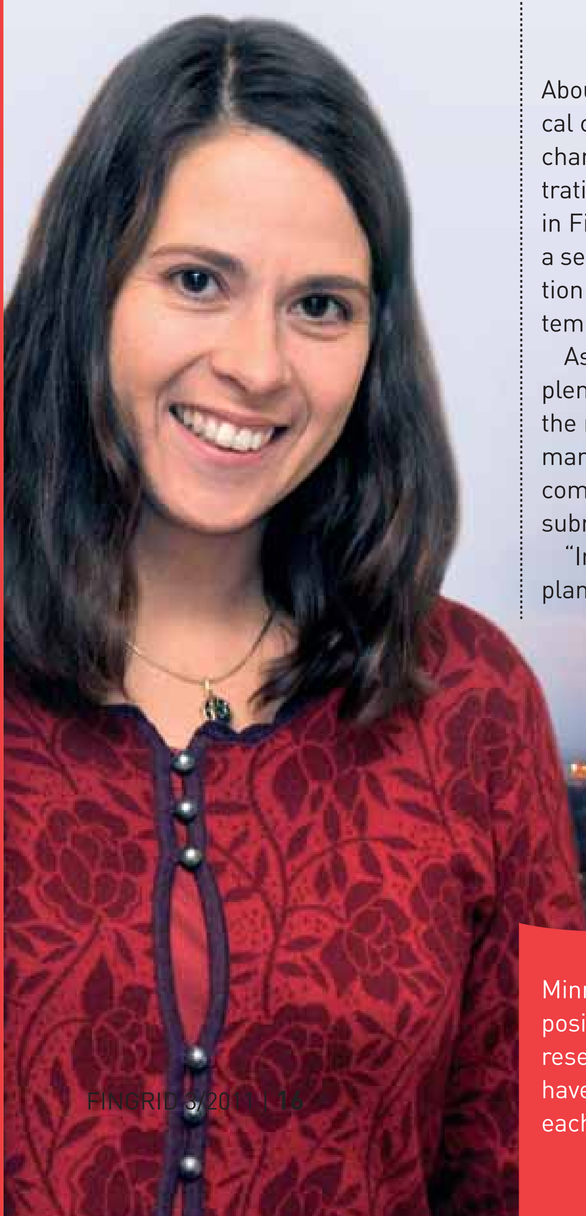
As a matter of fact, there have been plenty of challenging assignments in the new position; one of the most demanding of these was the successful commissioning of the Fenno-Skan 2 submarine cable link this autumn.

"In general terms, system operation planning has become increasingly demanding as a result of Fingrid's extensive ongoing construction programme. It is more and more challenging to guarantee system security when some part of the grid is being worked on all the time," Minna Laasonen describes the changes.

The Finnish electricity transmission system is operated so that it is prepared to withstand a single serious fault at all times. Such a fault could be caused, for example, by the unexpected stoppage of the largest nuclear power unit in Finland. And in 15 minutes after the first failure, the grid must be prepared for a disturbance caused by another potential fault.

The role of Fingrid's system operation planning is to make plans and preparations for various system operation situations and in this way facilitate the work of the Power System Control Centre.

"The transmission limits are reviewed whenever changes take place in the grid, for example because of the construction of a new line or due



Minna Laasonen has worked in many positions within Fingrid. However, research and development projects have been a crucial component of each job description of hers.

to maintenance work. The operators at the Power System Control Centre have good tools for monitoring the transmission situation and also a feel of the potential risks and abnormalities involved in a certain situation."

### Reserves weighed

Reducing the risk of a large-scale blackout is a crucial starting point also in an inter-Nordic development project, in which Minna Laasonen became involved as soon as she started in system operation planning. The objective is to determine the technical requirements and sufficiency of frequency controlled reserves in the Nordic transmission system.

**"System operation planning has become increasingly demanding as a result of Fingrid's extensive ongoing construction programme."**

The task force consisting of experts of transmission system operators in Finland, Sweden, Denmark and Norway completed its first report last summer. In the future, there will also be focus on the market impacts of the reserve system alongside its technical issues.

The development project was launched, because it is currently more and more common that the actual frequency of the Nordic power system is above or below the normal frequency range of 49.9 to 50.1 hertz.

"Frequency stability has deteriorated significantly since 1995, and in recent years the number of minutes exceeding the normal range has grown especially much. This increases the risk of a total blackout, among other things," Minna Laasonen says.

She says that one explanation for the frequency problems is the present way in which the market works. "The changes in electricity production and imports at the change of hours are reflected in frequency variations. However, they do not explain the cases of excess frequency in all respects; the problem still calls for further analysis."

### Winds of change

According to the report of the Nordic task force, the technical requirements of the present frequency controlled reserves may be changed. It is likely that the volumes of the various reserve types will also change.

"It may be that we will also see a completely new frequency controlled reserve type in the next few years," Minna Laasonen says.

The new LFC reserve (Load Frequency Control) would be a little slower than the present frequency controlled reserves, and it would be carried out by means of a central controller. The task force studying the more detailed technical requirements and commissioning of the new reserve type started its work in October.

A couple of other recently established task forces are also working on reserve issues. They examine the market-based procurement of the reserves and the financing of reserve costs, and frequency variation in the system at a cycle time of 30 to 60 seconds. According to Minna Laasonen, the development of a procurement model for cost-effective reserves calls for close co-operation. This is why the producers of reserves have been approached this autumn so as to survey the available volume, type and procurement terms of the reserves.

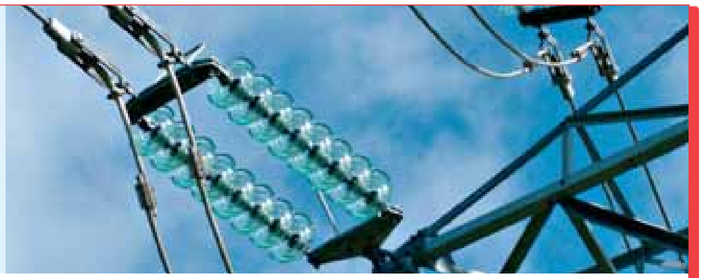
### Cutting edge expertise

The key question in Fingrid's R&D is how the latest technology and expertise can contribute to the company's established transmission reliability of 99.9998 per cent also in the future. A couple of potential responses can be found in the development projects on which Minna Laasonen is working.

One of the research projects has focused on examining the use of a battery-based energy reserve as a frequency controlled reserve.

According to Minna Laasonen, in

## The inter-Nordic system determines the need for reserves



In a power system, there must be a constant balance between electricity production and consumption. This is why there is a need for controllable electricity capacity, which is activated by changes in the frequency of the grid. This capacity is referred to as frequency controlled reserves. The Nordic transmission system operators have agreed on the reserves needed in the power system and on their allocation into country-specific reserve requirements.

**The frequency controlled normal operation reserve** controls electricity production continuously to conform to consumption within a frequency range of 49.9 to 50.1 hertz (Hz). This reserve is activated as soon as the frequency changes; in 2 to 3 minutes it has activated in full.

The reserve obligation for Finland (139 megawatts in 2011) is covered mainly by domestic hydropower and by electricity imported on the Vyborg direct current link from Russia and Estlink 1 from Estonia.

**The frequency controlled disturbance reserve** begins to activate when the frequency goes below 49.9 Hz. The full reserve must activate within 30 seconds.

The country-specific disturbance reserve obligation is determined at prescribed intervals between the Nordic transmission system operators on the basis of the largest individual fault (usually the largest power plant connected to the grid).

The Finnish obligation normally ranges between 220 and 240 megawatts. This is mostly procured from domestic power plants and from disconnectable industrial loads, which trip from the grid by virtue of a relevant agreement if the frequency goes below a certain limit.

the scale of the high-voltage grid in Finland, the size of a usable energy battery would correspond to a small single-family house. Experiences of the relevant applications have been obtained elsewhere in the world.

"The technology is there, but the key question is cost. So far, the price level is high as compared to the benefits derived from an energy reserve. The situation may balance in the future, if the technology becomes more common and if the price level comes down, and on the other hand also if there are more benefits to be achieved."

A battery reserve could be implemented in a swift schedule, even within a couple of years.

Fingrid also considers that demand response of small-scale consumption is a potential new reserve source worth examining. The project launched under Helsingin Energia studies the opportunities of intelligent technology in the energy solutions of modern housing. The partners in the project also comprise ABB, Nokia Siemens Networks and Mitox.

"The planning of the residential area of 20,000 people at Kalasatama in Helsinki will utilise, among other things, solutions provided by the smart grid for electricity consumption control," Minna Laasonen says. What especially fascinates her in the project are Finnish innovations devised by Finnish enterprises.

### House full of information

Many of Minna Laasonen's duties call for constant learning and in-depth knowledge of the matters at hand. She says that her work integrates challenges with interesting assignments.

"I am in a lucky position in that the answer even to the trickiest questions can be found from within our own company. There is always someone who knows," she says and especially commends the earlier generations of grid builders and experts. "In addition to theoretical education, they have become familiar with the transmission system and its technology through practical experience, having done things with their own hands."

Minna Laasonen herself draws on a strong technical legacy: her father worked in engineering, and three out of his four daughters have chosen the same career. Are there any more engineering professionals lined up in the family?

"I'm afraid there's a good chance for that, even though I have attempted to tell my children that there are other professions out there," says the mother of three sons and one daughter with a laughter.

She finds counterbalance to her work in her interests: gardening, crafts, listening to music, and skiing in the winter with the whole family. ■

# Online map of the Nordic Power System goes live

**The Nordic transmission system operators (TSOs) Energinet.dk, Fingrid, Statnett, Svenska Kraftnät and Elering have introduced the State of the Nordic Power System Map.**

The map shows the real-time power flows between countries and the wholesale prices of electricity in the bidding areas in Denmark, Finland, Norway, Sweden and Estonia. Other information published includes data on electricity production by generation type, net exchange, and consumption per country.

By disclosing information on the physical situation in the Nordic power system close to real time, the TSOs take another important step to increase the transparency of the Nordic power market. This is of significant value for the market players and leads to a more efficient market, which ultimately also benefits the consumers.

The data on the Nordic map are updated every minute. ■

The map is available on Fingrid's website under Electricity market.

# More disturbances than normal in the grid in the summer

**The exceptionally numerous strokes of lightning in Finland last summer are also reflected in Fingrid's disturbance statistics. By the end of September, there have been more than 300 disturbances in the nation-wide grid. This is about one fifth more than the annual average in the 21st century. On the other hand, most of the disruptions in the grid caused no disadvantage to electricity users.**

The disturbance duration per grid customers' connection point has been slightly above the average. The disturbance caused by lightning usually passes by means of automatic protection, which is why the power cut experienced by customers is very short.

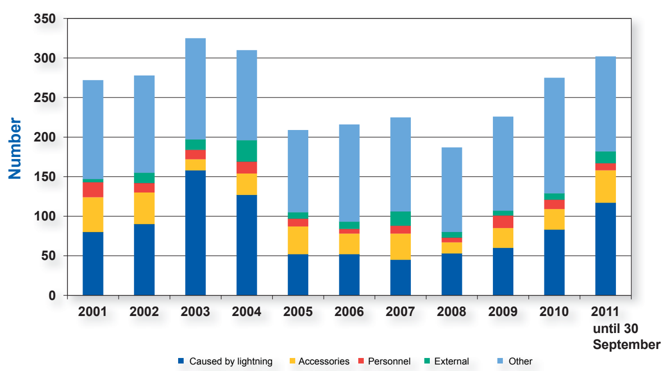
Sometimes there are so-called permanent faults which automatic protection cannot remove. Such faults can be caused for example by the collapse of a tower.

The number of permanent faults last summer was in the normal range, i.e. just a few. Two of these were the result of damage to towers. The first incident occurred on a 110 kilovolt line of a customer of Fingrid's, and also caused a disturbance in the nation-wide grid. In the other case, blasting work at the construction site of a new transmission line damaged the nearby 400 and 110 kilovolt towers. In both cases, the failure times were short and did not result in significant disadvantage to the customers.

There were a few disturbances on the cross-border interconnections to Sweden, Estonia and Russia in the summer. These were reflected in extensive variations in electricity transmission, but they did not have a direct adverse impact on the system security of the Finnish grid. Probably the foremost of these failures was the disturbance on the Russian interconnection. It was reflected in an instantaneous large power change in electricity transmission and also had a short-term effect on the frequency of the integrated Nordic power system and locally on the 400 kilovolt voltage. System security was maintained by means of automatic protection.

The disturbances on the Swedish and Estonian connections were caused by failures in the direct current links. Fenno-Skan experienced two disruptions, in conjunction of which electricity transmissions in Finland were controlled by adjusting electricity production. These measures managed to keep up system security in a controlled manner. There was extensive power oscillation on the Estlink connection, and this was managed by means of control measures on the link. The system security of the power system was not jeopardised during the power oscillation. ■

**Number and reasons of disturbances annually**



Before the exercise, there was a press conference for the media in Fingrid's premises.

# Successful disturbance exercise also revealed room for improvement

**Touko 2011 was a large-scale exercise for the eventuality of a major blackout in the Finnish electricity network, arranged last spring. The exercise progressed well, but it also revealed some general and detailed requirements for improvements. The real worth of the exercise depends on how the various organisations will make input in implementing the identified improvement ideas.**

**Text by** Erkki Sohlberg • **Photographs by** Jonna Monola

The Power and District Heat Pool, which co-ordinates contingency planning in the electricity industry in Finland, made a decision in the autumn of 2009 on a large-scale major disturbance exercise to be arranged in the Finnish electricity network. The planning of the exercise was a major effort, extending over 1½ years and involving a number of experts from several organisations alongside the actual planning group.

The objective of the exercise was to practise how to keep up and forward awareness of the situation, co-operation between the various parties as required by the situation as well as communications in the event of a serious and prolonged disturbance in the power system.

The main venues of the exercise were Fingrid's facility containing the operation control simulator, where Fingrid's Network Control Centre and Power System Control Centre personnel were working in simulation mode, and the management centre of the exercise located in Fingrid's auditorium, from where the tactical progress of the exercise was managed. The network companies involved in the exercise worked at their own locations.

Invitations to the exercise were sent to companies engaged in electricity distribution in the power areas of Southern, Eastern and Western Finland under the Power and District Heat Pool. Thirty-five organisations expressed their willingness to participate. Other organisations participating in the exercise were the Ministry of Employment and the Economy, rescue services, Emergency Response Centre Administration, National Emergency Supply Agency, Government situation centre, and Finnish Broadcasting Company. Fortum and Pohjolan Voima represented electricity generating companies.

Well before the actual exercise, the participating network companies were given advance assignments to respond to. Their purpose was to activate the participants to review their own in-

The exercise involved some 200 persons and about 30 different organisations.

structions and facilities for a disturbance situation. The advance assignments were responded to actively.

In early May, there was a preliminary event for the participating network companies, electricity producers and authorities in Tampere. The event reviewed the advance assignments sent to the network companies, explained the objectives and progress of the exercise, and gave instructions to the use of tools used in it.

### Co-ordinated communications

Communications for the exercise were arranged to take place in two steps. The Power and District Heat Pool and Fingrid were to reach the main media in Finland. A press release template was drawn up for local communications, and network companies took care of communications in their regions.

A press conference was held in Fingrid's premises in the morning before the start of the actual exercise. The electricity companies released their own press releases at the same time elsewhere in Finland. Both the electronic media and regional newspapers communicated the exercise and also advised consumers how to prepare for blackouts.

The exercise showed well how the electricity industry can send a shared message of responsible efforts.

### Challenging exercise scenario

The actual exercise lasted for 24 hours from 24 to 25 May 2011. The exercise began at noon, and the first day ended at around 18.00; there were no activities at night.

The imaginary exercise day selected was a cold January day, when electricity consumption in Finland is approx. 80 per cent of the maximum. Since Northern Finland did not participate in the exercise, the fault was limited south of the Oulu-Kajaani line.

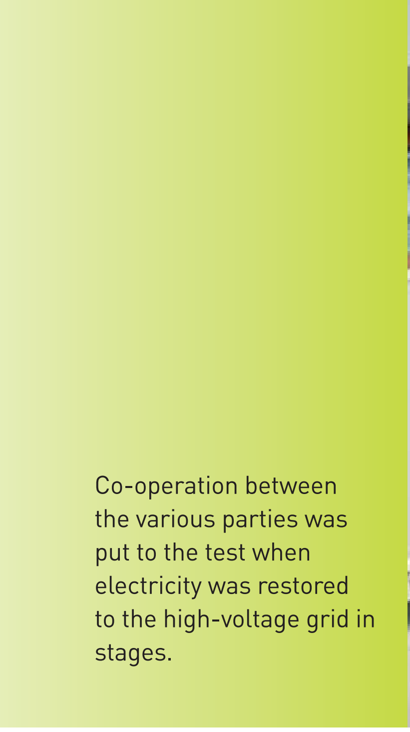
The exercise began by the collapse of the nation-wide transmission grid as a result of a small aircraft colliding with 400 kilovolt transmission lines. The emergency response centre was informed about the accident as soon as it had happened, and the centre immediately alarmed the rescue service to attend to the situation.

Fingrid's Network Control Centre and Power System Control Centre working in simulation mode began

- Cold weekday in early January
- There is hoar frost on the conductors
- Load 80% of maximum

**The figure shows the initial situation of the exercise.**

operations equivalent to those in an actual disturbance. On the basis of voltage status information received from the management centre of the exercise plus other information obtained from the Network Control Centre, the network companies and power plants commenced their disturbance clearing processes. The Network Control Centre and Power System Control



Co-operation between the various parties was put to the test when electricity was restored to the high-voltage grid in stages.

Centre began to restore voltage to the nation-wide grid. During the exercise, the management centre gave additional assignments to the network companies and power plants.

The exercise was resumed the next day at 8.00. During the night, some of the imaginary failures in the nation-wide grid had been repaired and electricity had been restored to the entire grid, but the load restrictions were still in force.

The second day of the exercise intended mainly to test how the giving of permits for additional loads works. As power plants were connecting to the grid and as electricity production was picking up, the Network Control Centre gave network companies permits for additional loads. A short feedback session was held at the management centre right after the exercise had ended.

### Contingencies call for collaboration

The exercise was a success, because all the participants took it seriously and managed their duties well. A large number of general and more detailed issues requiring improvement were identified during the course of the exercise. The real worth of the exercise depends on how well the various organisations will focus on implementing the identified improvement ideas.

After the exercise, there was a feedback session for the participating network companies, electricity producers and authorities in Tampere. The session reviewed the progress of the exercise and the questions presented to the network companies during the exercise plus the replies given to them. The participants' views about the things learned were also heard in the feedback session.

During the actual exercise, observations were gathered about the events of the exercise situation, and the participants were asked to provide feedback on its planning and implementation. Ideas for further development were also recorded.

In the exercise, telephone services worked to some extent throughout the exercise. There is no certainty of the availability of telephone communications in an actual blackout. Judging by the blackouts caused by storms in Finland in the summer of 2010, it is likely that telephone communications would be disturbed significantly or even lost completely in a few hours after the start of a wide-spread blackout. The restoration of electricity supply in the absence of working communications is almost impossible. For this reason, network companies and power producing companies should have a backup communications system sure to function in all circumstances.

Even though Fingrid's performance in the exercise gathered much positive feedback from the participants, there is still room for improvement. The issues requiring improvement, raised in the exercise, have been recorded as action, for which preliminary responsibilities and schedules have been specified. The required improvements will be dealt with in more detail in the operational planning of the different functions and units, and then taken to practical implementation. The degree and schedule of implementation will be monitored.

In an actual blackout, the network companies and power plant companies which took part in the exercise would have to contribute to restoring electricity supply in Finland. It is therefore important that the shortcomings detected in the exercise are corrected and that the issues requiring improvements are pushed forward. It is good to practice, but practice alone cannot correct everything. The shortcomings must be put right between the exercises. In preparing for contingencies and in the clearing of disturbances, we need good co-operation between the various parties.■

## Touko 2011 and investigation of storms of summer 2010

An investigative committee appointed by the Accident Investigation Board of Finland has drawn up a comprehensive analysis of how the storms experienced in Finland in the summer of 2010 and the consequent wide-spread blackouts affected the vital functions of society. The blackouts resulting from the storms caused largely similar problems to those envisaged in the Touko 2011 exercise.

In major disturbances, the various parties in the affected areas are highly dependent on each other's status information. When the damage caused by the storms was being repaired, the communications between the authorities were complicated, which made it difficult to gain an up-to-date understanding of the situation. Because weather phenomena which cause serious damage have been rare occurrences in Finland, the various parties have not had sufficient procedures for responding to serious weather warnings, and last summer action was only taken after damage had occurred during the first storm.

The blackouts resulting from the storms had a significant impact on the vital functions of society, such as the operation of communications networks, water supply, and transport. As an example, at worst the storms led to the loss of more than 1,000 base stations of telephone communications after electricity supply to them had been cut because trees had fallen on the lines.

Successful decision-making and leadership call for up-to-date awareness of the current situation. The various parties in the area inflicted by the damage depend on each other's knowledge of the situation. Rescue services need information from electricity network companies and telecommunications companies on the areas where there are electricity supply and communications disorders and how long the problems potentially persist. On the other hand, electricity network and telecommunications companies require up-to-date information from rescue services and road administration about how long it takes to clear the fallen trees. These factors have an impact on how quickly the electricity distribution and communications network problems can be solved.

From the perspective of the management and communications of wide-spread and diversified disturbance situations, Finland does not have sufficient arrangements for gaining awareness of the current situation, required for decision making. An overall view of the situation is created on the basis of the information possessed by the local and regional levels of different sectors. The main functions are the rescue services, police, social welfare and health services, emergency response centres, telecommunications companies, energy supply, transport routes, and water supply.

As a result of the investigation, the Accident Investigation Board issued a total of 14 recommendations to improve safety and precautions for serious natural disasters. The recommendations concern matters such as contingency planning by electricity network, telecommunications and water supply companies, the security of supply of electricity networks, and the formation and distribution of an overall view of the current situation.

After the recommendations issued by the Accident Investigation Board and the improvements prompted by the Touko 2011 exercise have been implemented, it is time to test the disturbance immunity capability by means of a new comprehensive exercise.

The work of the investigative committee examining the impacts of the storms in July and August 2010 in Finland was headed by **Veli-Pekka Nurmi**, Director of the Accident Investigation Board of Finland. He also served as an expert in the management of the Touko 2011 exercise.

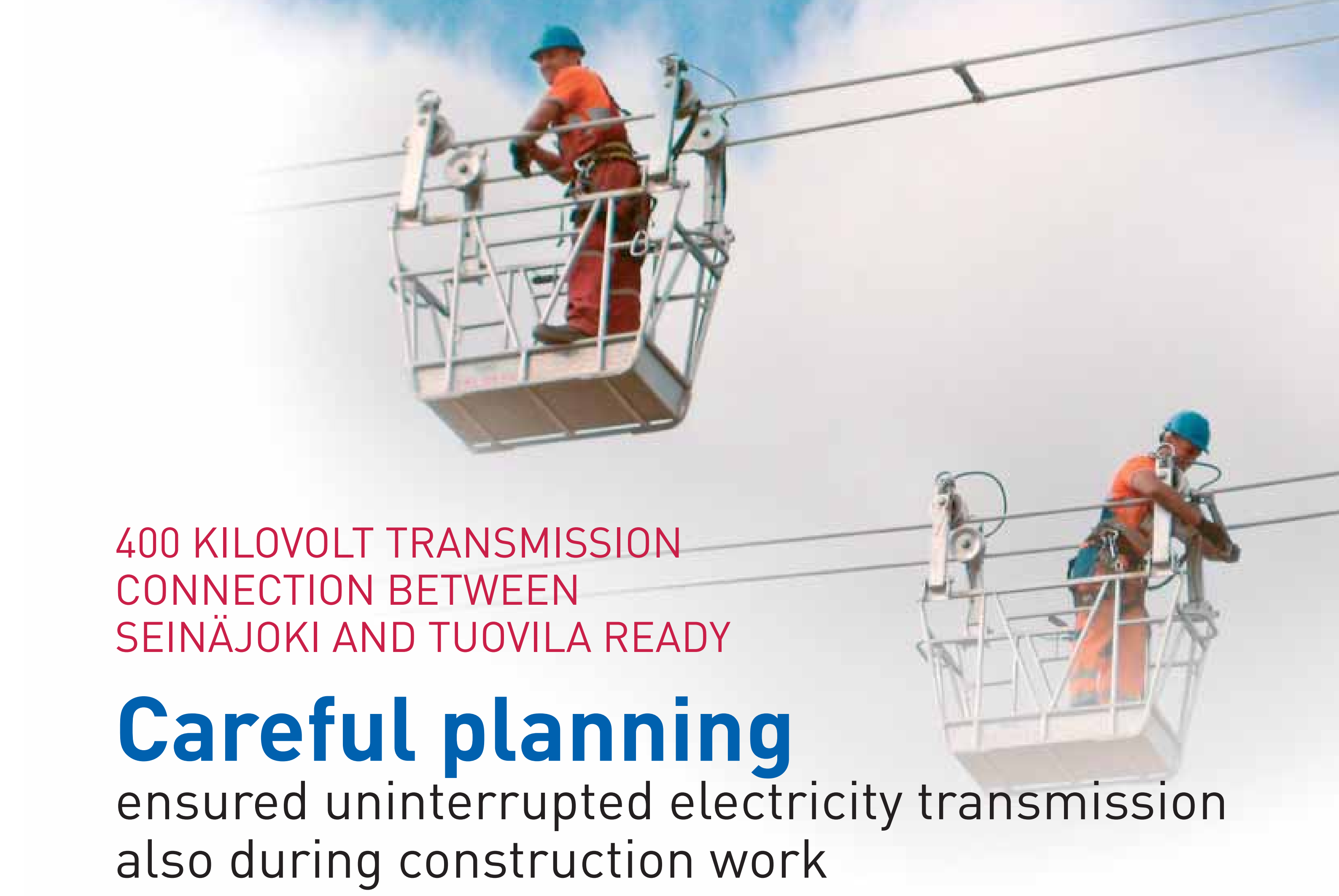
## Disturbance site shared by distribution network operators now opened

**A disturbance site shared by all distribution network operators in Finland has now been opened as part of the website of the Finnish Energy Industries. The links on the site provide up-to-date information on potential power failures.**

The disturbance site gives an opportunity to find the disturbance sites of all distribution network operators in Finland plus the necessary contact details in a single place. The site contains a map of the distribution network areas in Finland, with the network area of each distribution network operator marked on the map. By clicking on a network area, you can access the disturbance site of that particular network operator, or the necessary contact information, such as the telephone number of fault service.

The site also contains other news and useful information on outages in electricity distribution. The service is available at http://www.energia.fi/hairio.

The site can also be accessed from the home page of the Finnish Energy Industries at http://www.energia.fi, from the link opening under "Sähkökatkot".



400 KILOVOLT TRANSMISSION CONNECTION BETWEEN SEINÄJOKI AND TUOVILA READY

# Careful planning

## ensured uninterrupted electricity transmission also during construction work

**An important stage was reached in the extensive reinforcement project for the transmission grid in Ostrobothnia in Western Finland, when the 400 kilovolt connection between the Seinäjoki and Tuovila substations was completed ahead of schedule. The 110 kilovolt portion of the line became available in the early autumn, and the 400 kilovolt transmission connection was commissioned at the beginning of November, when the transformer installation work finished at Tuovila. The actual line arrangements at the Tuovila substation together with the construction work there were mostly ready as early as the beginning of September.**

**Text by** Antti Lagus • **Photographs by** Ritva Laine and Sami Mäki

The most critical stages in the entire project were related to the construction of the new Tuovila substation. During this work, many outages had to be carried out in order to transfer the old 110 kilovolt (kV) lines to the new 110 kV substation. At Tuovila, changes were made to 9 lines, and 3 new lines were built.

There was previously one 110 kV line between the Seinäjoki and Tuovila substations. Now it has been replaced by a new power line with the 110 kV and 400 kV lines running on the same towers. The required right-of-way was reduced as a result of this double-circuit tower solution.

"The substation used to have 110 and 220 kV connections but no 400 kV connection. New 110 and 400 kV connections and switchgear bays had to be built at Tuovila. The problem was to have a simultaneous outage on several lines in conjunction with the transfer of the 110 kV lines," says Fingrid's Project Manager **Ritva Laine**.

"The great need for outages was due to the fact that the new 110 kV substation was built 'behind' the existing station, which meant that in conjunction with the stringing of the conductors, the busbar at the old substation and all lines connected to the busbar had to be de-energised. For this reason, it was necessary to build a temporary connection from Vaskiluoto to the new 110 kV substation, and a temporary connection between Seinäjoki and Vaskiluoto was also constructed."

Fingrid's Grid Operation Adviser **Kimmo Toivonen** says that in the summer the Tuovila substation underwent a number of outages which had an impact on system security. There were also many contacts with customers and power plants in the region during the preparation of the system security plan.

### No interruptions

"There were no transmission interruptions, because the old substation was bypassed by means of temporary lines. The outages and their various stages were verified by many calculations. If some stage involved a specific

◀ Spacers were installed in the 110 kV conductors in the late summer.

risk, a backup plan was prepared for it," Kimmo Toivonen says.

Ritva Laine characterises the two-year construction stage as an entity consisting of Lego blocks. In the summer of 2010, the right-of-way was cleared for the new lines and for the new 400 kV substation by dismantling some of the 220 kV connections at the Tuovila substation.

Electricity supply to the region had to be secured in each work stage, which is why the temporary line arrangements were made in the early summer of 2011, prior to the actual modification of lines.

No new towers needed to be erected at the substation for the outage arrangements, because existing structures could be used. The 110 kV transmission line owned by EPV Alueverkko routing to the Tuovila substation from Vaskiluoto has been installed on the same towers with Fingrid's 400 kV (in 220 kV operation) line routing from Kristiina. The Vaskiluoto line was connected to the new 110 kV substation by utilising the 400 kV line and the substation structures.

The connection between Vaskiluoto and Seinäjoki was constructed by connecting the Vaskiluoto-Tuovila line and the new Tuovila-Seinäjoki line in front of the Tuovila substation.

Kimmo Toivonen says that there were quite a lot of work stages in the project.

"Last summer alone, there were 10 stages during each of which the outage situation in the region differed from the other stages. There was one particularly critical week, when both the old 110 kV and the 220 kV substations were out of operation and only two feeding 110 kV lines were connected to the new substation. In that situation, only a few lines supplied electricity to the region. Of the outage of one week, two days were first reserved for dismantling work, and in three days the transmission line crew installed the new connection between the 220 kV and the new 110 kV substations," he says.

### Co-operation secured the arrangements

According to Kimmo Toivonen, several co-ordination meetings were held to ensure the practical arrangements, because the site was subject to simultaneous demolition work on the substation, construction of the new substation, outages, and transmission line modifications.

The outage arrangements were also reviewed on many occasions with the local electricity companies EPV Alueverkko Oy and Vaasan Sähköverkko Oy, whose electricity supply depends on the Tuovila substation.

How was it secured that there are no electricity supply interruptions?

"The most important thing was that everything was planned carefully and that all potential situations were calculated in advance. We attempted to take into consideration even the worst case scenarios, like a situation where we would have started an outage and at the same time there would have been a serious disturbance in our customers' networks, and on top of that some power plant would have tripped from the grid," Kimmo Toivonen says. ■


Switchgear bay at the new Tuovila substation.

## Upgrading the grid on the west coast

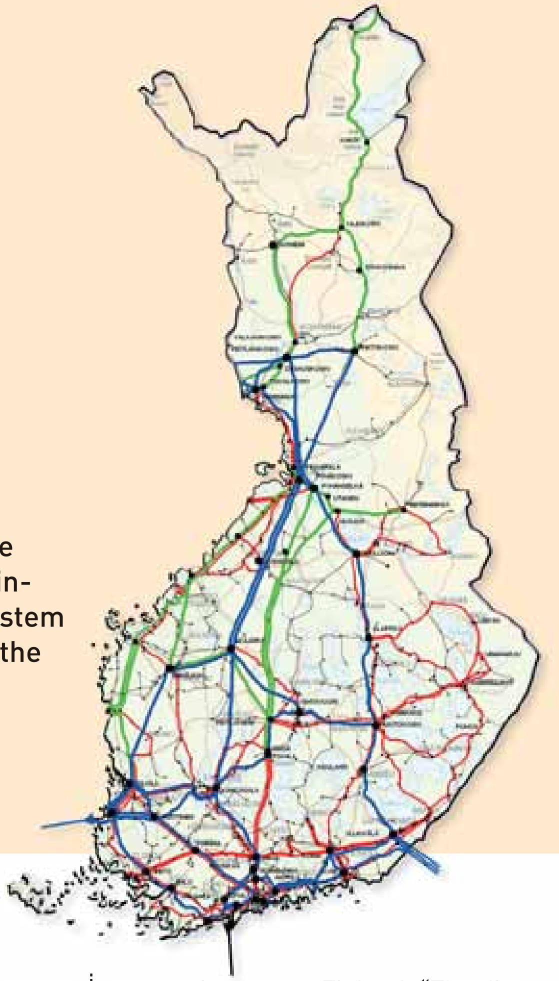
**The 220 kV voltage level is being abandoned in Ostrobothnia in Western Finland, to be replaced by a 400 kV network. The ultimate goal is to abandon the 220 kV voltage level all the way to Oulu.**

Fingrid's Project Manager **Ritva Laine** points out that the time span of such projects is long, because in addition to transmission lines it is also necessary to build substations.

The reinforcement of the grid in Ostrobothnia is necessary because electricity demand in the region has increased and also because some of the 220 kV devices are beginning to be aged. The new lines will be built directly to 400 kV voltage.

"The actual construction work on the Seinäjoki-Tuovila line commenced in the autumn of 2009. This was preceded by planning work and environmental impact assessment. All in all, a 400 kV transmission line project with a scope such as this takes about 5 years. We might have been able to squeeze the construction period to a single year, but we wanted to have two winters available for the eventuality that the first winter would be poor in view of construction work. Now both winters were good, and the timetable was not tight in any way. The contract agreement specified that the project had to be completed by October, but the 400 kV line work was largely ready by last spring," Ritva Laine says.

# Front row seat to power system development



The members of Fingrid's Operations Committee feel that the best part in the efforts of the Committee is the possibility to influence the reforms relating to the operation of the power system as early as in the drafting stage, and the opportunity to hear the views of the various parties involved in the power system.

**Text by** Suvi Artti • **Photograph by** Juhani Eskelinen

Fingrid has a total of three customer committees. Of these, the Operations Committee focuses on the operation of the power system and on system security management. The roots of the Committee go back more than 10 years ago, when the Power System Committee was set up to discuss similar issues.

Recently, the Operations Committee has discussed matters such as the new procurement models for the reserves, increasingly closer Nordic transmission co-operation, and the reforms in the statistics for disturbances in the Nordic power system and in their communication. The Committee has also followed closely the new regulations and other matters affecting the operation of the power system as these have been prepared by ENTSO-E, the European Network of Transmission System Operators for Electricity.

The Committee assembling 4 times a year consists of 8 members who represent Fingrid's different customer groups: electricity producers, large-scale electricity users, regional and distribution network operators, and operators of urban networks. The Chairman of the Committee is **Reima Päivinen**, Fingrid's Senior Vice President responsible for power system operation, and its secretary is Senior Advisor **Kimmo Kuusinen**.

### Two-way flow of information

**Erkki Nuortio**, head of the control centre of Kemijoki Oy, considers the Operations Committee a good channel of interaction between Fingrid and parties involved in the power system.

"Fingrid is transparent in disclosing if some procedure or other is being changed. The members of the Committee take forward the message to their colleagues, and the members can also relay their colleagues' feedback to Fingrid," he says.

Erkki Nuortio has been a member of the Operations Committee since its establishment, and likes to be in the forefront when it comes to making a difference. He has accumulated solid experience of electricity network operations for more than 30 years.

**Hannu Halminen**, manager of technical services in electrification at Boliden Harjavalta Oy, is another original member of the Committee. He commends the extensive level of knowledge of the members and the geographical distribution of their companies across Finland. "The discussions highlight the interests and problems of different players when matters related to the reforms in the nation-wide grid are discussed."

> **"The nation-wide grid is a playing field shared by us all, and the opinions of us all should be taken into account."**

**Ilona Erhiö** of Vantaan Energia Sähköverkot Oy has belonged to the Operations Committee since the beginning of 2011. She brings the aspect of an urban network operator to the discussions conducted within the Committee. Ilona Erhiö, who works as an operation manager, says that she is pleased to be involved in the Committee which has influence on her industry. One interesting experience was the Nordic System Operation Workshop, in which the members of Fingrid's Operations Committee participated in conjunction with the September meeting.

According to Ilona Erhiö, the matters discussed in the Committee so

The Operations Committee's September meeting also involved participation in the Nordic System Operation Workshop. Pictured from left to right: Jaakko Puotinen, Jukka Rajala, Erkki Tiippana, Raimo Peltola, Kimmo Kuusinen, Erkki Nuortio, Ismo Reinikka, Ilona Erhiö, Reima Päivinen and Hannu Halminen.

far have mostly dealt with balance management and market functioning rather than the technical operation of electricity networks.

### Reserves under focus

Erkki Nuortio names the shift-over to the new procurement model for the frequency controlled normal operation reserve at the beginning of 2011 as an important event in the efforts of the Operations Committee.

"As a representative of a hydropower company, it has been interesting for me to hear about this reform all the way from the early stages and also to influence it from the viewpoint of a hydropower producer in terms issues such as production machinery."

Erkki Nuortio regards the new reserve market as a good arrangement: whoever has reserves gains a compensation for frequency control.

The reforms with the reserves continue, and alongside the new reserve market, there will also be other developments affecting frequency control. The objective of Nordic reserve co-operation is to analyse the present reserve requirements and propose necessary amendments.

### Various viewpoints from within the common playing field

The members of the Operations Committee consider that the Committee has an important role within Fingrid.

"Through the Committee, Fingrid obtains opinions and experiences from various players operating in different parts of Finland. The relevant issues can concern for example different types of disturbance events and the potential impacts of new practices on the customers' daily operations," Hannu Halminen states.

Erkki Nuortio also commends Fingrid for taking heed of the opinions of its committees.

"The nation-wide grid is a playing field shared by us all, and the opinions of us all should be taken into account. Of course, the committees cannot control Fingrid's business, but Fingrid listens to the opinions of others."

Ilona Erhiö, on the other hand, is in her first year in the Committee and has only had time to attend 3 meetings. So far, the agenda has contained matters which are almost ready for implementation, and she is looking forward to hearing about future reforms as early as when they are being drafted so as to also have an opportunity to affect them.

### Up to date with ENTSO-E reforms, too

In addition to the changes taking place in the grid within Finland, Fingrid also keeps the members of the Operations Committee up to date about transmission system matters on a European scale.

Fingrid has made sure, among other things, that the various parties can get to know ENTSO-E's proposals in good time so that they can submit their statements to them.

"The technical system requirements imposed by ENTSO-E on power plants are currently on circulation for comments, and hydropower producers should also get to know them," says Erkki Nuortio. "These regulations will ultimately become legislation, and now we have an opportunity to influence them." ■

Transmission line maintenance faced with

# FROSTY CHALLENGES

**The snowy winters experienced in Finland in recent years have meant busy times for transmission line maintenance. It is hard work to keep the transmission lines clear of snow, ice and hard rime.**

**Text by** Ursula Aaltonen • **Photographs by** Jarmo Lahtoniemi, Fingrid and Eltel Networks

**Jarmo Lahtoniemi** remembers only too well the record-high snowfall and long periods of very cold weather in the winter before last. "We had 7 times more assignments for the dropping of snow and ice loads from the lines than in an average winter," says Jarmo Lahtoniemi, who works as Fingrid's transmission line specialist for Eastern Finland.

Eastern Finland has traditionally been the area where snow and ice accumulating on the lines cause the biggest problems. This was also the case in the winter of 2009–2010. The extraordinary snow situation continued last winter, when there was "only" 3 times more dropping work than in years regarded as normal.

"The record winter took us from one extreme to the other, because in the winter of 2008–2009 there was so little snow that we had no need at all to drop snow or ice from the lines. The following winter we dropped ice and snow from more than 700 spans in Eastern Finland alone, while the average number in a single year is about 100."

## Brute force into play

Monitoring the ice and snow situation and dropping them from the lines constitute part of the normal maintenance of transmission lines. Ice and snow are usually dropped when the accumulation is about 10 centimetres. This can take place in a short period of time. "Several centimetres of ice may gather on the lines in a single day. This happened on more than one occasion in the winter before last, because at worst we had to drop ice and snow twice in the same place in the same week."

Ice and snow are conventionally fought by brute muscular force. The most common method is a rope thrown over the overhead ground wire or phase conductor by means of a weight, and when the rope is pulled along the wire or conductor, the ice and snow drop down. Sometimes, when the snow is very light, it may be enough to shake the towers.

"The dropping work is physically very strenuous. Moreover, the circumstances are often such that it is time-consuming and difficult to move in the terrain. Occasionally, we have to first clear the coppice in the right-of-way before we even get to the actual dropping work," Jarmo Lahtoniemi says.

"The work progresses slowly – one patrol can clear a maximum of 10 spans in a work day. Winter days in Finland tend to turn dark so early in the day that the actual working hours in the terrain are limited."

## Many work stages

The accumulation of snow and ice on the lines is monitored systematically in the winter, so there are not that many big surprises. "The ice load period begins as soon as the first snow falls. We monitor especially places where we know by experience that ice loads tend to appear first. These are typically high places, like slopes and tops of hills."

As the winter goes on, the inspections continue and the ice load situation is surveyed regularly. The spans to be cleared are recorded and classified into three urgency categories: in the most urgent category, the loads are dropped within 24 hours from the observation, and in the second most urgent category within a week. "In practice, the third category means some time before the spring," Jarmo Lahtoniemi says with a smile. "In many cases, changing weather helps us in this work, and we often look forward to temperatures above zero degrees Celsius. A couple of degrees above zero is normally sufficient to ensure that we do not have to drop snow loads. Of course, we still have to inspect the sites."

## Only a few disturbances

As a rule, snow and ice tend to accumulate on the overhead ground wires located highest in a transmission line, since the ground wires are not heated by the electric current that travels in the phase conductors. Sometimes, however, it is necessary to drop ice and snow also from the live phase conductors. In this case, the current does not have to be switched off from the line. Instead, blocking of automatic reclos-

Traditionally, ice and snow loads have been dropped from the ground wires and conductors by means of a rope thrown over them. The snow and ice load accumulating on a single span may weigh thousands of kilos.

ing is sufficient to ensure the safety of the dropping work if something out of the ordinary happened.

"The dropping of ice and snow must be controlled and carefully planned so that the wires and conductors cannot sway during the cleaning process, causing a distribution disturbances or other damage. Careless action could damage not only the ground wires and conductors but also the tower structures," Jarmo Lahtoniemi says.

Ice loads cause relatively few disturbances in electricity supply. "In the winter before last, when there was more snow than ever, we recorded a total of 8 disturbances which caused outages of usually less than a second, and in any case no more than a minute, to the customers. The customers often do not even notice interruptions of this type."

"What was exceptional in the winter before last was not only the record-high amount of ice loads, but also the fact that these loads occurred in extraordinary places. Never before have we dropped snow from transmission lines located in the middle of a large open bog, but now we know that it is also possible."

### Helicopters to the aid

Nobody can yet forecast the amount of snow in the coming winter, but if there is much snow like in the previous winters, Fingrid is also prepared to use more robust methods alongside the conventional manual snow and ice load dropping methodology. "The use of a helicopter for dropping the ice loads has been tested, and the method has proven to be effective," Jarmo Lahtoniemi states.

Ice removal by means of helicopter is based on a hook hanging from the helicopter by a rope, with the hook placed under a ground wire or conductor covered with ice. The hook rubs the ice or snow off. Alternatively, the work can employ a hook equipped with an electric vibrator, where the vibration of the hook shakes the conductor so that the ice or snow comes off.

"This method was originally developed in the United States and Canada, where the road network is sparse and the distances are long. In such conditions, the helicopter is a convenient and cost-effective tool for the maintenance of transmission lines. The method is also used in Norway, where the terrain conditions are also often challenging," says Product Manager **Matti Seppälä** of Eltel Networks, which is responsible for the practical implementation of ice load dropping in Southern, Eastern and Northern Finland.

Eltel's linesmen are trained for maintenance work using a helicopter. "In Finland, helicopters have been used mainly for other maintenance tasks, such as cutting the tops of trees. Our linesmen are trained continuously, and next winter we have full capability to use a helicopter also for dropping snow and ice if the situation so requires."

### Efficient and fast

Helicopters are not intended to supersede the traditional methods of dropping ice and snow, but to work alongside them. "Even though the use of helicopters is relatively pricy for fuel costs alone, the method is very fast and efficient. A helicopter can cover up to 10 times as many spans as a crew from the ground in a single day," says Matti Seppälä.

"Of course, there are still places and situations where the traditional method works best. For example, if there is

Ice and snow load removal by means of helicopter is based on a hook placed under the overhead ground wire or conductor in the air, with the hook dropping the ice and snow from the ground wire or conductor. The helicopter dropping method was tested last winter.

close to 20-30 centimetres of snow on the conductor – as there sometimes is – the weight of the snow has brought the conductor so close to the ground that the snow cannot be dropped from the air for safety reasons alone."

Helicopters will probably be used to an increasing extent also for surveying the ice load situation. To facilitate this work, the helicopters now have a new map application where the inspection entries can be made directly in an electronic map. The new method expedites and facilitates the inspections and also contributes to occupational safety since it is no longer necessary to use paper maps in the confined interior of a helicopter.

Jarmo Lahtoniemi is satisfied with the developments. "When the area to be monitored is as large as the whole of Eastern Finland, the use of helicopters facilitates and speeds up the work considerably. Weather permitting, it only takes 4 to 5 days to inspect all transmission lines in our area from a helicopter. On foot and by snowmobiles, this would naturally take much longer," he sums up. ■

# Storm prompted a forecasting model

**The Finnish Meteorological Institute in co-operation with Fingrid has developed a computer-aided model, which seeks to anticipate ice and snow load accumulations on transmission lines. The so-called ice load model forecasts weather conditions, in which ice and snow loads build up on the overhead ground wires and conductors. The objective is to prevent disturbance situations in the transmission system. The functioning of the model in its pilot stage was tested for the first time last winter.**

"The ice load model has been developed from the forecasting model for crown snow load, used by the Meteorological Institute since 2006 for anticipating crown snow loads building up on trees. The model has proven to be a fairly reliable tool for predicting crown snow situations which cause power failures," says Meteorologist **Petri Hoppula** of the Meteorological Institute.

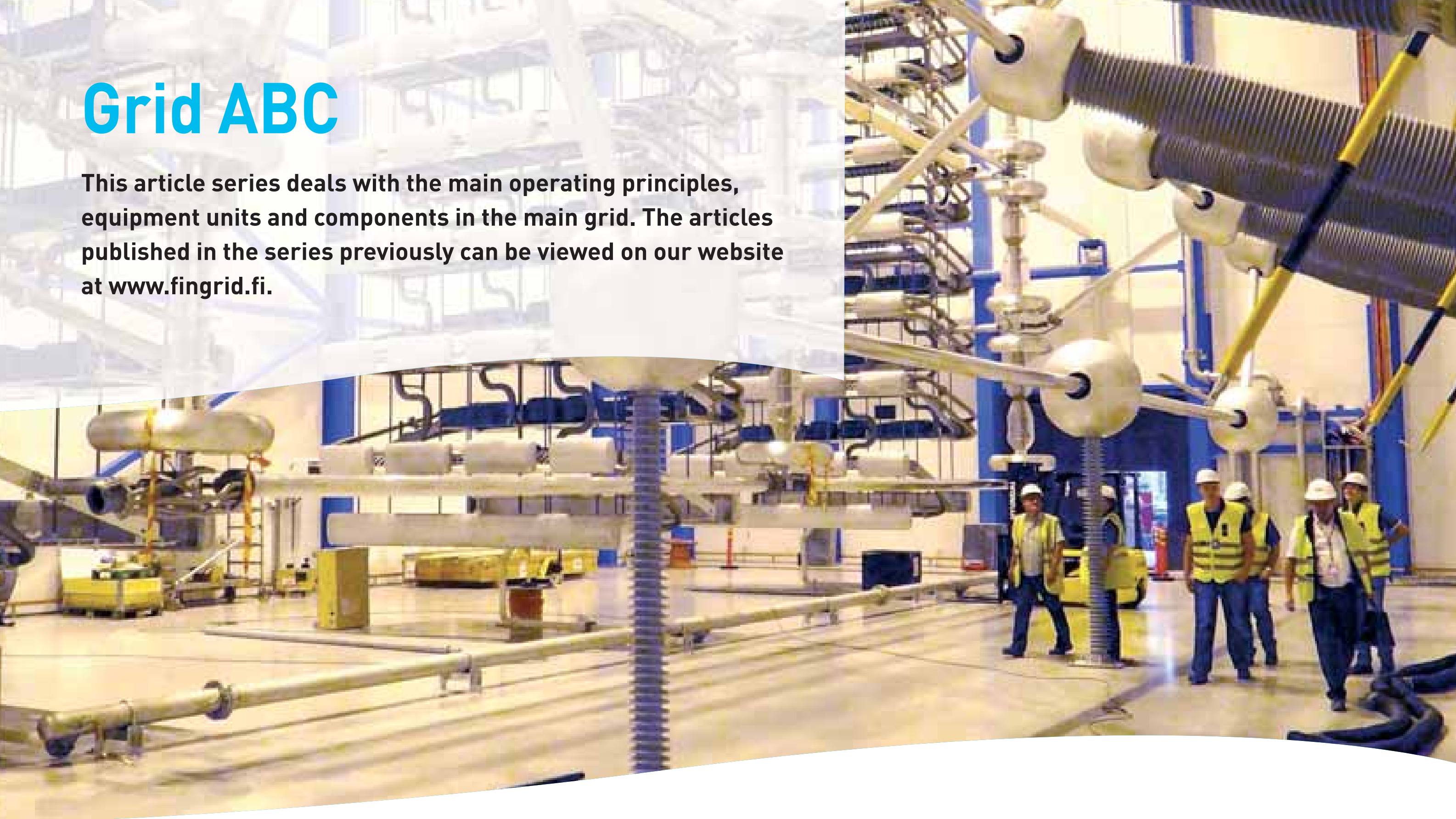
The ice load model is based on weather observations made by weather stations in various parts of Finland. These observations are the source material for anticipating snow and ice load accumulations on transmission lines. The weather observations considered are snowfall, temperature, wind, and air humidity.

"Weather conditions have a crucial impact on where ice loads build up on trees and conductors. Air humidity and wind are the decisive factors. The most optimal weather for the build-up of ice is a temperature below -10 degrees Celsius and a moderate wind of about 5 metres per second."

Petri Hoppula got the idea for the model from the Pyry (which means snowstorm in English) storm in Finland in November 2001. "The storm felled many trees in my brother's forest in Central Finland, which prompted me to study the relationship between the accumulation of ice and snow and the falling of trees. This provided me with the topic of my Master's thesis and later these forecasting models."

## Grid ABC

**This article series deals with the main operating principles, equipment units and components in the main grid. The articles published in the series previously can be viewed on our website at www.fingrid.fi.**



# Fenno-Skan 2 is a THOROUGHLY TESTED HVDC LINK

**The trial operation period of the Fenno-Skan 2 high-voltage direct current (HVDC) transmission connection between Finland and Sweden commenced in October. Before this, it has passed a series of system-level tests, which were used for verifying the proper functioning of the link in both normal and extraordinary situations.**

**Text by** Timo Kiiveri and Tuomas Rauhala • **Photographs by** Harri Nurminen and Futureimagebank

Ensuring the technical performance of the HVDC link began as early as in the specification stage of the project. The functional specification covered guarantee value requirements concerning system performance, such as energy availability, number of faults, losses, transmission power etc. In addition, the specification required certain tests and referred to international standards and recommendations to the extent that such exist.

> Fenno-Skan 2 provides a response to the challenges of the electricity market. The 800 megawatt high-voltage direct current (HVDC) link will increase the electricity transmission capacity between Finland and Sweden by 40 per cent. The link will reduce the area price differences and transmission losses, improve system security, and integrate the market more closely together.

The submarine cable supply included the type tests to be performed on the cable. These tests follow to a large extent Cigre's (Conseil International des Grands Réseaux Electriques) "Recommendations for tests of power transmission DC cables for a rated voltage up to 800 kV, Electra 189, April 2000".

**The submarine cable was tested** mechanically and electrically at the factory in Halden, Norway. The electrical tests included load cycle tests and reversal of polarity tests in both a cold (0°C) and warm (15°C) ambient temperature. The cable must not be damaged mechanically or electrically in the tests. In the load test, the voltage ranged between +900 kV and -900 kV (+/-1.8·$U_0$, where $U_0$ denotes the rated voltage of 500 kV of the cable) and in the reversal of polarity test between -700 kV and +700 kV (+/-1.4·$U_0$). The quantities monitored during the tests were the current, voltage, pressure, temperature, and partial discharge (PD) values of the cable. Moreover, the cable was subjected to switching voltage tests at a pulse of ±950 kV 250 µs/2,500 µs. The lightning impulse tests were carried out with a pulse of ±1,000 kV 0.5-5 µs/50 µs.

At the end of the type tests, the cable was subjected to a test attempting to break it electrically in order to determine the maximum withstand level. However, the tests were ended at a level of 1,050 kV because there were fears that the laboratory test system, not so much the submarine cable

View of the valve hall in Rauma.

itself, would break. The type tests at the factory lasted for a total of about one year.

**Informative type tests,** which re-measured the partial discharge levels of the cable, were carried out in order to obtain further information. The original partial discharge measurements were useless because a large amount of interference outside the laboratory mixed up the results. After installation, the cable was tested at 700 kV DC voltage for 15 minutes, and the electric fingerprint of the cable was determined using a time-domain reflectometer.

**The testing of the components** and subsystems at the converter stations can be roughly divided into type testing and routine testing at the factory and testing taking place at the construction site (operational testing of circuit diagrams, test control and inspections of the instruments before voltage supply, and subsystem tests) and before the power transmission test. This article describes how the power transmission tests were performed, plus the relevant system effects.

Fenno-Skan 2 and 1 make up an HVDC connection alongside the AC transmission system between Finland and Sweden. Since the power transmission tests took place during normal system operation, the high-capacity tests (>550 MW) caused temporary restrictions in the cross-border transmission capacity between the two countries. Additional challenges to the running plans of the tests were caused by the large volume of inexpensive hydropower in Norway and by the rather unexpected decisions made by the Swedish authorities to shut down seven nuclear power units in Southern Sweden "until the necessary studies have been made". The power transmission tests lasted for a total of about six weeks.

**The tests started** at minimum power (40 MW) with the transmissions taking place to the east (Finnböle as the rectifier and Rauma as the inverter), because east was the more optimal transmission direction in view of the electricity market. At first, the current control of the link was tested at minimum power, at slow current control ramping. This was done to ensure that all the basic features and functionalities work properly before moving to higher powers. At the end of the day, there was a disruptive discharge in the differential current transducer in the neutral circuit at the Rauma converter during the testing of the fast stop function. In the fast stop function, the electric charge of the submarine cable, which works like a large capacitor, is uncharged within a few dozen milliseconds. Due to the disruptive discharge in the differential current transducer, the transmission direction in the tests was changed from east to west. The tests continued with current control at minimum power, with the cross-checking of the various sequences utilised in the sudden stopping of power transmission on the link (the thyristor control pulses are switched off, and direct current is given a direct path through the valve), i.e. the so-called X, Y, Z and S blocking, and the parallel A and B control systems. After successful testing, the power of the link was run to 200 MW by current control, and the functioning of control in the absence of telecommunications connections between the converter stations was tested in the same conjunction.

The next set of tests comprised normal power control between 40 and 200 MW in synchronous and asynchronous operation. The link was also subjected to a test for reduced voltage (0.8 pu), at which for example CDVC (cable dependant voltage control) works. The functioning of the converter station was tested by cutting the auxiliary power feeds one by one and by making sure that the protection and control systems still work flawlessly.

The low-power tests were resumed the next week, with the transmission direction being to the east. This time, the underdimensioned and defective devices had been removed

### Table 1. Special controls of Fenno-Skan 2 HVDC link

| Special control | Objective of control function | Method of testing of control |
|---|---|---|
| Emergency power control (EPC) | To reduce the level of power transmission on the AC connections by automatically changing the DC transmission based on the pre-defined measurement parameters of the Nordic power system. | Various EPC functions were activated manually by the person managing commissioning. |
| Power oscillation damping control (POD) | To change quickly, in sequences of about 3 seconds, the DC transmission in accordance with the power oscillations with a cycle time of approx. 3 seconds, taking place between the large electricity production centres in Southern Finland and Southern Scandinavia. | A sine signal with a cycle time of approx. 3 seconds was fed from the signal generator to the POD measurement circuit, with this signal activating the control. |
| Automatic frequency control (AFC) | To change the DC transmission power based on the frequency difference between Finland and Sweden. In practice, the control is limited to those rare situations where the Finnish and Swedish power systems are not in synchronous operation. | A sine signal with a cycle time of approx. 3 minutes was fed from the signal generator to the AFC measurement circuit, with this signal activating the control. |
| Subsynchronous damping control (SSDC) | In the extraordinary situations of the power system, to improve the impact of the DC connection on the damping of mechanical torsional oscillations in turbine generators with a long shaft. | Subsynchronous oscillation was excited by means of an emulated DC fault, i.e. a malfunction was created in the protection system of the DC connection, with this malfunction activating the high-speed automatic reclosing sequence. |

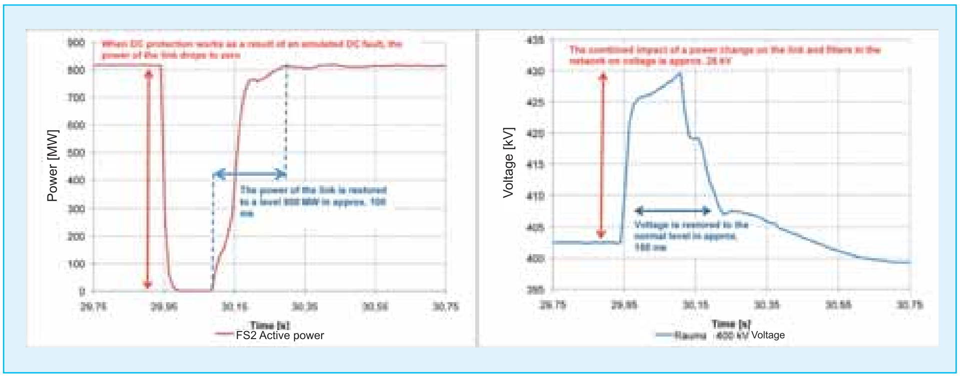



Figure 2. Change in the power of Fenno-Skan 2 HVDC link during the emulated DC fault test, and the impact of the test on the 400 kV voltage in Rauma, Finland.

from the neutral circuit. In practice, these tests involved repeating the tests of the previous week to the opposite transmission direction.

**After successful low-power** transmission tests, the high-power tests were started. The transmission direction continued to be east, because this disturbed the functioning of the market as little as possible. The tests began with current control again. The next test case was power control, but this time the link was run to the rated power of 800 MW. Fenno-Skan 2 transmitted 800 MW (AC power at the receiving end) for the first time on 21 September 2011. The next item to be tested was reactive power control (RPC), with filters switched on and off manually to see whether automation restores a sufficient number of filters to the scheme, depending on the set dead band. Constant reactive power and constant voltage control modes were tested in the same conjunction. The normal mode of reactive power control for Fenno-Skan 2 is automatic Q-control (the reactive power between the converter and the AC grid is controlled), with the reference value being 0 Mvar with a 65 Mvar window.

After the testing of the basic controls, the tests continued with the tests of higher-level control functions, i.e. so-called special controls. Since the objective of special controls is to support the operation of the Nordic power system in conjunction with exceptional operating situations and in fault situations, the test arrangements of special controls required special preparations so as to verify the correct functioning. The special controls of Fenno-Skan 2, their purpose of use, and the method in which the special controls were verified in conjunction with the commissioning tests are summarised in table 1 on page 33.

**Various ways to carry out the tests** pertaining to the special controls were assessed while planning the commissioning tests. At the planning stage, it was found that there were no grounds to arrange critical operating situations corresponding to the actual operating situations of the controls, taking into account the normal mode of operation of the transmission system. As an example, the testing of automatic frequency control in this respect in a manner that corresponds to the actual operation of the system would have required the opening of the AC connections between Finland and Sweden for the duration of the test. This is why the tests were carried out in the manner described in table 1, largely by "deluding" the various control functions in a way where the controls experienced the system to be in an extraordinary state, even though this was not the case in reality.

**Even though the testing** of the special controls was carried out in a normal system operation situation, the response of the DC link to the "fake" extraordinary situations had some impact on the voltage and frequency of the AC system. This is why the tests required special preparations by both the link supplier and the TSOs so as to minimise the system impacts of the tests related to the special controls and to the reactive power con-

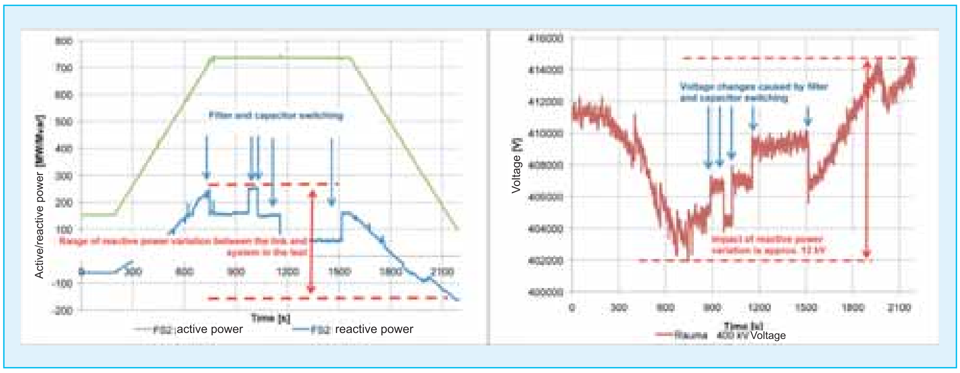
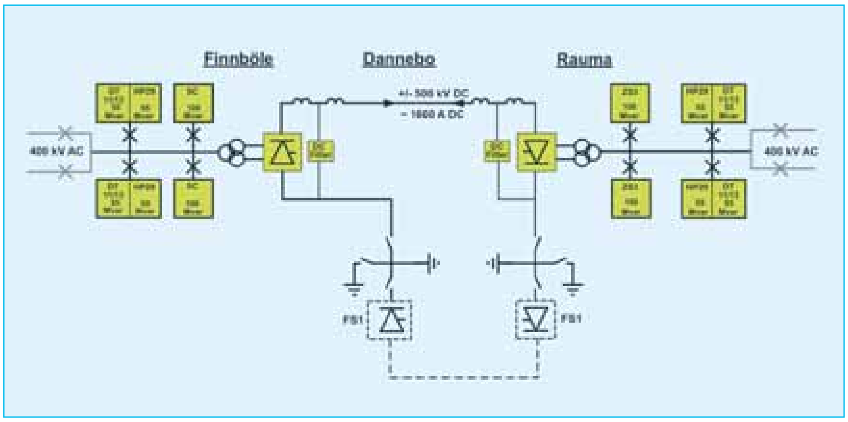



Figure 1. Variation of the power of Fenno-Skan 2 HVDC link and of the reactive power taken by it from and fed by it to the system during the test, and the impact of the test on the 400 kV voltage in Rauma, Finland.

trol of the link. The subtest pertaining to the reactive power control of the link turned out to be one of the most relevant tests in terms of the system impacts. This subtest verified the biggest differences in the reactive power balance between the DC link and the power system during normal operation. Another subtest which was important in terms of the system impacts was the emulated DC fault related to the testing of subsynchronous damping control. The system impacts of the said tests are illustrated in figures 1 and 2.

As shown by figure 1, the biggest reactive power change between the link and the power system in the test was approx. 400 Mvar (-150 Mvar to +250 Mvar), but the impact of the reactive power imbalance on the 400 kV voltage was only about 10 kV. Figure 2 illustrates the impact of a fault in the DC system on 400 kV voltage in South-Eastern Finland.




Fenno-Skan 2 and 1 HVDC scheme (bipolar)

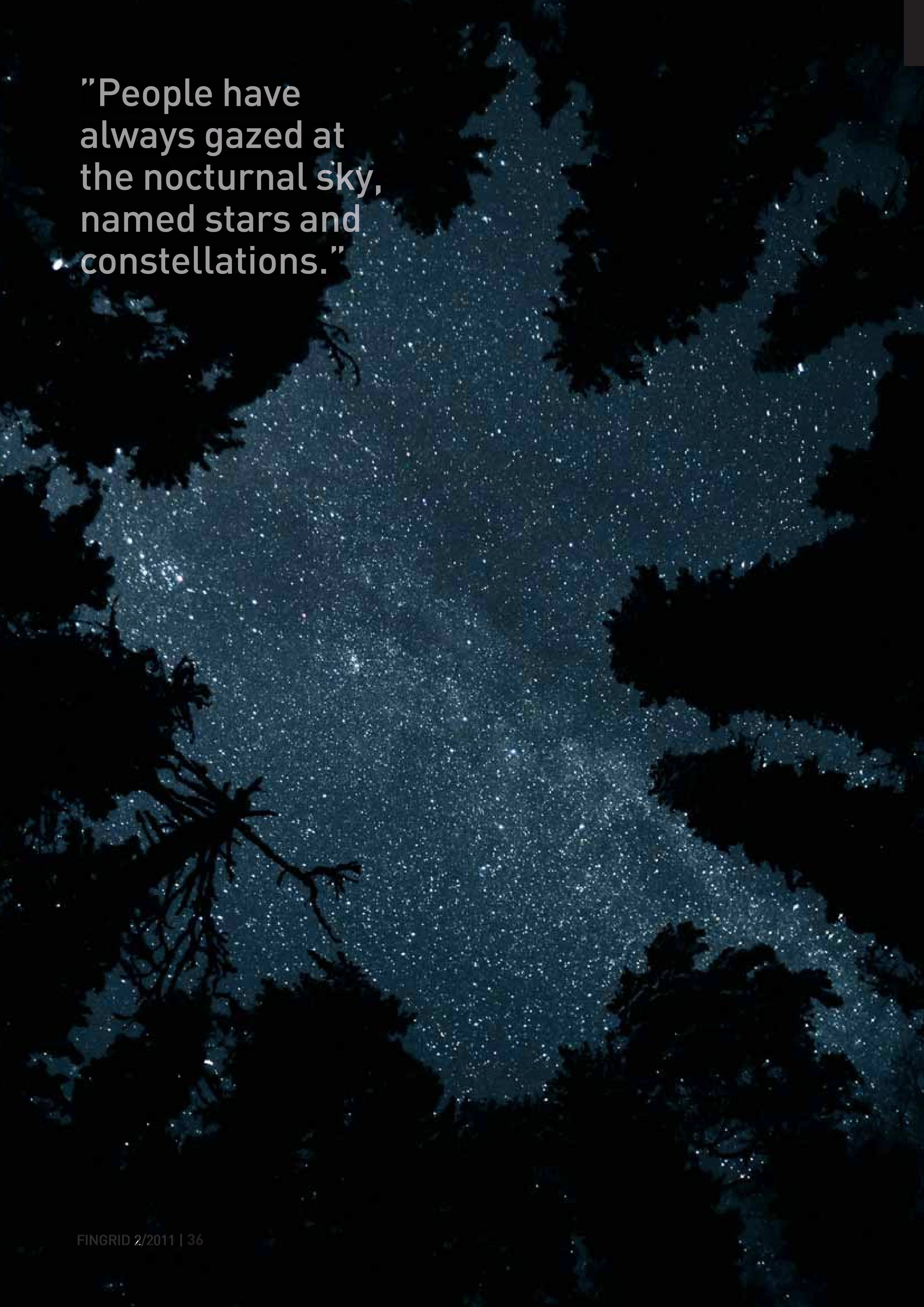
In conjunction with the loss of DC power, the reactive power consumption of the link also drops to zero, whereby the filter units used for the compensation of harmonic currents fed by the link raise the 400 kV voltage temporarily by approx. 25 kV. The raised voltage lasts until the link re-starts power transmission after a successful automatic reclosing sequence caused by an instantaneous fault. Figure 2 also illustrates very well the ability of the link to control its power extremely quickly. Following a successful automatic reclosing sequence, the link returns from zero power to full power in approx. 100 ms as shown by the figure.

**After the successful transmission tests**, Rauma was made the rectifier, in other words the transmission direction was changed to the west. This was not quite that straightforward a process due to the inexpensive Norwegian hydropower. The area price in Sweden ranged between 10 and 15 €/MWh and in Finland between 30 and 40 €/MWh, so we had to run 800 MW against the intrinsic transmission direction of the market. Fortunately, Fenno-Skan 1 compensated for this by importing 500 MW into Finland, so the limitation on the market was not very dramatic.

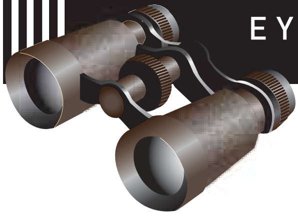
The tests performed were almost a mirror image of the tests carried out in the previous week, considering certain "specialities" at Finnböle in Sweden, such as the starting sequences of the emergency diesel generators in the event of auxiliary power failures. The test period culminated in 10 hours of uninterrupted heat run test, operation at a constant load of 800 MW.

**The high-voltage machinery** in Rauma and Finnböle was subjected to thermal imaging in order to find hot spots and other similar issues. The installation work had been done very carefully; there was only one joint of a filter capacitor unit in Rauma that had to be tightened. Performance measurements related to the acceptance tests were conducted at the same time in Finnböle. The audible noise caused by the link, the harmonic components in the AC network produced by the link, and the auxiliary electric energy consumed by the converter station were measured to verify the guarantee values. The behaviour of the control system of the link in a commutation failure was not modelled, because this would have called for a phase-to-earth fault to be made in the 400 kV AC network. However, mother nature came to the scene in the form of a rare autumn storm: a lightning struck the 400 kV transmission network, causing a significant voltage reduction in the high-voltage grid. Fenno-Skan 2 managed the commutation failure well.

The testing period of Fenno-Skan 2 continued by the trial operation period of two months conducted by Fingrid and Svenska Kraftnät. During this period, the issues tested included the overload capacity of the link. ■



”People have always gazed at the nocturnal sky, named stars and constellations.”



# Under the Milky Way

The first snow falls in the morning. It covers the base of the forest and descends on the spruce branches, illuminating the short day. Then it gets clearer; the first subzero night is ahead.

I am sitting on a cliff beside a pond, awaiting the night to come. The last rays of the Sun light the treetops to an orange and red glow, then the twilight creeps in the forest. The shadows turn darker slowly, but the new snow shimmers on the stones and stumps. Even though the eyes become accustomed to the diminishing light, the world changes into something else: imagination inhabits the unsociable black of the shadows with creatures that you do not come across in daylight.

Finally, the last glimmer of light dies, and the first stars spark up in the sky. I descend into the darkness of the spruce copse, where each step requires careful consideration. A few minutes more and above me is a fantastic ceiling of stars, which is split by the bright belt of the Milky Way. The tops of tall spruces reach for it forming a circle, with an opening leading to beyond immeasurable times in its centre. I see stars whose light has been emitted towards the Earth millions of years ago. Some of them may have died already, but they are still visible well into the future. So far into the future that people no longer exist.

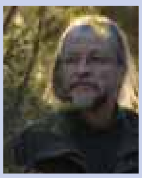
It is a staggering thought, the dimensions are dazzling, and the number of stars glowing in the night is stunning. Yet I can only see a minuscule part of the universe. And not a long time ago, we thought that the Earth is the centre of everything.

People have always gazed at the nocturnal sky, named stars and constellations, written their myths in them, and navigated by them on their journeys. Our forefathers have known the cycle of the firmament around the North Star and seen the Swan lead the migratory birds of the autumn along the Milky Way. Both of the sacred animals of the ancient Finns, the bear and the elk, were born among the stars.

In the darkness of the moonless night, under the staggering sky, it is easy to let your thoughts lead you. Nothing is like in the daytime. The cold makes a dried tree trunk snap sharply, then it is absolutely quiet again. This highlights the importance of hearing as darkness renders the eyes almost useless. Man shrinks to his actual size, the imperfection of human senses is concrete. I am smelled and every step I take is heard, but I can but guess what goes around me. I see the sky brightened by the stars and the treetops stretching out towards them, everything else is black darkness.

I am not afraid of the dark, and there is actually nothing to fear here amidst the forest. Still, the darkness occasionally brings to surface a suggestion of fear. It concerns nothing specific, it is just a strong, inexplicable feeling, maybe a memory embedded in my heredity from times when my ancestors crouched beside a fire tormented by the forces of darkness. The feeling comes from somewhere far in human history.

We are daytime animals, darkness represents something unknown and unsafe to us. It is easy to explain the instantaneous jitters away, they disappear and peace comes in their place. The hurry and the unnecessary fade away, the thoughts find their way naturally to the beginning of everything and to one's own existence on this tiny planet swarming with life as it circles its star in one corner of the cold space. The thoughts crystallise in the miracle that this has just happened to be, that a solar system just like this has come about from void and dust. That everything surrounding me has evolved into something like this over billions of years. That I am here and viewing the past spreading above me – messages of light from beyond the times.■



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 "Hirven klaani" (Otava 2005), "Pyhät kuvat kalliossa" (together with Timo Miettinen, Otava 2007), "Huuhkajavuorella" (together with Leo Vuorinen, Maahenki 2008) and "Viimeiset vieraat – elämää autiotaloissa" (together with Kai Fagerström and Risto Rasa, Maahenki 2010). Heikki Willamo's special objects of interest include forest nature in Southern Finland, Northern rock art, and myths related to animals.

# History of industry and everyday life in an electronic archive

**The digital material at the Arjenhistoria.fi portal is increasing steadily. Electricity Museum Elektra is involved in the co-operation for the relevant collection.**

Electricity Museum Elektra began collection co-operation within the Akseli consortium in 2009. Akseli encompasses eight museums in different parts of Finland, all recording industrial history and the history of everyday life in various formats.

Elektra's role as a special museum for the history of electrification is suitably associated with the recording of electric items and pictorial material. The collections in the Akseli system contain lists of approx. 1,400 objects, 1,100 books and other printed publications, and 2,500 photographs. Much of this material can be browsed publicly at portal www.arjenhistoria.fi maintained by the consortium.

Elektra's portion consists largely of the following materials:

• The articles represent consumer electronics dating back as far as the end of the 19th century. There are also some items related to the high-voltage electricity transmission grid.

• About 80 per cent of the photographs date from the days of Imatran Voima and are related to the construction and operation of the transmission grid. The collections also contain pictorial material of the former Finnish Electricity Utility Association, with electricity instruction directed at consumers as the main topic.

• The library covers a very wide range of electricity-related materials, from the history of electrical engineering to today's game culture.

• In addition, Elektra possesses some of the archive material of Imatran Voima related to the construction and maintenance of the transmission grid.

The online collections can be browsed freely, and for example photographs can be requested for use in research and publications. On a case-by-case basis, the use of the material may be subject to a fee, or it may be free of charge.

The purpose of the Arjenhistoria portal is to serve random visitors interested in history, and also research organisations and for example advertising agencies. No other online source in Finland contains as much material related to electrical engineering, and as the cataloguing work goes on, the amount of the material will increase steadily.

# New service procurement for maintenance management

**Fingrid has made decisions concerning the procurement of basic maintenance for substations and transmission lines, maintenance of secondary devices, and management services for the central warehouse for 2012 to 2014. The qualification system was applied for the first time to the procurement of basic maintenance for substations and transmission lines.**

**The basic maintenance agreements for substations** are used for procuring the basic maintenance, inspection, local operation and standby duty services for Fingrid's 110 transformer and switching stations and 150 disconnector stations, including their material, spare part and subcontracting services, and the basic maintenance services for the substation components of the company's 10 reserve power plants.

The suppliers of basic maintenance services for substations in the various work areas are as follows:

| | |
|---|---|
| Eastern Finland | VR Track Oy |
| South-Eastern Finland | Voimatel Oy |
| Häme | VR Track Oy |
| Uusimaa | Infratek Finland Oy |
| South-Western Finland | Empower Oy |
| Western Finland | VR Track Oy |
| Northern Ostrobothnia | Infratek Finland Oy |
| Lapland | Kemijoki Oy. |

**The basic maintenance agreements for secondary devices** are used for procuring the seasonal testing, guarantee testing, fault repairs, device replacements, setting changes, minor improvement work, and local switching for secondary devices.

The suppliers of basic maintenance services for secondary devices in the various work areas are as follows:

| | |
|---|---|
| Eastern Finland | Infratek Finland Oy |
| Southern Finland | Infratek Finland Oy |
| Western Finland | Infratek Finland Oy |
| Northern Ostrobothnia | Infratek Finland Oy |
| Lapland | Kemijoki Oy. |

**The special maintenance agreement for secondary devices** is used for procuring issues such as expert services, maintenance of busbar fault and circuit breaker fault protection, demanding guarantee testing, demanding fault repairs, and condition monitoring measurements of power and instrument transformers.

The supplier of special maintenance services for secondary devices is Infratek Finland Oy.

**The basic maintenance agreements for transmission lines** are used for procuring the inspections, some of the repair work, minor modification work, and regional fault tracing and fault repair readiness for Fingrid's 14,300 kilometres of transmission lines.

The suppliers of basic maintenance services for transmission lines in the various work areas are as follows:

| | |
|---|---|
| Eastern Finland | Eltel Networks Oy |
| Häme and Uusimaa | Eltel Networks Oy |
| South-Western Finland | Empower Oy |
| Western Finland | Empower Oy |
| Northern Ostrobothnia | Eltel Networks Oy |
| Lapland | Eltel Networks Oy. |

**The service agreement** for the management of the central warehouse is used for procuring the daily services for Fingrid's central warehouse in Hämeenlinna, which stocks backup devices and parts for substations. The service provider is Empower Oy.

## 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 10 January 2012. Address: Fingrid Oyj, PL 530, 00101 HELSINKI, FINLAND. Mark the envelope with "Verkkovisa".**

Among all those who have given right answers, we give 5 Silvan ex-10 pace counters as prizes by drawing lots.

**1. If the frequency in the grid changes, the frequency controlled disturbance reserve is activated in full in**

- 30 seconds
- 2 to 3 minutes
- 5 to 6 minutes.

**2. Fingrid will renew the transmission network on the west coast from Pori to Oulu in this decade. The most recently completed transmission line included in this major project extends from Seinäjoki to**

- Alajärvi
- Kokkola
- Tuovila.

**3. The work of the so-called SIMA task force is related to the**

- improvement of electrical safety
- preparations for the introduction of the new single market directive
- cherishing of Mayday traditions in Finland.

**4. The level of return of the transmission business in Finland is regulated by the**

- Competition Authority
- Consumer Agency
- Energy Market Authority.

**5. Fingrid is involved in examining the use of a battery-based energy reserve as a frequency controlled reserve. In view of the nation-wide grid, a usable energy battery would be approximately as large as a**

- medium-sized block of flats
- medium-sized single-family house
- small single-family house.

**6. The present Chairman of Fingrid's Advisory Committee is**

- Helena Walldén
- Hannu Linna
- Tapani Liuhala.

**7. The Touko 2011 exercise tested the**

- co-operation between various parties in a major disturbance of the power system
- level of occupational safety at Fingrid's transmission line sites
- first aid capabilities of Fingrid's personnel.

Name ______________________________

Address ______________________________

Post office ______________________________

E-mail address ______________________________

Telephone number ______________________________

Winners of prizes of the Grid Quiz in the previous Fingrid magazine (2/2011): Marjut Honkavaara, Helsinki; Keijo Lindberg, Mikkeli; Juho Louhelainen, Oulu; Pauliina Pietikäinen, Kontiolahti; Veli Wirkkala, Porvoo.

# Merry Christmas
## and a Happy New Year!

This year, we donate the sum reserved for our Christmas greetings to the operations of the Finnish Red Cross in Finland.

# FINGRID OYJ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