Corporate magazine
Fingrid Oyj 2/2012

FINGRID

EVOLVING TRANSMISSION GRID

4 Design in a national landscape

10 Strength of transmission line towers put to the test

22 Planning the network with the customer

FINGRID
Corporate magazine
Fingrid Oyj
15th volume
2/2012

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Cover photograph: Fingrid's new field tower was given the first prize in the Fennia Prize 2012 design competition in June. Shown in the photograph (from the left) are Fingrid's Kari Lindholm, who served as the Project Manager in the tower project, Managing Director Pekka Toivanen of design agency Muotohiomo, Fingrid's Executive Vice President Kari Kuusela, and Muotohiomo's designer Iikka Airas around a scale model of the tower.
Photograph by Jonna Monola

Printed by Libris Oy, Helsinki
ISSN-L: 1456-2693
ISSN: 1456-2693 (Print)
ISSN: 2242-5985 (Online)

In this issue

4 **Design in a national landscape** | Fingrid's field tower won the Grand Prix in the Fennia Prize 2012 design competition.

8 **First field tower to be erected in Hyvinkää** | The award-winning field tower will be seen first in Hyvinkää next summer. The tower will be erected on the Nurmijärvi–Hyvinkää–Hikiä transmission line.

10 **Putting the towers to the test** | Fingrid has launched a testing programme which covers all the type towers used in the company's transmission lines.

13 **Safety at work as the topic in asset management seminar**

14 **Responsibly for the future** | Fingrid's land use and environmental policy has been compiled into a single volume. Fingrid is highly committed to the relevant principles.

16 **Money is a scarce commodity** | The uncertainty prevailing in the global economy and financial market has influenced corporate fund raising. This is reflected in the everyday work of Treasury Manager Katrina Klinge-Sonninen.

18 **Campaign on the dangers of transmission lines** | Electricity is a good servant but a poor master. A campaign shared by the electricity industry tells you to beware before action near electrical networks.

21 **Know the terms** | Step voltage

22 **Grid planning in co-operation** | According to Special Adviser Antero Reilander, the execution of grid projects works best when the customers and all stakeholders are closely involved in the efforts.

25 **In brief**
Grid Quiz

26 **New nuclear power capacity to the grid** | Fingrid is making preparations to connect the new nuclear power units to the transmission grid. The surveys concerning the grid reinforcements have been launched.

28 **Transmission system operator on Åland Islands** | The grid owned by Kraftnät Åland covers about 300 kilometres of 110 and 45 kilovolt lines, substations and interconnections to mainland Finland and Sweden.

31 **Powered by electricity** | Electric partner of commuter cyclist

32 **Grid ABC** | Voltage in electricity transmission and distribution systems

34 **Eyes on nature** | Master of the forest

EDITORIAL

COMPETITIVE TRANSMISSION SYSTEM
at competitive tariffs

The energy infrastructure is an important competitive factor for Finland. We have learned it the hard way that our society requires more and more from electricity networks. This is so because the dependence of society on electricity and its sensitivity to disturbances have increased substantially.

The updating of our existing electricity networks calls for considerable financial input. With Fingrid's system, the price tag is about 1.7 billion euros during this decade. A corresponding update was carried out most recently in the 1970s, when electricity consumption grew rapidly and large coal and nuclear power plants were connected to the grid.

Our heavy capital investment programme together with a rise in market-based costs has created a pressure to increase the transmission tariffs. The tariffs were raised by 30 per cent at the beginning of this year. Our customers referred to this raise as "huge", although they understood why the raise was needed.

The reasonableness of the transmission fees levied by Fingrid is monitored by the Energy Market Authority. In accordance with the regulation model applied, Fingrid's owners have the right to a reasonable return on the basis of the capital invested in the transmission system. Our owners have decided that a level of return allowed by the regulation model will be gradually introduced during the regulatory period of 2012 to 2015. This will translate into annual tariff adjustments.

Simply put, the tariffs are determined by the regulation model and based on the company's cost level. A cost-effective company has a lower tariff. Fingrid's cost control measures also serve our customers. Our key objective is to retain our transmission prices at a level which is competitive on a European scale. We are determined in improving our organisational performance. We report transparently the trend in factors which influence our financial performance. We also measure our cost efficiency by participating in international benchmarking studies.

We do everything we can to avoid unnecessary investments. Firstly, we follow the principle of transparency in terms of our capital investment programme. On the other hand, the programme schedule is mostly determined by the completion times of new electricity generation facilities. Future investments in power generation capacity involve many political and market-related uncertainties. This is why we make the decisions concerning the transmission system investments only after a customer of ours has made its own investment decision.

Such a just-in-time approach involves a schedule risk. What if the generation plant is ready before its connection to the transmission system? In order to control the risk, we carry out the environmental impact assessments, permitting processes and necessary preliminary planning in advance. This approach also facilitates the service providers, because most of the uncertainties related to the schedules have been eliminated through the work carried out in advance. This is reflected in the prices of work and equipment. And ultimately it is our customers who draw the benefit.

This year has shown that Fingrid's finances also involve a number of uncertainties. It is really difficult to forecast electricity consumption in the current economic situation. The market prices of power system reserves have increased rapidly. There should absolutely be more competition and new players in the reserve market, both among electricity producers and users. The volume of electricity imports from Russia has dropped dramatically as a result of the capacity compensations introduced there, so our cross-border income has reduced correspondingly. Somewhat paradoxically, our finances have been relieved by the record-high congestion income resulting from the inadequacy of cross-border transmission connections. On the other hand, these congestions have also disturbed the electricity market mechanisms.

In the future, operational and investment efficiency can be enhanced through closer co-operation between the players in the industry and by finding new kinds of shared procedures. A more active contribution of electricity consumption to the security of supply is one possibility, as are investments to be made in reserve power capacity. Co-operation enables us to keep up a high level of security of supply cost-effectively – to benefit our customers and society.

Jukka Ruusunen
President & CEO

fenniaprize 12
good design grows global
GRAND PRIX

Design in
A NATIONAL LANDSCAPE

Well designed, thoroughly considered, a beautiful and simple entity. These were among the characterisations that won Fingrid's field tower the Grand Prix in the esteemed Fennia Prize 2012 design competition.

Text by Ursula Aaltonen | **Photographs by** Mait Jüriado, Jonna Monola, Muotohiomo and Futureimagebank

"The first prize was not only awarded to a well-designed product, but also to a well-implemented process and a brilliant entity. Fingrid is an exceptionally interesting enterprise also because it has been an internationally prominent trailblazer in its industry in the utilisation of design," says **Mikko Kalhama**, Managing Director of Design Forum Finland.

Fennia Prize is a biennial international design competition for enterprises. The primary objective of the competition is to promote the competitiveness of Finnish businesses. The competition is arranged by Design Forum Finland, which promotes Finnish design, and the insurance group Fennia. This year, about 100 works participated in the competition. In addition to the Grand Prix, 4 Fennia Prizes and 20 commendations were given.

Earlier, Fingrid has used design know-how mainly in the landscape towers. Probably the most renowned landscape towers are Sinikurjet (Blue Cranes) designed by **Antti Nurmesniemi**, located in Espoo. According to Mikko Kalhama, the field towers take the concept a long step forward. "The field tower is not a unique design item, but a bulk product intended for serial production. It brings design to somewhere where you do not expect to see design. It brings design as part of the immediate infrastructure in Finland."

Beneath the surface

What appeals to Mikko Kalhama's professional eye in the field tower is its airy and balanced structure. "For a structure that big, the tower sits amazingly well in the landscape type for which it has been designed – in the Finnish field landscape."

That is much to say about something that is more commonly thought to be a necessary evil ruining the landscape. Mikko Kalhama thinks that in the case of the field tower, the traditional setup has been turned upside down. "The tower can even be said to bring scenic benefits. It is a streamlined, simple and thoroughly thought-out entity, which pleases the eye."

Another decisive thing was that design was used for discovering a new, well-functioning solution for the foundations of the tower. Foundations made of concrete elements which are assembled at the site and for the most part buried beneath the ground surface give savings in transport costs and take up less space on farmers' fields. "Extending the design aspect also to the foundations allowed the use of a simpler tower structure. In other words, the design process literally went beneath the surface," Mikko Kalhama says.

Practical is beautiful

Mikko Kalhama thinks that the field tower also reflects the contemporary approach in Finnish design; "back to the roots" in a sense. "The scope of design has expanded and diversified tremendously in recent years with the introduction of digital design and new immaterial areas." Another good example of modern design, alongside the field tower, given by him is the service design project of the Helsinki City Library. This project was also awarded in the Fennia Prize competition.

Mikko Kalhama considers that the growth and diversification of the design industry is, of course, a primarily positive thing. However, he adds that the success of the field tower in the competition serves as a good reminder of what Finnish design is all about at best. "Finnish design has never been luxury, but above all 'beautiful practicality'. However, simplicity and practicality have been forgotten at times and overshadowed by excessively complex and purpose-oriented solutions."

According to Mikko Kalhama, the essential thing is that design is anchored to concrete things. At best, it changes culture. "This is also the case with the field tower."

"The jury was exceptionally unanimous about the winner of the Grand Prix," says Design Forum Finland's Managing Director Mikko Kalhama, who was also on the jury.

Making a farmer's life easier

However, the field tower is a solution to an everyday problem in transmission →

The opening ceremonies of the Fennia Prize exhibition were held at Kaapelitehdas in Helsinki in early June. The field tower was also on display in the centenary exhibition of the Finnish Association of Designers Ornamo.

On the next page, the happy winning team behind the field tower in the awards ceremony. The certificate of honour is held by Fingrid's Kari Kuusela (at the front), and Muotohiomo's Pekka Toivanen is standing on his right. Also shown is Antti Kuljakka (at the back on the right), CEO of Fennia, which sponsors the prize. The right-hand photograph shows Fingrid's former Environmental Manager Sami Kuitunen, who was also involved in developing the idea of the field tower.

line construction rather than a design item. A transmission line tower model enabling work close to the tower was needed for field areas where transmission lines run. The guys, or support wires, of conventional towers prevent the use of agricultural machinery right next to the towers and hence reduce the available arable field area.

In fact, the idea for the design of the new tower model originally came from feedback received from farmers. The most important target group has also been heard in the various stages of the design process. "Based on feedback given by farmers, we enlarged the openings between the legs of the tower so that all agricultural machinery used in Finland can be driven through them," says **Pekka Toivanen**, Managing Director of Muotohiomo, the design agency that designed the field tower.

The design work of the field tower took a total of about 18 months, including thorough familiarisation with the topic and background work. The design work was limited by the strict structural, technical and safety considerations. "The decisive factor was that the design process involved Fingrid's own experts right from the outset. Their contribution was crucial – as was the fact that we got a free hand to create ideas and come up with something new," Pekka Toivanen praises the seamless co-operation between the various parties.

Out to conquer the world

The World Design Capital Helsinki 2012 project in Finland has generated a lot of positive activity and raised design into the hub of current debate even on a wider scale. The field tower has also benefited from this. It has been presented in two different places during this summer – in the Fennia Prize exhibition erected at Kaapelitehdas in Helsinki and in the centenary exhibition of the Finnish Association of Designers Ornamo.

Mikko Kalhama predicts that the field tower will have a prosperous future even after the summer. Next, the exhibition composed of the items awarded in the Fennia Prize competition will be packed into crates and sent abroad to gather international fame. "It is conventional that those reaching success in this competition have done well also in other parts of the world."

Design and technology hand in hand

The first idea of the field tower came about – naturally – in the field.

"I have spent a lot of time in the countryside since childhood; my first job was working on the potato field. My present home is also in the country, in Kirkkonummi, next to a transmission line. I have been looking at the towers for a length of time and thinking whether or not something could be done to them," says Muotohiomo's Managing Director **Pekka Toivanen**. The tower design project that lasted a couple of years ended up well. "A successful outcome and a satisfied customer are the best thanks we can get. Fennia Prize is a great bonus on top of it all; these things are a rare treat for any designer."

"Fennia Prize is a great recognition of persistent work," said Fingrid's Executive Vice President **Kari Kuusela** in commenting on the prize. "In this project, we have managed to combine design and technology in a successful manner. The way I see it, this recognition is above all a testament to that."

Despite the strong presence of design, the planning of the field tower has been based on the practical aspects. The goal was to achieve a tower that not only adapts to the landscape but one that is also as safe and functional as possible. "The key objective for us was to accomplish a new tower that needs no guys. A tower with no guys not only facilitates cultivation but also adds to safety when moving on fields," Kari Kuusela says.

The field tower to be taken into use in 2013 has passed exacting strength and safety tests. Kari Kuusela estimates that 10 to 20 field towers will be erected on Fingrid's transmission lines annually.

The price of a single field tower is about 60,000 euros, which is roughly twice as high as that of a conventional tower. "However, if we look at the total costs, the difference is small, because on average the towers only account for about 2 per cent of all the costs of a transmission line. We will use the field towers only where they are necessary, in other words primarily on arable field areas. The parts of transmission lines traversing forests continue to have conventional towers." ■

Project Manager Hannu Kuikka following the erection of a 110 kilovolt transmission line tower south of Hyvinkää in early June.

Nurmijärvi–Hyvinkää–Hikiä transmission line project in brief

- total project budget 13.5 million euros
- schedule
  - completed in September 2013
  - foundation work Jan 2012 to Feb 2013
  - 110 kV installation work Apr 2012 to Jun 2013
  - 400 kV installation work Jan 2013 to Sep 2013
  - dismantling work in Metsäkalteva area Sep 2013 to Oct 2013

FIRST FIELD TOWER
to be erected in Hyvinkää

Fingrid will renew the transmission lines running between Nurmijärvi, Hyvinkää and Hikiä in Southern Finland. Proximity to urban settlement affects the way in which the transmission line is constructed: part of the existing line will be transferred to a new route, and new types of towers will be used to streamline the landscape. Fingrid's first field tower will also be erected in Hyvinkää.

Text by Tiina Miettinen | **Photograph by** Juhani Eskelinen

Fingrid is strengthening the high-voltage transmission system in Southern Finland by building a new 400 kilovolt transmission line from Hyvinkää to Hikiä in Hausjärvi. The 110 kilovolt double circuit line originally built in the 1920s between the Hikiä and Nurmijärvi substations will be modernised at the same time, and transmission line rearrangements will be carried out in the Metsäkalteva area in Hyvinkää.

The renewal of the transmission line between Hyvinkää and Hikiä is part of the ten-year capital investment programme in the Finnish transmission system. The Hyvinkää switching plant will be decommissioned, and line rearrangements will be made at the Hikiä substation which forms a node in the network. Preparations will be made at Hikiä for a situation where the 400 kilovolt network will be extended further to Forssa and later to the east and north. The 110 kilovolt transmission line between Hikiä and Nurmijärvi also calls for a renewal, because the old line built as early as the 1920s is in a poor condition.

Around a new residential area in Hyvinkää

The transmission line work will mostly take place in existing transmission line routes. In some places, the new 400 kilovolt transmission line will be located in a new route or shift slightly at the corner points of the line. In Hyvinkää, the 400 kilovolt transmission line will be transferred to a new route to give way to the new residential area of Metsäkalteva and the Kravunharju housing fair area.

The length of the line section between Hyvinkää and Hikiä is approx. 17 kilometres and the section between Nurmijärvi and Hikiä about 29 kilometres. The contractor in the project is the Finnish company Eltel Networks Oy.

The construction of the transmission line between Nurmijärvi and Hikiä begun by foundation work in January this year. The dismantling of the existing transmission line structures and the construction of the new lines are progressing in stages so that the entire project will be ready by the end of October 2013.

According to Fingrid's Project Manager **Hannu Kuikka**, the project adjacent to a residential area is a fairly typical transmission line construction project. However, a few kilometres of the line will be built using new types of tower models.

"We have taken the impacts on the landscape into account near residential areas. On the north side of the Hyvinkää substation, we will use streamlined conical tube towers. They are considerably more expensive than standard tower models, but they are also better adapted to the built-up landscape," Hannu Kuikka says.

The first field tower designed for Fingrid will also be erected in Hyvinkää.

"The field towers will primarily be used in the construction of new transmission lines in field areas. A model tower will be erected near the Hyvinkää housing fair area in early 2013," says Hannu Kuikka. ■

PUTTING THE TOWERS TO THE TEST

Fingrid testing its most common tower types

A transmission line tower must be able to withstand considerable loads in the Finnish conditions. It must stand without breaking in heavy winds and burdened by ice loads accumulated on the structures. To secure this, Fingrid has launched a comprehensive testing programme, which covers all the type towers used in the company's transmission lines.

Text by Maria Hallila | **Photographs by** Ritva Laine

The testing programme is based on a project aiming to put together a "tower family" of Fingrid's type towers. It would cover up to 90 per cent of the tower types most commonly used by the company. According to Project Manager **Ritva Laine**, the number of type towers selected in the family is close to 30.

"By having an established basic range of towers and by using ready-made plans, we can intensify and expedite both the construction of transmission lines and line maintenance," she says.

Not many testing stations

During her career of more than 20 years, Ritva Laine has participated in the testing of 20 or so transmission line towers. In the past four years the tests have concerned the so-called type towers. The tests for the new towers used on the overhead line section of the Est-Link 2 transmission interconnection between Finland and Estonia have been conducted under the supervision of Project Manager **Ritva Hauvonen**.

What makes the testing of the towers complicated is the fact that there are not that many testing stations available. In Europe, there are such facilities only in Spain, Italy and Romania, and only the one in Romania enables the testing of guyed 400 kilovolt transmission line towers more than 30 metres in height.

Fingrid has had towers tested also in China, where the testing station is unique in that it can test towers as high as 140 metres.

"The testing station in China is less favourable than its European competitors in terms of logistics. There is no point in transporting the towers there, so they are manufactured in China," Ritva Laine says.

She says that this is sometimes standard practice also with European testing stations. Tubular towers are mostly manufactured in Finland and transported to the testing site in parts by road.

Ritva Laine and Ritva Hauvonen commend the Romanian testing station for service flexibility, activity and response ability. The station has acquired new equipment and facilities specifically for Fingrid's needs.

Efficiency from IT

The strength requirements applied to towers used in the Finnish high-voltage transmission system are laid down in European transmission line standards.

The load has been raised to just over 100 per cent of the test load, whereby the steel bends somewhat in accordance with its characteristics.

Fingrid's type towers have passed the strength tests without any major problems.

The tests model a range of forces exerted on the towers – for example ice, wind, installation and safety loads – by means of pull wires, pulleys and winches attached to the structures. The tests verify that the strength calculations of the tower hold true and that all joints are correctly designed.

Ritva Laine says that it typically takes about four months for a single tower to be manufactured, transported, erected, tested and dismantled. The actual testing by the current methods can be carried out within one working day.

Information technology has gained an increasingly important role in the testing process in recent years. "As a result, the testing times are now shorter and the work stages have become easier. Information technology has also improved the manageability and safety of the tests," she adds.

The testing programme detects, for example, if the tower bends too much at some point. "In such a case, the load is released automatically, and there is no damage or accident."

Solid structures

The testing of transmission line towers complies with the relevant European standard. According to Ritva Laine and Ritva Hauvonen, Fingrid's towers have passed the strength tests without any major problems.

"There have been slight problems a few times during the tests, but the tests have been completed successfully after correcting these problems," they say.

The testing takes place in stages: the load is first adjusted to 50 per cent and then gradually to 75, 90, 95 and finally to 100 per cent of the limit value set for the capacity of the tower.

The testing can continue even after the 100 per cent load level has been reached. "This is not mandatory on the basis of the standards, but it is a way of finding out what the tower really withstands. The information may be useful when the goal is to optimise material cost-effectiveness, for example," Ritva Laine says.

After testing, the tower is dismantled, and it is examined whether the deflections have remained within the prescribed limits. A tower that passes the test is included in Fingrid's type tower family. →

Stages of testing of transmission line tower

Before testing, the designer of the tower and the testing station draw up a test programme. The test programme contains information on the loads that the tower is designed to withstand, and the proposed testing sequence and testing method, including the fixing points of pull wires.

Manufacture of the tower, transport to the testing station, and erection.

The load sensors are calibrated to ensure the accuracy of the results.

Pull wires and load sensors, which measure the load exerted on the tower by the wires, are attached to the tower.

If the testing also covers the measurement of stresses occurring in the steel, strain gauges are attached to the towers.

The guys of the tower are provided with measuring instruments used for monitoring the forces created in the guys.

The load situations are examined in accordance with the test programme. Displacements are measured at each load step (50%, 75%, 90%, 95%, 100%) and also when the load has come down to zero (permanent deflection).

Material samples are taken from the tower, used for ensuring that the steel in the tested tower is of the right quality.

After the tests, the tower is scrapped and recycled. The towers are tested with no zinc coating, because galvanizing is expensive, and it does not change the strength properties of the steel.

1. The tests model a variety of forces exerted on the towers. The forces are directed to the tower structures via portals by means of pull wires.

2. The loads are created by means of automatically-controlled winches.

3. The load sensors of the test equipment are provided with a direct optical fibre connection to the computer in the control room of the testing station.

4. Before testing, the pull wires are secured to the tower structures and tightened. The tapes on the tower are used for fastening the strain gauges, which measure the tensions occurring in the steel.

Asset management day focused on occupational safety

Fingrid arranged the traditional asset management seminar for its service providers at the end of May. This time the seminar concentrated on safety at work.

The topic was covered in a number of speeches and in a panel discussion. In recent years, there have been both successes and failures in occupational safety. The number of serious injuries has decreased, but at the same time the accident frequency has grown. The primary goal therefore is to change the attitudes and working culture.

In the seminar, Fingrid's Executive Vice President **Kari Kuusela** described the company's extensive construction programme. The year 2011 was a record year in the number of person-workyears alone: a total of 625 person-workyears were performed at Fingrid's work sites, while the normal figure is about 500. There were as many as 160 people working at the Forssa reserve power plant. Some of the increase in the number of accidents is explained by the higher amount of work, but despite this the goal must be to reach zero accidents.

In the asset management seminar, awards were presented to the builder of the year and to the maintenance person of the year. These are service providers' representatives who have excelled themselves. The builder of the year award was given to Infratek's **Kari Likander**, who served as the project manager for the Uusnivala, Tuovila and Huutokoski 400 kilovolt substation projects in 2011. Kari Likander's efforts in substation projects are characterised by thorough and detailed technical knowledge and expertise, also as regards installation work and switching planning.

The maintenance person of the year award went to Empower's **Juha Laukkola**, who is responsible for Fingrid's transmission line maintenance in Western and South-Western Finland. Juha Laukkola was credited for improving the quality of maintenance service. His contribution has been flexible, and the work has been completed well even with a short notice. The development proposals presented by Fingrid have been received positively, and they have been put into practice.

Photographs by Juhani Eskelinen

Juha Laukkola and Kari Likander emphasised the importance of teamwork in their speeches.

Elering and Litgrid become Nord Pool Spot shareholders

The Estonian and Lithuanian electricity transmission system operators Elering and Litgrid each acquired a 2 per cent share of Nord Pool Spot, Europe's largest power market, at the beginning of August.

In addition, it has been agreed that the right of the Latvian TSO, Augstsprieguma Tīkls (AST), to acquire a 2 per cent share of Nord Pool Spot will be granted when the new Latvian power market opens.

Once all three Baltic TSOs are established as shareholders, existing shareholders Statnett and Svenska Kraftnät will each hold 28.2 per cent of Nord Pool Spot, and Energinet.dk and Fingrid will both hold 18.8 per cent.

The four Nordic TSOs see the extension of ownership to the Baltic TSOs as an important and natural step in the further integration of the Baltic and Nordic electricity markets.

For the Baltic TSOs, part ownership of Nord Pool Spot is a strategic investment. It will enable their participation in the decision-making process, ensuring that the market interests of the respective Baltic countries are discussed and accommodated. It also allows the Baltic TSOs to contribute to Nord Pool Spot's corporate activities in developing the regional and European power markets.

Meanwhile **Nils Nygren** has been appointed the new chairman of Nord Pool Spot, effective from the same date. Mr Nygren was previously responsible for public affairs at the Nordic energy business Fortum and now works as a private consultant.

RESPONSIBLY for the future

As a result of more than a year's work, Fingrid's land use and environmental policy is now compiled into a single volume. "The principle was that we will not record anything to which we cannot truly commit ourselves," says Land Use Manager **Ilkka Alm**.

Text by Ursula Aaltonen | **Photograph by** Valtteri Kantanen

The compilation work was undertaken, because the fragmented principles pertaining to land use and environmental matters needed to be put together and given a concrete substance. "The basic idea was to make it work right from the outset so that everything is really well thought out. No wishy-washy statements, but things we can vouch for," Ilkka Alm points out.

Even though the land use and environmental policy principles were to a large extent already in place, it was not an easy task to record them. "When we build and maintain transmission lines, we usually work on other people's lands, so the very starting point is fairly unenviable. What we do and how we do it are under strict scrutiny, which is why we need to think especially carefully what we say of these things."

The land use and environmental policy is part of Fingrid's Code of Conduct, which has also been recently published as a separate publication. "Even though we are in a certain type of a special position because we are the Finnish transmission system operator, it is really important to us that whatever we do is socially acceptable in every way. We want to develop all of our activities in this direction – and also serve as a trailblazer here."

Into practice right away

The practical application of the land use and environmental policy principles will begin with the company's own personnel in the autumn. The personnel will be arranged for example group work sessions, where each business unit can consider the importance of the principles and their implementation as regards their own work.

Another major target group are Fingrid's partners, contractors and service providers. "For us, this is the most challenging target group, because they are the very people with whom landowners and our other stakeholders commonly come into contact."

> All efforts stem from a genuine desire to enhance the company's environmental policy.

In the future, the land use and environmental issues will be incorporated more closely into Fingrid's contract terms. The relevant matters will also be brought regularly to the agendas of site meetings. "We intend to monitor that things make progress as agreed. There will also be more regular environmental audits at the worksites than before."

All these efforts stem from a genuine desire to enhance the company's environmental policy. "Land use and environmental issues give us more feedback than any other sector," says Ilkka Alm.

This is why, he adds, it is of paramount importance to make all the partners committed to the implementation of these principles. "No matter how strong our strategic intent is, we can never reach a situation where everyone would always be happy with the way in which we work. And of course we sometimes give cause for criticism – but so that we can do something about it, we need to know about the problems. Therefore, it is very important for us to receive feedback."

Whenever transmission lines are constructed, the goal is always to produce as little inconvenience as possible to the environment, landowners and local residents. This is why the heaviest construction work on arable land is preferably scheduled for the winter season, when the ground is frozen and the work causes less damage to fields. However, this is not always possible, but sometimes the timing of construction work is determined for example by power plant outages. "The most important thing is of course to ensure uninterrupted electricity supply," Ilkka Alm says.

Wisdom of forethought

The changes in Fingrid's ownership last year have also increased the need for environmental reporting. Ilkka Alm is satisfied that the process to launch the reforms was started in good time – in fact, even before there was any knowledge of the coming changes. "The state owner requires from us accurate environmental reporting. We had some sort of wisdom of forethought, so now we can be really satisfied."

The long-term goal is to progress towards more comprehensive environmental management – one where the environmental matters are perceived as a natural part of all corporate management and operations. This requires that there is genuine commitment to the goals, throughout the organisation. "We worked on these principles for over a year. There were some 15 persons actively involved in the work, including the executive management. Of course, much more have been able to give their comments, so all who have been willing to contribute have certainly had their voice heard," Ilkka Alm sums up. ■

Fingrid's land use and environmental policy can be found on our website at www.fingrid.fi under Environment.

MONEY IS A SCARCE COMMODITY

Following several months of intense and thorough preparations, Fingrid issued a public bond of 300 million euros at the beginning of April this year. Fingrid's Treasury Manager Katrina Klinge-Sonninen played a key role in the arrangement which consolidates the funding base of the company's capital investment programme of 1.7 billion euros.

Text by Maria Hallila | **Photographs by** Juhani Eskelinen and Heidi Sonninen

Katrina Klinge-Sonninen considers it meaningful to have close co-operation with the company's Board of Directors in financial solutions. The principles of financing adopted by the Board guide the efforts, and the Board also receives regular reports of the financing situation.

"The uncertainty shadowing the global economy and financial markets has influenced corporate funding activities. 'Cash is king and money talks', but now, if ever, you can say that money is a scarce commodity," Katrina Klinge-Sonninen says.

"Only change remains constant"

Katrina Klinge-Sonninen says that turbulent times are testing the strength and reliability of companies' debt financing base. "Fingrid's financial policy is founded on a long-term approach. We assume that only change remains constant."

Fingrid's principles of financing are approved by the Board of Directors, and the financial exposure and financial risks of the company are reported regularly to the Board.

"The risks and their limits are set at Fingrid so that they are not changed frequently. Within the framework of risks, it must be possible to execute financing in a sustainable manner; financing must not cause fluctuation in the company's financial performance or compromise liquidity and financial position."

According to Katrina Klinge-Sonninen, the recent market volatility has proved clearly that Fingrid's financing principles are sustainable. It has not been necessary to change the principles even during great instability.

Money at the right price

Fingrid's capital structure is heavily debt-based. The company has an in-

There are some common traits in Katrina Klinge-Sonninen's work and favourite game. "Golf keeps you humble and requires practice, but the strategy in the course must be such that the game is certain in any situation – and that is the case also when you are looking for money to borrow," Katrina Klinge-Sonninen says with laughter.

ternational debt issuance programme of 1.5 billion euros, under which 757 million euros worth of bonds were outstanding before the major bond arrangement this spring. The company's total debt was 1.23 billion euros.

"As the treasury manager, I am to assure that the company has access to sufficient funding at the right price and at market conditions to carry out the operations and obligations of the company," is how Katrina Klinge-Sonninen summarises the key objective of her work.

"Since the debt portfolio has grown in terms of its size, there was a clear need to extend the maturity profile with this bond arrangement," she says.

An even maturity profile, i.e. the ratio of short-term and long-term debt to the total debt, is an important factor in the company's debt portfolio management. Well-working debt issuance programmes form a solid base for debt financing, diversified funding sources, high credit rating as well as long-term bank and investor relations activities. Leading international rating agencies have assigned Fingrid's credit ratings as follows: AA- (Standard & Poor's), A1 (Moody's) and A+ (Fitch Ratings).

The key terms and conditions of the bond of 300 million euros issued in early April are 12-year maturity, bullet redemption and an annual coupon rate of 3.5 per cent. The loan is unsecured, which means that the investors take a credit risk in Fingrid, in other words a risk of the company's ability to meet its obligations to repay the interest and principal over the next 12 years.

"In the European capital market, there have been very few corporate bonds issued in this maturity, which on one hand was an additional challenge, but on the other hand the bond listed on London Stock Exchange attracted great investor interest, and the bond was oversubscribed. The subscribers were about 70 European, Nordic and Finnish institutional investors," Katrina Klinge-Sonninen says.

According to her, the bond further strengthened Fingrid's position in both the domestic and international capital markets, and rendered the company better known among major European investors.

Actively on the cutting edge

Katrina Klinge-Sonninen finds the structure of Fingrid's debt financing and its management an exciting task. "The issuance of bonds and the stakeholder relations with investors and banks are a positively challenging playing field. The relations with these stakeholders are based on interaction and long-term co-operation, and they have become even more important in recent years," she says.

Having worked in Fingrid's treasury for more than 14 years, Katrina Klinge-Sonninen with her two degrees (Master of Science in Economics, and CEFA) has obtained demanding tasks, and also rewarding feedback for her expertise and success.

"The best response is that I can do my work independently and that I have always been able to move over from one project to the next. You must get an insight of the matters at hand and give all you've got," she says, still emphasising the importance of a good team.

"In the long-term bond arrangements of this spring, the work input of my superior CFO **Tom Pippingsköld** and Finance Advisor **Aila Siirilä** was invaluable."

At her workstation, Katrina Klinge-Sonninen has two computer screens to be able to follow the key indicators of global economies and markets. It is important to stay up to date not only in terms of debt financing but also the other duties included in her job description.

"Of the equity and liabilities in Fingrid's balance sheet, 70 per cent are liabilities. The company does not speculate, but hedges and secures risks. Risk management is emphasised, above all an active management of the interest rate risk, and the importance of the analysis and management of liquidity and counterparty risks as the uncertainty in the market has increased."

Leisure instruments

Katrina Klinge-Sonninen's days at work are spent with financing and risk management instruments. What kinds of instruments are part of her leisure time?

"All kinds of skis, bicycle, walking sticks, inline skates, running shoes, golf clubs, fishing gear," she lists her favourite equipment for the management of her own well-being.

"Outdoor exercise, no matter what the weather is like, is an integral part of my lifestyle," she says. She also commutes the 11 kilometre distance from Espoo to Helsinki daily on a bike. ■

A GOOD SERVANT
but a poor master

The man cage of a personnel hoist is ascending underneath an electricity transmission line. The ominous music in the background and the coffin awaiting in the hearse make the viewer anticipate that the man holding an iron bar in the man cage is not in for anything good. The videos of a recent campaign induce people to pay attention to the dangers of electricity.

Text by Suvi Artti | **Photographs by** GoodMood, Juhani Eskelinen and Valtteri Kantanen

The undertaker played by the actor **Ville Virtanen** has plenty of customers in the videos of the campaign "BEWARE BEFORE ACTION near electrical networks": Felling of a tree next to a power line does not go very well. The bucket of an excavator hits an underground cable, and an electric shock kills a man standing beside the pit. A farmer concentrating on finding his mobile phone drives his tractor against a transmission line tower with disastrous consequences. The videos on the campaign website at www.hengenvaara.fi indicate in a harsh manner what implications the neglecting of safety instructions can have.

According to the accident statistics of Tukes, the Finnish Safety Technology Authority, there have been as many as 42 serious accidents when working close to overhead power lines or underground cables during the period of 2000 to 2011. Fatal accidents resulting from electricity work have decreased significantly since the 1970s, but one to two fatal accidents still happen in Finland annually.

Goal: zero electricity accidents

The campaign stems from a concern shared by the entire electricity industry regarding the safety of work conducted near transmission networks. "In recent years, there have been many near miss situations and also unfortunately some occupational accidents, which are often caused by sheer thoughtlessness," says Fingrid's **Marcus Stenstrand**, who works as the Project Manager of the campaign.

Work sites located close to power lines are commonplace. In addition to electricity professionals, many other people work close to transmission lines: civil engineering contractors, home owners, forest workers and farmers.

Typical hazards comprise the cases presented in the videos, where a tree is felled on a transmission line, a work machine reaches too close to a power line, or an excavator bucket hits an

"All accidents can be prevented," said Fingrid's Executive Vice President Kari Kuusela in the press conference of the campaign. He pointed out that electricity companies and Fingrid welcome any observations of abnormalities concerning electricity networks.

Campaign shared by the electricity industry

The website of the campaign "BEWARE BEFORE ACTION near electrical networks" at **www.hengenvaara.fi** contains basic information about how to take an electricity network into account at work sites, and instructions for situations where a power line is damaged. The campaign material also covers a pocket-size safety brochure and training materials in PowerPoint format.

The two-year campaign launched in May 2012 is backed by ten electricity companies and organisations: Elenia Verkko Oy, Finnish Energy Industries, EPV Alueverkko Oy, Fingrid Oyj, Fortum Sähkönsiirto Oy, Helen Sähköverkko Oy, INFRA ry, a consortium of electricity companies in Eastern Finland, Tukes, and Vantaan Energia Sähköverkot Oy.

underground cable. Blasting work too close to lines as well as construction and storage in the power line right-of-way are also prohibited as dangerous operations.

Undertaker on a muddy field

The startling videos on the campaign website have been designed and filmed by the video production company GoodMood. Instead of direct bans, the videos wish to show what can happen if you work contrary to the safety instructions.

"From the outset, we thought of unconventional ways to make safety videos," says **Otto Hietaharju** of GoodMood. The idea of the undertaker came about as a result of creative brainstorming. "There are plenty of prohibitions, commands and orders in Finland. Maybe people have become accustomed to thinking in the lines of: 'OK, there is a prohibition sign, but that's quite alright, nothing has happened to me before'."

The videos were directed by **Teemu Nikki**, who has previously directed mu- →

sic videos and short films. He joined the project when the initial manuscripts were ready. "The basic setup was there, and I started to take the idea a bit towards a Gothic ambience," Teemu Nikki says. Although the outcome is not funny in any way, the team spirit was good. "It was terribly cold, wet and fun," he says in recalling the November shooting sessions on a muddy field with sleet pouring from the sky.

When the completed videos were shown for the first time to the campaign people, the makers were excited to see how the audience would react. "People stared at the videos with amazement, and they had serious expressions on their faces," Otto Hietaharju says.

However, after initial bewilderment everyone agreed that the videos accomplish exactly what they should: make people see that electricity involves a real danger to life.

Project Manager Marcus Stenstrand hopes that the campaign message reaches as many people as possible. The electricity companies and organisations involved in the campaign convey the message for instance in various events.

Accidents to zero

Fingrid's new work sites have applied a stringent policy since the beginning of this year: an employee who does not have appropriate protective equipment such as helmet, safety shoes or high-visibility clothing will be removed from the site for the rest of the day. If the same employee repeats the offense, the employee will have to leave the entire project. The main contractor will also be subject to a written complaint and a fine of 250 euros. The penalty is less severe in old projects: there is no fine, and the employee will receive one warning before being removed from the work site.

"The penalties were introduced as part of our new development project for occupational safety," says Development Manager **Suvi Lokkinen**, who heads the project. She says that the service providers have been mostly positive about the new practice. On the other hand, the planned reward system for good occupational safety has not received as enthusiastic reception. "Some service providers feel that since taking care of occupational safety is self-evident, there is no reason to reward for it separately," Suvi Lokkinen says.

The new penalty and reward systems are just a small part of a sizeable project launched at the beginning of this year by Fingrid to reduce the number of service providers' accidents at work. Fingrid has paid special attention to occupational safety for several years now, but the index indicating the frequency of accidents at Fingrid's construction sites has still not come down to the targeted level. "However, what is positive is that the index describing the seriousness of accidents inflicted on the service providers has taken a downward turn," says Suvi Lokkinen.

Fingrid has outsourced its construction and maintenance operations, so in practice the service suppliers carry out the work at Fingrid's sites. The Finnish Occupational Safety and Health Act stipulates that both the party ordering a service and the service provider have the right and the obligation to ensure the safety of work sites.

The safety project aims at influencing attitudes in particular. One example of the power of attitudes given by Suvi Lokkinen is the construction industry, where the number of occupational accidents varies greatly between different companies. Some companies get close to the goal of zero accidents while in others the accident figures are continuously too high. "This reflects the fact that the working culture has an important role in the number of accidents." ■

Fingrid considers occupational safety as a key component of high-quality project execution, says Development Manager Suvi Lokkinen.

KNOW THE TERMS

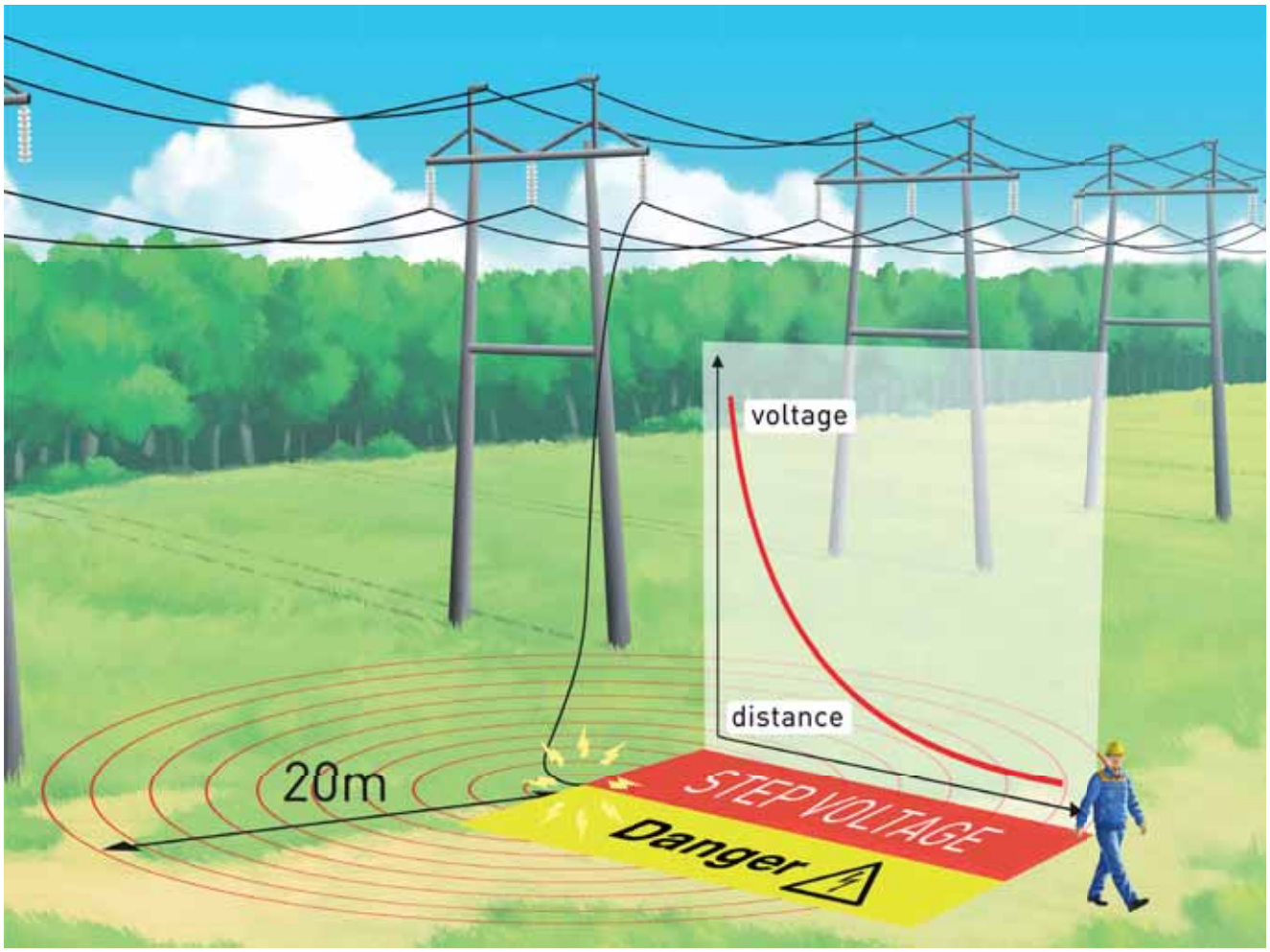
This column presents and defines terminology in the electricity transmission business and related fields.

Step voltage

Text by Juhani Mäkelä

A step voltage which is dangerous to people may emerge in conjunction with earth faults in the high-voltage system between two points under a person's feet. An earth fault occurs when, during a fault, a conductor in a circuit gets into a conducting connection with the earth. As an example, electricity flowing into the ground from a tree which has fallen on an energised transmission line or from a machine which has hit a line causes step voltage: legs which are apart from each other have a different potential, and some of the electric current gets into the body.

The step voltage is at its highest right next to the earth fault. In order to avoid an electric shock, you must leave the fault area either by jumping with your legs kept together or bounding so that only one foot at a time touches the ground. It is important that only one point of you is in contact with the ground at a time. The safe area starts at a distance of approx. 20 metres from the fault location. ■



Planning the network with the customer

The planning of an electricity network calls for expertise in network technology, economic matters and environmental issues. The skills of a clairvoyant would also come in handy, as a network planner should see some 20 years ahead.

Text by Maarit Kauniskangas | **Photographs by** Juhani Eskelinen, Helsinki City Planning Department and Futureimagebank

"Fingrid plans the transmission system one region at a time, because a plan encompassing the whole of Finland would be way too comprehensive. This work is not carried out solely at Fingrid, but our customers – local network companies, electricity production companies and manufacturing industries – are also actively involved in the planning work," says **Antero Reilander**, who works as Special Adviser in Fingrid's grid planning.

Fingrid's grid plan consists of 13 regional plans. Of these, the plans for Lapland, South-Western Finland, Kymenlaakso/South Karelia and the Helsinki area are currently being updated. About three to five such extensive regional plans are made each year, which means that the whole of Finland is covered in about four years. However, the plans are flexible and the planning process is continuous, because in many cases there are events in the operating environment compelling modifications to the plans.

Information from customers

"We need local information about electricity consumption, and estimates of future developments. The representatives of our customer network enterprises are involved in drawing up the regional plan from the outset," Antero Reilander says.

Antero Reilander says that grid planning work is much about dialogue and about letting ideas evolve.

Fingrid's planning team also keeps contact with the representatives of electricity production companies and local manufacturing industries. New residential areas, factories, logistics centres etc. add to the need for electricity. It is challenging to foresee the electricity demand of manufacturing industries in particular, because a single production plant may consume as much electricity as a medium-sized town.

"As an example, if an industrial company is planning to build a new factory or shut down an existing plant, it would be good for us to know about it so that we can take the matter into account in network planning. The changes may be swift, but years should be reserved for the upgrading of the network. On the other hand, the companies themselves rarely know about these things several years in advance. Still, it would be good to be informed of these cases as early as possible," Antero Reilander hopes.

Electricity production anticipation, in turn, is complicated by factors such as uncertainties involved in the construction of wind power capacity. The changes caused by wind power in the transmission system have been rather moderate to date, but now there are plans for more than 300 wind farm projects, totalling about 15,000 megawatts. The original target set for wind power was only about 2,500 megawatts. However, it is still uncertain how many of

these projects will actually become reality.

From ideas to solutions

Transmission system planners use initial information acquired by them to sketch various scenarios for the future prospects in a certain area and explore what kinds of impacts these have on the transmission network. Will there be a need for new high-voltage transmission lines or substations? How could wind power capacity be connected to the system? Does a network company need a new transmission line connection because of the expansion of its own network?

The regional plans also take into account the management of the ageing of the transmission system. The system may contain parts that should be dismantled, repaired, or rebuilt entirely.

"We always aim to use the existing network as optimally as possible. We cannot and should not make preparations for every eventuality by overbuilding the system. It is our goal to find flexible as well as technically and economically correct solutions in a timely fashion. This is so because network construction is very expensive, and the network also has environmental impacts," Antero Reilander says.

Electricity production anticipation is complicated by factors such as uncertainties involved in the construction of wind power capacity.

The planning team works together, but each member also works independently. After joint meetings for creating ideas, it is time to return to the computer to simulate the possible solutions. Antero Reilander says that the work is much about dialogue and about letting ideas evolve.

The plans are modified on the basis of feedback received during the discussions. A regional plan shaped and honed in co-operation with the customers is distributed to all parties in a shared event arranged by Fingrid. If necessary, customer-specific confidential reports address the development needs involved in the network and grid connections of a particular customer. It takes about a year to draw up the regional plan.

"When we can do things for the regional plans in advance with no hurry and when we have proper discussions with all stakeholders, the actual implementation of the projects is also much easier," says Antero Reilander. →

Regional grid planning in the Helsinki region

Challenge: growth and compaction

Fingrid's regional grid plan for the Helsinki region is currently being updated in a thorough manner. The representatives of the network company Helen Sähköverkko Oy in Helsinki in the planning process are **Atte Pihkala**, who works in network planning, and **Markku Hyvärinen**, head of the unit for network development.

"Helen's network is connected to Fingrid's system at several points; it is a meshed, ring-like network. This is why all solutions related to our network development must be carried out together with Fingrid," says Markku Hyvärinen.

What makes the development work challenging is that the Helsinki region is growing and becoming increasingly compact. A dense urban structure calls for new electricity transmission infrastructure. The projects require much preparation in issues such as land use and technical solutions.

"New people keep moving to the Helsinki region, and new residential houses and business premises are built. Even though the per capita energy efficiency has improved, this improvement only mitigates but does not cancel out the increase in electricity consumption," Markku Hyvärinen points out.

When more electricity is needed, more transmission capacity is also needed. One of the factors complicating network planning is the uncertain situation with the Hanasaari power plant. The decision on the future of the plant will be made in early 2015. Before that decision, preparations must be made in network planning for various alternative scenarios. ■

Markku Hyvärinen (left) and Atte Pihkala say that network projects within a compact urban structure call for much preparatory work, both in terms of land use and technical solutions.

A visualisation of the Kalasatama area adjacent to the heart of Helsinki. The area will provide a home for about 20,000 people by the early 2030s.

Fingrid remains at the top of international comparison

Fingrid ranked at the top in the international ITOMS* maintenance benchmarking study for the ninth consecutive time. The benchmarking covering the years 2010 and 2011 concerned 27 transmission system operators from around the world.

In the cost-effectiveness comparison, Fingrid's placing was slightly lower than in the previous study. The result reflects Fingrid's considerable input in the restoration of guy structures in transmission line towers in recent years so as secure safety and system security.

Fingrid did particularly well in circuit breaker maintenance and in the management of vegetation in the rights-of-ways. In both of these sectors, the quality level was very high, while the costs were among the lowest in the reference group.

The ITOMS study compares the performance quality, efficiency and economy in the electricity transmission industry every two years. The goal is to find best practices and methodologies as well as to learn from other companies.

*International Transmission and Maintenance Study

Fingrid in social media

Fingrid has expanded its communications in Finnish to social media. The company is now on both YouTube and Facebook.

Fingrid's YouTube website shows presentation films of issues such as the operations of the transmission system operator, its compliance with the principles of corporate social responsibility, and its role as an employer. You can also get to meet Fingrid people working with various duties, see the video material of a topical electricity safety campaign, and learn about the principles of the Finnish power system.

The company's Facebook site (www.facebook.com/fingridfi) is the basic information channel for the general public in the Finnish language. In addition to current news, the site contains information on issues such as all vacancies in the company.

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 30 September 2012. Address: Fingrid Oyj, PL 530, 00101 HELSINKI, FINLAND. Mark the envelope with "Verkkovisa". **You can also send your reply to Grid Quiz online. The link can be found on the home page of our website www.fingrid.fi.** Among all those who have given right answers, we will give five lanterns powered by a solar cell as prizes by drawing lots.

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

1. Fingrid's first field tower will be erected in
- Hyvinkää
- Hikiä
- Forssa

2. The testing of a single transmission line tower at the testing station takes in all approximately
- 2 months
- 4 months
- 6 months

3. Last April, Fingrid issued a bond with a value of
- 200 million euros
- 300 million euros
- 400 million euros

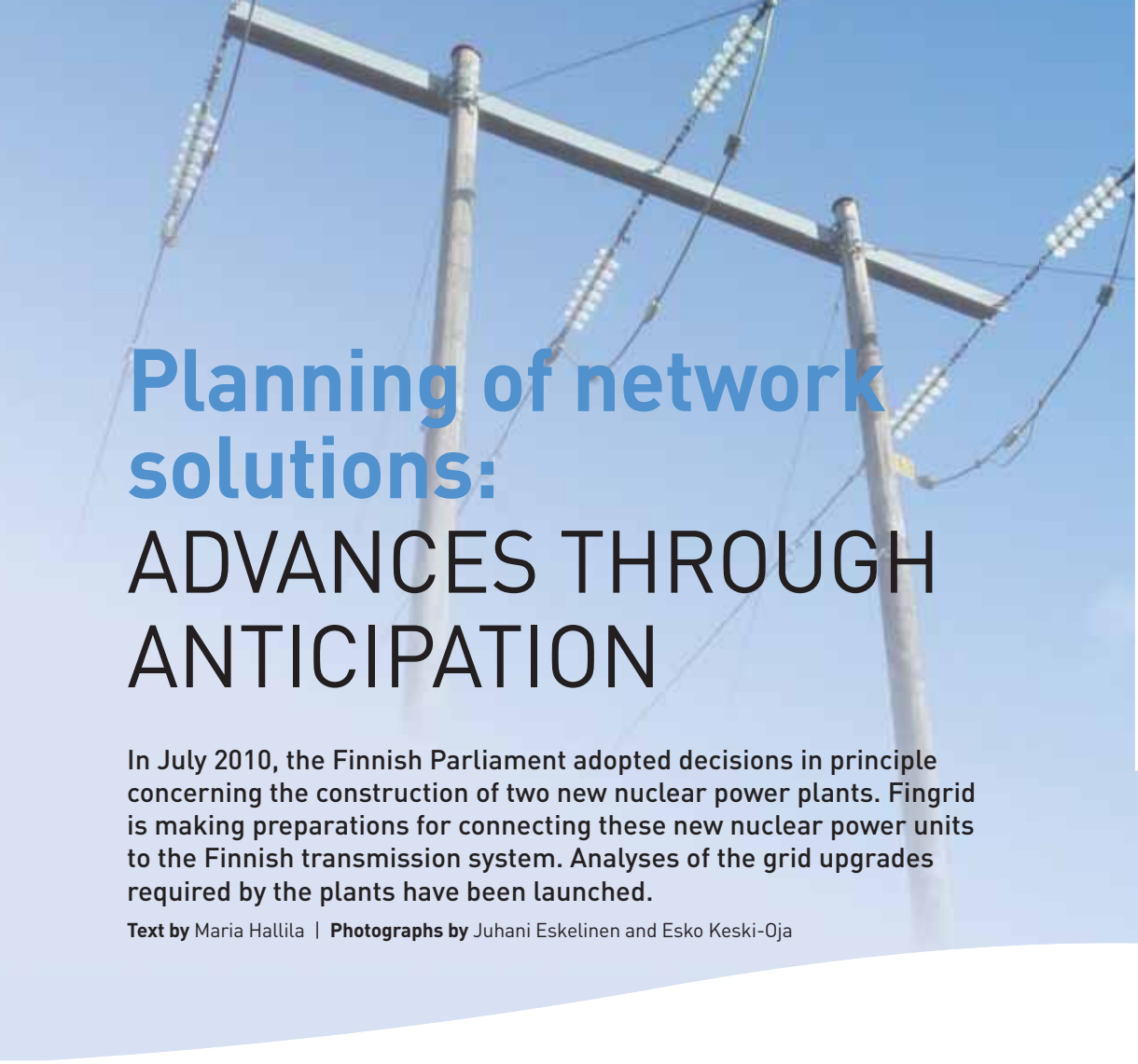
4. The undertaker in the videos of the campaign "Beware before action near electrical networks" is played by
- Antti Reini
- Tapio Liinoja
- Ville Virtanen

5. If a machine part has hit the transmission line or if a tree has fallen on the line, you need to leave the site
- running as fast as you can
- jumping with your legs kept together or bounding so that only one foot at a time touches the ground
- creeping while crouched

6. Of the electricity used on the Åland Islands, how much is produced on mainland Finland?
- approx. 7 per cent
- approx. 15 per cent
- approx. 20 per cent

7. What was the first country in the world to introduce the 400 kilovolt voltage in electricity transmission?
- Japan
- Russia
- Sweden

Winners of prizes of the Grid Quiz in the previous Fingrid magazine (1/2012): Jarmo Henriksson, Turenki; Lidia Lybek, Helsinki; Kimi Patja, Turku; Arto Köykkä, Muhos; Tuomo Jokinen, Helsinki.



Planning of network solutions: ADVANCES THROUGH ANTICIPATION

In July 2010, the Finnish Parliament adopted decisions in principle concerning the construction of two new nuclear power plants. Fingrid is making preparations for connecting these new nuclear power units to the Finnish transmission system. Analyses of the grid upgrades required by the plants have been launched.

Text by Maria Hallila | **Photographs by** Juhani Eskelinen and Esko Keski-Oja

The grid reinforcements will require that the planning and environmental surveys of the projects are carried out in stages. The environmental impact assessment (EIA) of the 400 kilovolt transmission line routes related to Teollisuuden Voima's (TVO) Olkiluoto 4 nuclear power plant unit in Western Finland unit was launched towards the end of 2011. The EIA procedure for the transmission lines required by Fennovoima's Hanhikivi 1 nuclear power plant further up north is also being prepared.

Fingrid will make the decisions on the further planning and construction of the transmission lines later on the basis of the decisions made by the companies responsible for the nuclear power projects.

Far-reaching development

In just over one year after the decision by Parliament, Fingrid presented the EIA programme concerning the transmission line projects required by the Olkiluoto 4 plant unit. The swift reaction was enabled by the company's long-term and flexible approach to network development plans. This mode of operation has also become standard procedure as a result of experience accumulated from numerous transmission line projects.

"We have been thinking about the rough outlines of network solutions for additional nuclear power capacity for a length of time. Routes were introduced in regional land use plans as early as 2007 and 2008," says Fingrid's Project Manager **Mika Penttilä**.

He says that connecting a generation facility the size of the Olkiluoto 4 nuclear power plant unit to the transmission system always calls for new 400 kilovolt transmission lines. Preparations are being made to build a double circuit 400 kilovolt transmission line from Olkiluoto to Rauma and a new 110 kilovolt line to run parallel with it.

Moreover, the transmission grid needs to be reinforced by new transmission lines from Rauma to Ulvila, Forssa and Lieto.

The transmission lines will be located in the area of 19 towns and municipalities in the regions of South-Western Finland, Satakunta and Kanta-Häme.

In accordance with the national land use objectives, the goal is to plan and build the new transmission lines parallel with existing lines or to replace them, using existing transmission line areas wherever possible.

Surveys ahead

Mika Penttilä says that the total length of the transmission line routes covered by the EIA of the project is 390 kilometres. Numerous nature and archaeological surveys have already been conducted in the routes.

"There is much to survey, because the west coast of Finland has been settled since times immemorial, and the area contains many historical sites. Some nature values have also been investigated over several years."

Visualisations will be drawn up of sites along the line routes. These give an understanding of what the new transmission lines will look like in a familiar

Fingrid's online map service can be used for providing feedback on the transmission line solutions required by the Olkiluoto 4 nuclear power plant project. The feedback page (in Finnish) can be found on the website of the EIA project, which can be reached by clicking "Ympäristö" in the top menu of Fingrid's website, or using search "fingrid.navici.com/ol4/".

The transmission line projects required by Olkiluoto 4 and their environmental impacts were the topic in the three public events arranged by Fingrid in early 2012. Mika Penttilä (on the right) and Hannu Ylönen (in the middle) had plenty of questions to answer also in coffee table conversations.

landscape.

The impacts of transmission lines required by Fennovoima's Hanhikivi 1 nuclear power plant on the environment and people will be investigated in a similar manner within an EIA procedure to be launched at a later date. The transmission line routes to be examined within this project total over 100 kilometres.

Opinions expressed in public events

Within the first stage of the EIA procedure in South-Western Finland, Fingrid arranged public meetings in three places in January: Alastaro, Harjavalta and Mynämäki.

The events presented the project in general, the planned transmission line routes, and the environmental impact assessment programme. In addition to Fingrid's experts, the questions were answered by representatives of the Centre for Economic Development, Transport and the Environment in South-Western Finland, the EIA consultant as well as TVO, the nuclear power company.

"The purpose of these events is to make people involved and share information," Mika Penttilä says.

However, information supplied in the early stages of the EIA project did not appear to attract too much interest among the local residents. The three events gathered a total audience of about 100.

"The attendance was low considering that the planned transmission line routes traverse the land of a total of 1,500 to 2,000 landowners. On the other hand, people tend to become more interested in the projects as the work makes progress, and we have received some questions and comments also by telephone and through the map feedback service on our website."

Mika Penttilä says that landowners and local residents are typically interested in issues such as the project schedule, land use impacts, expropriation compensations, and the tower locations, which, however, are only decided later during the more detailed planning of the line routes.

EIA results to be expected in the autumn

The environmental impact assessment work continues, and the assessment report compiling its results is expected to be ready in the autumn. This is another opportunity for the general public to obtain more information, present their views and discuss the transmission line project face to face with the relevant experts. The statement of the co-ordination authority will close the EIA process in early 2013.

"The construction of the transmission lines will take about three years. The launching of the actual construction and the progress of the work will depend on TVO's schedule for the Olkiluoto 4 nuclear power plant unit," says Mika Penttilä. The plant is expected to be complete in the 2020s. ■

Åland Islands produce a quarter of their electricity

The Åland Islands, an autonomous region of Finland, use approximately 300 gigawatt hours of electricity per year, in other words just under one per cent of the total electricity consumption in Finland. About a quarter of the electricity is produced on the Åland Islands, over two thirds is imported from Sweden, and the remainder seven per cent from Finland. Kraftnät Åland, the transmission system operator of Åland, takes care of electricity transmission.

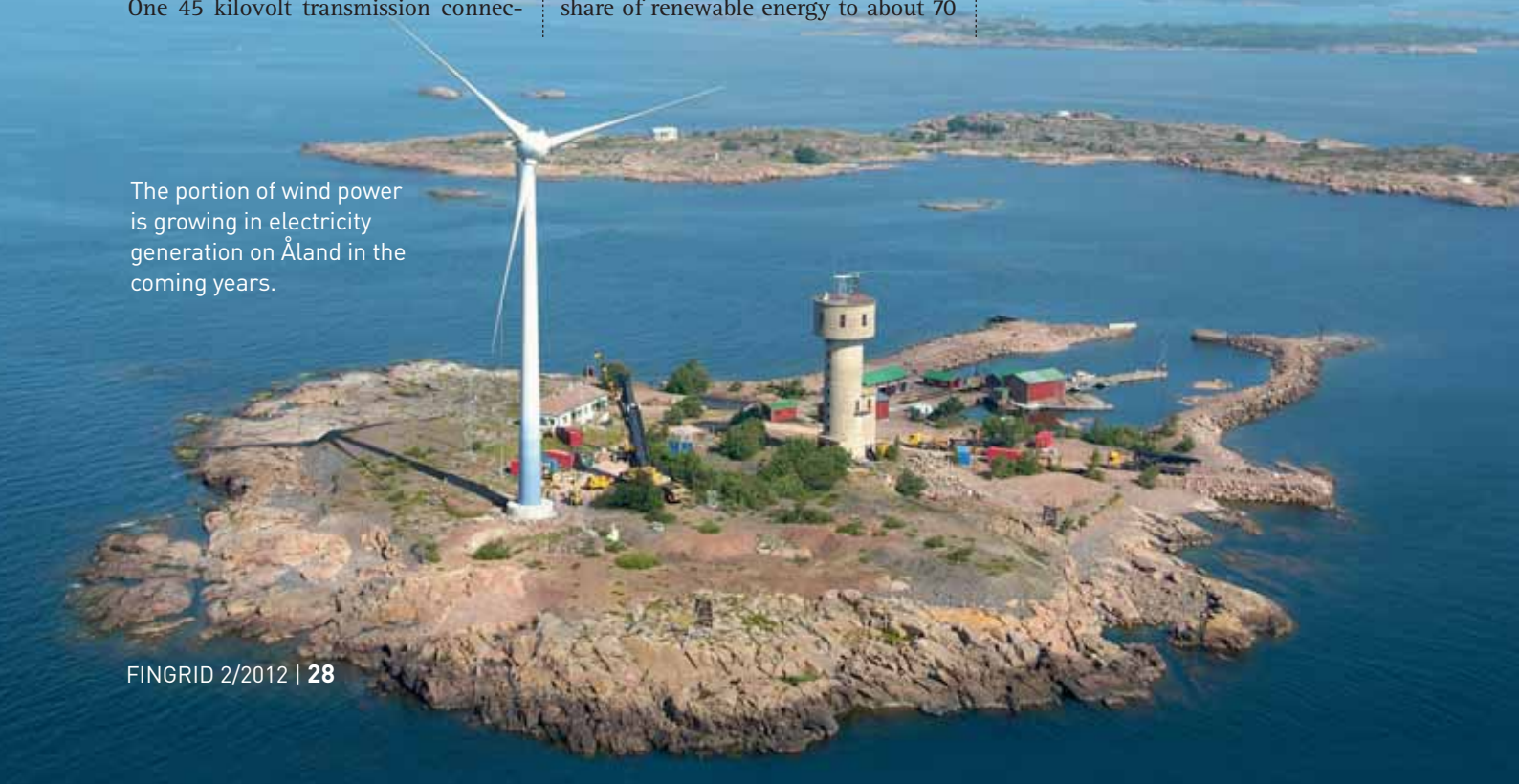
Text by Antti Lagus | **Photographs by** Kraftnät Åland's archives

There is a 110 kilovolt submarine cable from the Åland Islands to Senneby in Sweden, from where there is a connection to the Swedish high-voltage grid through Vattenfall's network. From the submarine cable, electricity is transmitted on an overhead transmission line to the Tingsbacka substation, from where Kraftnät Åland supplies electricity further along four 45 kilovolt branch lines to the eastern, western and northern parts of the Åland Islands and to the town of Mariehamn. One 45 kilovolt transmission connection traverses the archipelago of Turku to Kustavi.

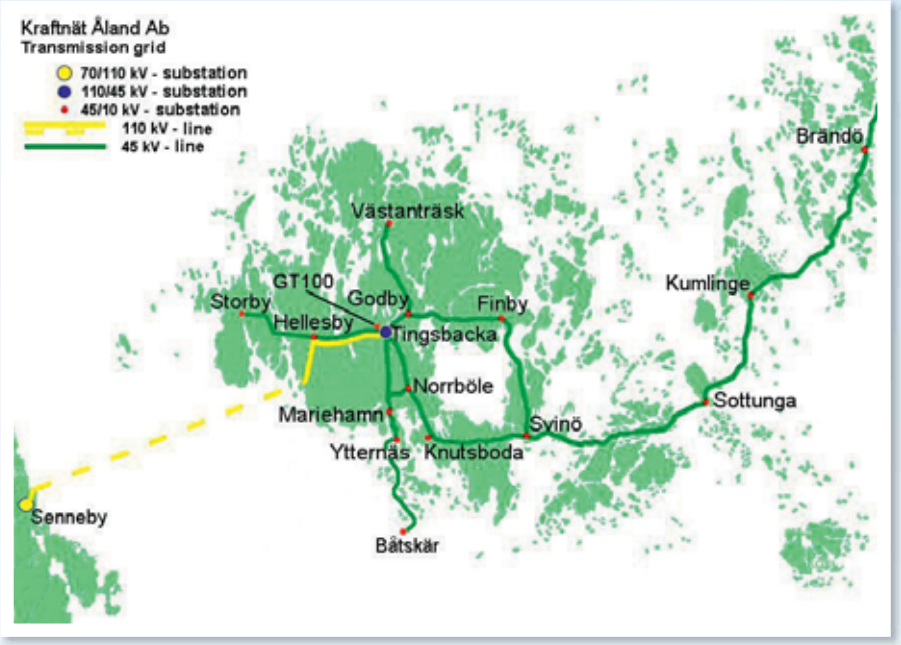
Of the energy used on Åland, 26 per cent is derived from renewable energy sources. In addition to 20 wind turbines, energy is produced in a thermal power plant firing bioenergy.

"Our goal on the Åland Islands is to raise the share of renewables of total energy to at least 38 per cent, which is the national objective in Finland. We already have the permits for new wind turbines which would elevate the share of renewable energy to about 70 per cent, but their construction is still waiting for subsidy decisions," says **Jan Kahlroth**, CEO of the transmission system operator Kraftnät Åland.

The demand for energy continues to grow. On Åland, the growth rate has been 1.8 per cent a year in the past ten years. Jan Kahlroth also thinks that the growth in population on Åland will influence the need for additional energy. Åland now has about 28,000 inhabitants.



The portion of wind power is growing in electricity generation on Åland in the coming years.



Kraftnät Åland uses its own transmission grid, which covers the Åland Islands completely, with about 300 kilometres of 110 and 45 kilovolt lines, substations and interconnections to mainland Finland and Sweden.

Alternatives to reserve power

The transmission connection from Sweden can in practice cater for the full electricity supply of the Åland Islands. This is needed especially when there is not enough wind to propel the wind turbines. If the Swedish connection is not available, the current archipelago connection can supply nine megawatts of energy. The rest of the electricity demand is due to be covered by reserve power machinery.

Kraftnät Åland has an agreement with a local electricity producer on it producing energy for Kraftnät Åland whenever necessary. The company's two gas turbines can produce 24 megawatts of energy, and the same amount using two diesel engines. Moreover, Kraftnät Åland has a 25 megawatt gas turbine of its own.

Ring in the making

Åland has 17 substations, some of which are currently being connected into a ring to safeguard continued operation. In addition, the old substations built in the 1970s are being upgraded to improve system security.

"We are renewing the substations partly because they are so old that there have been some problems in acquiring spare parts for them. Personal safety is also an important consideration, since modern substations are safer to work in," says **Sven-Anders Eriksson**, Network Manager of Kraftnät Åland.

Sven-Anders Eriksson and Jan Kahlroth: The transmission system operator of Åland is facing some significant changes.

Another problem with old technology is that there are fewer and fewer professionals left to use it. Sven-Anders Eriksson compares the situation to a taxi driver having a car from the 1970s.

Full ownership to regional government

According to the EU's third Electricity Market Directive, an electricity distribution company cannot be an owner in a transmission system operator. The regional government of Åland redeemed the ownership of all the other major co-owners of Kraftnät Åland in the summer. The regional government already has a majority of the shares.

Kraftnät Åland will face even other significant changes in the near future.

"The gas turbines of the local electricity company are old, and they must eventually be withdrawn from operation. Moreover, the demand for energy is constantly on the increase; as it is, we have a risk of a power shortage in the winter. As a result of the decommissioning of the reserve power machines and increasing electricity consumption, we have been planning a submarine cable connection to the Finnish mainland," says Jan Kahlroth.

The new cable will enable Åland to buy its electricity either from Finland or Sweden. At present, there are discussions about what type of a model will be introduced in the procurement of market electricity, and no final decision has been made yet as to the direction from which the majority of the electricity will be imported.

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Submarine cable linking the Åland Islands and mainland Finland

The transmission cable connection planned between the Åland Islands and mainland Finland would start in Finland in Naantali with an AC/DC converter substation and would reach the Åland Islands in the village of Ytterby in Jomala. The connection would continue via the DC/AC transformer substation in Ytterby as a 110 kilovolt overhead transmission line to the Tingsbacka substation, where the present connection from Sweden is already operated.

The cable could also be operated in the other direction. If wind power production increases on Åland as planned, surplus electricity could be supplied to the mainland on windy days. The important thing in the utilisation of wind power is that there is a strong grid, which can be used for reserve power supply whenever necessary and through which any excess electricity can be delivered further.

The cable connection is used for transmitting electricity on a market basis, in other words from a less expensive area to a more expensive area.

"The connection also provides yet another opportunity to integrate the transmission grids in Finland and Sweden. A submarine cable connects Åland to Sweden and to mainland Finland, and on Åland the connection would run on overhead lines. Such an additional connection could be used for electricity transmission between Finland and Sweden," says Kraftnät Åland's CEO **Jan Kahlroth**.

According to him, the practical solutions will be agreed upon at a later date between Kraftnät Åland, Svenska Kraftnät, Fingrid and Nord Pool Spot.

Kraftnät Åland will be responsible for the cable investment, and the company has applied for an investment subsidy from the regional government of Åland. The regional government, in turn, can apply for a subsidy for this type of special expenditure from the budget of Finland. The Delegation of Åland is responsible for this process.

The state of Finland has given a subsidy of 40 per cent to the earlier infrastructure investments on Åland – the electricity transmission connection to Sweden and the gas turbine power plant. The state has granted a subsidy of 40 per cent or a maximum of 50 million euros for the cable costing a total of 125 million euros. The final agreement on the construction of the cable can be made in the autumn after the EU has approved the subsidy package. ■

POWERED BY ELECTRICITY

In this column, Fingrid employees share their experiences of appliances driven by an electric motor. Corporate Adviser Risto Lindroos tested the Kalkhoff 8C HS electric bicycle.

Electric partner of commuter cyclist

Text by Risto Lindroos | **Photograph by** Juhani Eskelinen

I had been thinking of buying an electric bicycle for quite some time when I saw an article in the spring issue of magazine "Latu & Polku", comparing electric bicycles. The comparison was won by Kalkhoff 8C HS. The bike has a 540 Wh lithium battery and a 250 watt electric motor. The bike is given a range of 120 kilometres with a single charge.

I soon found myself as a happy owner of an electric bike, and I used the bike on the next morning to ride to work. Switching on the electric assist by the switch on the handlebar, and the LEDs indicate that the battery is full. This is really easy to ride! The riding position is erect, so it is effortless to follow the traffic. The bike negotiates curves very well, although in the lower position the pedal tends to scratch the asphalt.

It is speedy going, but still someone tries to pass. "Oh, you've got a doping bike," a passer-by says. It's like being a dog owner: it is easy for like-minded people to start talking. "I had to electrify my bike, because there was so much snow in the winter. I used a self-install kit," the passer-by continues.

On the second day, the trip to work goes as smoothly as dancing 30 years ago. Following an easier ride, I come to work feeling refreshed, and I return home less tired. On the third day, I feel like a pro. But why is that LED blinking? Maybe I should have read the manual after all. And behold, the battery goes dead on the way to work. Now I understand why this needs a transmission of eight speeds. There is no other option than to pedal harder! When I get home from work, I am exhausted, although riding without the electric assist is not any heavier than riding a bike with a single speed.

After one month's experience, I begin to be convinced. An electric bike is most competitive over distances of 15 to 25 kilometres, with relatively much urban routes and hills. In an urban environment, an electric bike is faster than conventional bicycles thanks to its better acceleration. During the test period, my electric bike was an estimated 20 per cent faster than my hybrid bike. The average speed was approx. 25 kilometres per hour. The greatest benefit came from the fact that I was not tired in the evenings after the way home. This is why I can use the electric bike for relatively long distances more often than the hybrid bike. I figured out that the electric bike will pay itself back in time savings and savings in travel costs in a period of two to three years.

If you want, you can use the electric bike for exercise purposes just like any other bike, because the electric assist is disengaged when the speed goes over 25 km/h. On the other hand, you can also use it for leisurely ride, because pedalling with the assist is child's play. The electric bike equipped with studded tyres is definitely also a competitive alternative in the winter.

The speed of an electric bicycle is more stable than when riding a hybrid bike. There is really no speed loss in a climb. Being quite heavy, the electric bike runs downhill a little faster than a regular bike. A cyclist with an electric bike is the first to shoot from traffic lights, because the electric motor kicks in at start.

One of the foremost technical characteristics of an electric bicycle is sufficient battery capacity. The brakes must also be effective. The bike must not assist pedalling in a jerky fashion. These characteristics were fine in the bike tested. However, the transmission ratio seemed to be too small at high speeds. Other drawbacks include the greater need for service and a relatively high price.

A few years ago, an electric bicycle was primarily just an aid for the disabled and aged. Electric bikes were not that commonplace mainly due to the expensive batteries. The prices of electric bicycles have come down in a few years and made them more popular. This is why electric bikes will probably become common in Finland, too, and find users among cyclists aged 50+, especially in the Helsinki region, where cycling is often a faster way of commuting than motoring and public transport anyway. ■

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.

Voltage in electricity transmission and distribution systems

Text by Jarmo Elovaara | **Photograph by** Juhani Eskelinen

The technology applied to electricity transmission is relatively young: It was not until the early 1880s that the conditions were created for the transmission of electricity over longer distances. The alternating current motor was developed in those days, and a patent was granted for an idea where the voltage provided by a generator was changed to a higher voltage for electricity transmission, and back to a lower voltage at the point of consumption so that the electricity could be used.

Since the generation and transmission of electricity require considerable capital, the related investments have had a long life. In some countries, such as Sweden, this has been reflected in the relatively great diversity of the voltage levels used. Only in the past 40 to 50 years has the electricity distribution system been rationalised by reducing the number of voltage levels used.

The magnitude of the power transmitted as electricity is determined by the voltage used and the current transmitted ($P \sim U \cdot I$). As electricity consumption and transmission distances have increased, a need for higher and higher transmission voltage levels has emerged. The most viable voltage depends on both the power transmission need and the transmission distance. The general principle is: the longer the transmission distance, the higher the transmission voltage, but the voltage values are case-specific. The nature of the most advantageous voltage is such that it is better to overdimension rather than to underdimension the voltage **(Figure 1)**. As an example, when the voltage needed to transmit a certain power is doubled, the current value drops to a half, and the resistance losses occurring in the transmission line are reduced in a square ($\sim I^2$), in other words to a quarter of the original. This improves the transmission and distribution efficiency. A smaller current also translates into a smaller cross-sectional area of the conductor and hence lighter and less expensive conductors and towers, but in other respects an increase in the voltage increases the size of the equipment and also raises their price. Moreover, a higher voltage usually also means fewer parallel lines in a certain link.

The current travelling in the line causes losses, which are manifested in both power losses (heat) and in a voltage reduction in the line. Electricity distribution networks are so designed that the sum of the investment costs and loss costs needed to transmit the necessary power is minimised. In high-voltage transmission networks, however, the distances are long, and attention must be paid to many other factors dependent on the voltage, such as the maximum transmittable power without disturbing the synchronous operation of different generators in the network. This depends on the product of voltages affecting at the ends of the transmission connection.

The highest voltage used anywhere in the world is usually also the highest option that is technically and economically available. The technical constraints are generally manifested in the current breaking capability of circuit breakers and in the maximum voltage withstand capability of the insulations of equipment (including overhead lines). As the voltages and currents increase, so do the environmental disadvantages and safety risks, such as the risk of a short circuit and earth fault. These must be kept under control.

In the early days of electricity use, there was limited technical knowledge, and the construction of large networks was not mastered. This is why the decisive factor in the selection of the voltage level was that the consumption devices would work as well as possible. Before the advent of alternating current (AC) motors, electricity was primarily used for illuminating major cities. The lamps were arc lamps powered by direct current, and a voltage of approx. 120 volts (V) was optimal for them. The AC system devised in 1883 enabled higher voltage levels and the use of electricity in manufacturing industries. As the AC systems developed further, lamps equipped with a metallic glow filament were introduced in lighting. These could be used at a voltage about twice the voltage of arc lamps. Nevertheless, the voltage of the low-voltage network in many Finnish towns in the early 20th century was still 110 volts.

Arc lamps were apparently more common in America than in Europe. This is why low-voltage distribution in Europe and the USA started to use different voltages, which are still in use: The standard voltage in Europe is 230/400 V, while in the United States and in countries that use the technology developed there the standard voltage is 120/208 or 120/240 V. The standard voltage series for high voltage were not harmonised between Europe and America until 2006.

Figure 2 shows the transmission voltage in the AC network over the years, expressed as the rated voltage of the network. The figure shows that when moving over to the use of a higher voltage, the ratio of voltages in consecutive voltage levels is in the order of two due

to technical and economic reasons. The highest alternating voltage nowadays used in overhead transmission lines for example in Russia, Japan and China is 1,000 to 1,200 kV (kilovolt, kV = 1,000 volts). Cable networks have to make do with a voltage which is about half of these, but the transmission connections employing the highest voltages are usually so long that the use of cables is not even possible in them, let alone economically viable.

Direct current (DC) is used in very long overhead transmission lines and in submarine cable connections. DC connections are not as numerous as AC connections, and standardisation does not give DC connections similar savings as with alternating current. This is why the DC voltages are determined by project-specific requirements and technological developments. The highest transmission voltage in DC overhead lines is at present 800 kV, and approx. 550 kV in DC cable connections.

As the volume of electricity consumption varies, so does the magnitude of voltage. In order to prevent excessive voltage fluctuation, voltage must be controlled at the different points of the network. Voltage can be controlled in an interconnected network by means of synchronous machines and at transformer substations by changing the number of windings on transformer coils (on-load and off-load tap changers). In other parts of the network, voltage control employs control provided by compensation devices, in other words capacitors and reactors ("coils"), previously also by synchronous compensators (no-load synchronous machines). A capacitor raises while a reactor decreases the voltage.

A properly connected combination of reactors and capacitors can also cater for matters affecting the quality of electricity. Instead of conventional compensation devices controlled by a circuit breaker, there are now also compensation devices operated by means of power semiconductors. These devices can be controlled almost continuously. In addition to compensation, they can also be used for changing the dynamic properties of the network, such as adding attenuation after transients. ■

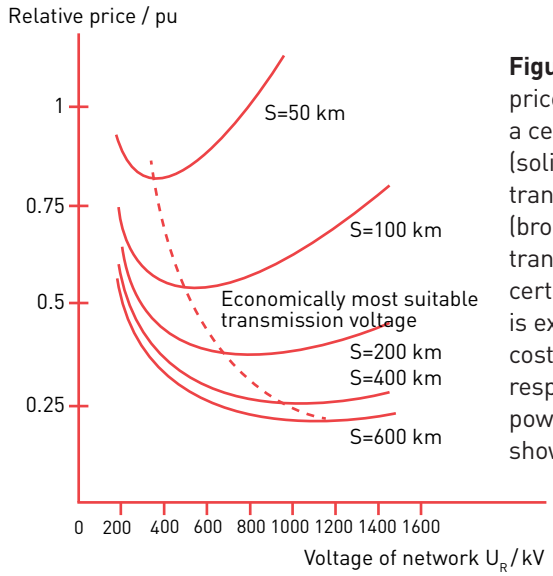

Figure 1: Dependence of the price of a transmission line of a certain length on the voltage (solid line), and the optimum transmission voltage (broken line) at different transmission distances in a certain situation. The price is expressed as the specific cost, i.e. as a price scaled with respect to the transmitted power. The end result is shown as a relative value.

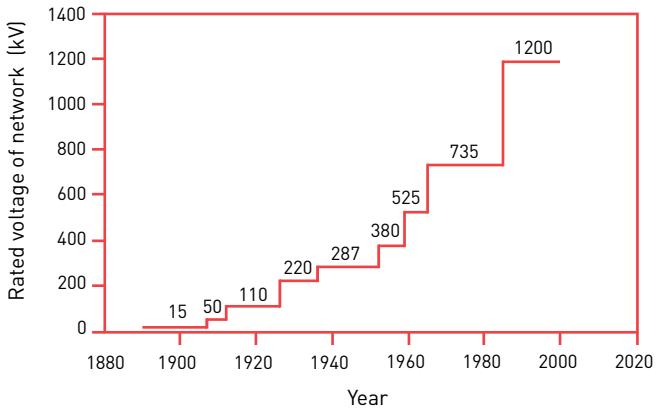

Figure 2: Development of transmission voltage. In some countries the voltage of 380 kV has replaced 400 kV, and 300 kV or 365 kV are used instead of 287 kV.

From 7.8 to 400 kilovolts in 60 years

The first three-phase electricity transmission line of 8 kilometres and 7.8 kilovolts (kV) in Finland was built in Ladoga Karelia in 1897 to feed electricity for pumps, crushers, cableways and other equipment used in the mining industry. The first power transmission system (15 kV and 33 km) planned completely by Finns was introduced in 1900 between Säkkijärvi and Vyborg in Karelia. The first 110 kV line in Finland was commissioned in 1929, transmitting the electricity generated at the Imatra rapids in Eastern Finland via Southern Finland further to Turku on the west coast.

Finland shifted to the 220 kV voltage level in the early 1950s. Sweden was the first country in the world to introduce the 400 kV voltage in the early 1950s, when power plants on the Luleå river were connected to the Swedish grid. Before that, the highest voltage anywhere in the world had been 287 kV. Finland was also among the first countries to adopt 400 kV transmission in the early 1960s.

At the end of the 1970s, Sweden even made preparations for the use of a transmission voltage of 800 kV. However, a reduction in the growth of electricity consumption and intensified debate about the environmental drawbacks and potential health impacts of 800 kV transmission lines resulted in that the Swedish Government did not give a permit in 1980 to the 800 kV line which had already been constructed between the Forsmark nuclear power plant and the Stockholm region.

Otso, Mesikämmen, Vaari... the Finnish language contains almost 400 names referring to the bear.

Master of the forest

Discoveries over 30,000 years old indicate that people have worshipped the bear since times immemorial. The bear has been a very special animal for the northern people. Many Siberian indigenous peoples still consider it holy, and the history of Finland also knows rituals performed after the killing of a bear only a couple of hundred years ago. These rituals were a feast lasting a week, held in honour of the slain bear and to appease its spirit. The bear was regarded as the progenitor of the human race, and the bear-slaying feast was a ritualistic wedding in which the mythical birth of the human race was repeated over and over again.

When you look at the bear, it is easy to see the features that have given it this special status. It is big and strong, and often stands on its hind legs. Its small eyes gaze soulfully straight ahead, just like ours. It is omnivorous, it uses its "hands" as it gulps down berries, and a whistle can be heard in its nostrils as it picks up a scent. This is probably why it is believed that bears can whistle. When a killed bear has been skinned, underneath the skin is revealed an astonishingly human-like body, which, according to one myth, has a heavy money belt on its hips.

I saw my first bear in a shack of my friend **Antti Leinonen** about fifteen years ago. The bear appeared in a bog in the dusk of a May midnight, as if it came out of nowhere. It came quietly and soon stood in front of me, just ten meters away. After that, to quote Antti, "the world was no longer the same". Knowing the mythical background of the bear electrified the encounter in a way that I have not experienced many times in the wild. I was hooked instantly, but with little possibility to photograph or encounter a bear. I live in the wrong part of Finland; there were no bears in my home region in those days.

Now, fifteen years later, the bear has spread further down south and some individuals even inhabit my home region of Uusimaa in Southern Finland. The possibility of an encounter is there. It is small, but the mere awareness of the fact that the master of the forest is moving in the same region brings a whole new dimension to observing the natural environment. It renders the forest a forest, giving it wildness and magic. Sleeping under the stars on an autumn night, the thoughts pass on to the bear instinctively. The myth has it that the Big Dipper, which is part of the constellation of the Big Bear, has a golden cradle and silver chains, on which the first bear was laid down on the Earth from its celestial home.

At the base of a large pine, the thoughts travel to a pine on which the cleaned skull of a killed bear used to be placed after the feast, and the bones of the bear were buried at the bottom of the pine in careful arrangement. The bones were taken to this site solemnly, accompanied by songs, and the skull was hung to gaze the rising morning sun. The pine was a symbolic tree of the world, along which the spirit of the bear could climb back to its home in the sky. A few old skull pines still stand stubbornly, but the myth primarily lives on in the names of places, indicating the locations of such pines.

The Finnish language contains almost 400 names referring to the bear. They are pseudonyms, because you were not allowed to utter the real name of the bear in vain. The names reflect kinship, great respect, adulation, the way a bear moves, or its sweet tooth. The forest is moving, it was said, when the bear was known to be in the vicinity. It was the forest itself!

The old myths are recorded history. They reflect our ancestors' way of explaining the world and the origin of people in the same way as the present-day religions tell of the beliefs of our days. The myths live on and change their shape, but the bear still has a special place in our minds. In some of us it raises fear and respect in others, but it fascinates the imagination in a whole different way than most other animals.

I am often asked whether I'm not afraid in the forest at night. When I say no, there is the inevitable follow-up question: "What if you come across a bear?" Well, that is my greatest dream – to meet a bear in my home region. So far, it has remained a mere dream, but maybe one day. ■

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

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