FINGRID

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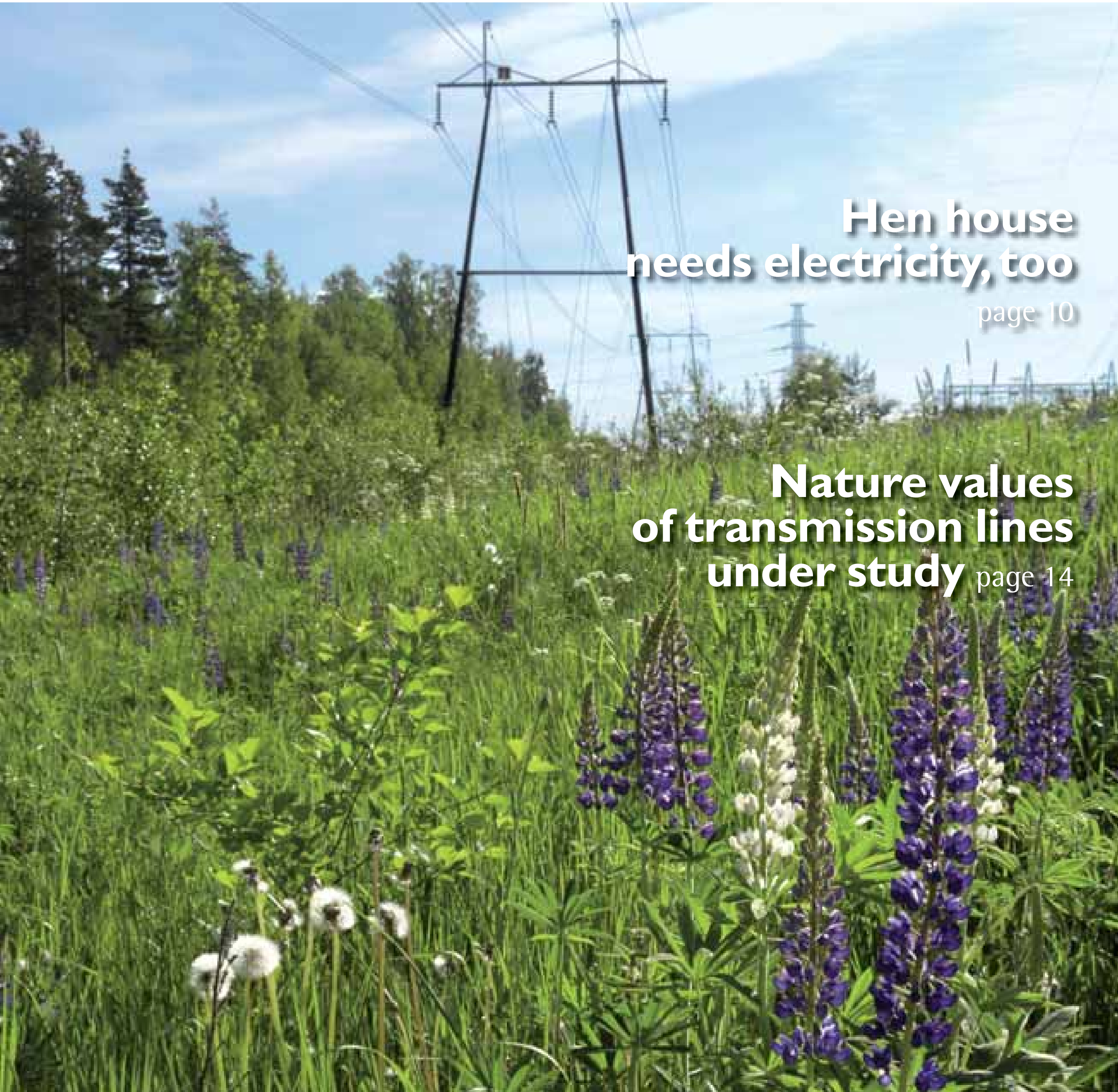
Fingrid Oyj
2/2007



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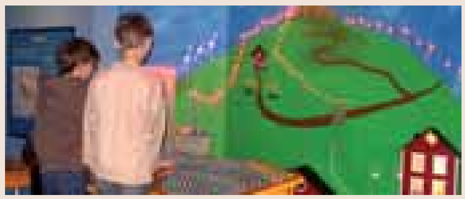

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Editorial

Capital expenditure on the

Fingrid's capital expenditure on grid investments is growing from an annual level of about 40 million euros as high as over 100 million euros per year in a few years at the end of this decade. By 2012, we will build more than 1,000 kilometres of new transmission lines and about 10 new substations alongside the expansions and renovations of existing substations. Our customers have asked us a justifiable question: why?

Transmission grids everywhere in the world have been constructed to serve the internal market in each country. However, the opening and international expansion of the electricity market have meant that the grids are now used in a way which differs greatly from the former way; high transmission capacities are needed in quite new places. In particular, transmission connections between countries are in many cases insufficient.

In the past decade, Fingrid has used approx. 70 million euros in opening the transmission bottlenecks both to the east and west. Towards the other Nordic countries, this has taken place gradually by improving the transmission capacity of the present grid by adding series compensation, various control systems and by raising the height of conductors. These measures have elevated the transmission capacity by some 800 megawatts.

These inexpensive solutions have now been used up, and transmission capacity between Finland and Sweden will be increased by the Fenno-Skan submarine cable, which will give

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increase

800 megawatts of additional capacity. The estimated costs of the cable project are 250–300 million euros depending on issues such as market situation and price trend of raw materials.

In order to secure the transmission capacity between Finland and Sweden, decisions have also been made to carry out the Keminmaa–Petäjäskoski 400 kilovolt transmission line, series compensation stations of Asmunt and Tuomela, and the static var compensator (SVC) unit at the Kangasala substation. The estimated total costs of these projects are approx. 50 million euros.

After these projects, Finland and Sweden will be practically always of the same price area, which means that the market can function efficiently.

Electricity consumption in Finland has increased by just under 2 per cent a year, and estimates suggest that the same pace will continue in the next few years. However, the growth is distributed rather unevenly between various geographical areas. As an example, the growth rate in Western Lapland is almost 6 per cent per year with the peak power growing even faster. In order to secure electricity supply in Lapland, Fingrid has decided to construct a new 220 kilovolt ring connection from the Rovaniemi region to Kittilä and from there further to Vajukoski. The costs of this project are about 50 million euros.

Correspondingly, four 400/110 kilovolt power transformer stations will be built in different parts of Finland – Kopula, Pikkarala, Uusnivala and Vuoksi – in order to secure regional electricity transmission and to raise the transmission capacity. The project in Vuoksi will also involve the construction of a 400 kilovolt transmission line. These projects total approx. 50 million euros.

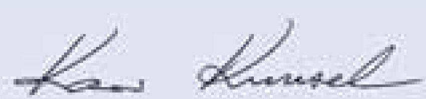
Relating to the third nuclear power unit at Olkiluoto, almost 80 million euros are being used on the grid (Olkiluoto - Huittinen and Ulvila - Kangasala 400 kilovolt transmission lines and necessary substation upgrades). The requirements imposed by the next potential large production unit on the Finnish grid are also being investigated. The costs relating to this will likely be higher than those of the previous unit, especially since it will also require more reserve power capacity. A 100 megawatt gas turbine plant will be completed at Olkiluoto this summer. Fingrid's share of the costs of this project are approx. 25 million euros.

In addition to what has been stated above, the existing equipment used in the Finnish grid is ageing. So far, most of the substations and transmission lines are of medium age and in a fairly good condition – thanks to years of efficient maintenance. However, it is necessary to continuously renew the most outdated parts of the grid and ones with insufficient transmission capacity. Such projects are particularly common at the 110 kilovolt voltage level, such as the Koria - Orimattila double circuit line and the Petäjävesi substation. The 220 kilovolt voltage level is gradually being replaced by 400 kilovolts in Ostrobothnia in Western Finland. The Seinäjoki - Tuovila line and the Tuovila substation (approx. 30 million euros) are part of this shift-over.

Fingrid is also drawing up a long-term grid development vision and a

management plan for grid ageing. The large number of equipment cannot be replaced in a few years, but this calls for a long-term programme.

The implementation of a capital expenditure programme as extensive as this will be challenging – not just for Fingrid's own personnel, but the resources of suppliers will also be put to the test. It is to be hoped that suppliers take advantage of this opportunity and have the courage to recruit new persons now that there is much work in sight and as the large post-war generations are retiring.



Kari Kuusela is Fingrid Oyj's Executive Vice President.

Mild winter in Europe

PEAK CONSUMPTION RECORD BROKEN IN FINLAND

Last winter, the Nordic countries did not experience surprising weather conditions or production disturbances which would have stretched the supply security of the power system to the limit. The winter in Finland was short and mild, but the earlier peak consumption was exceeded during a period of very cold weather in February. The winter in other parts of Europe was mild, too. The most critical situations in the European power system were encountered during the Kyrill storm and during the grid disturbance in Continental Europe in November.

Text by Timo Kaukonen

Photograph by Vastavalo

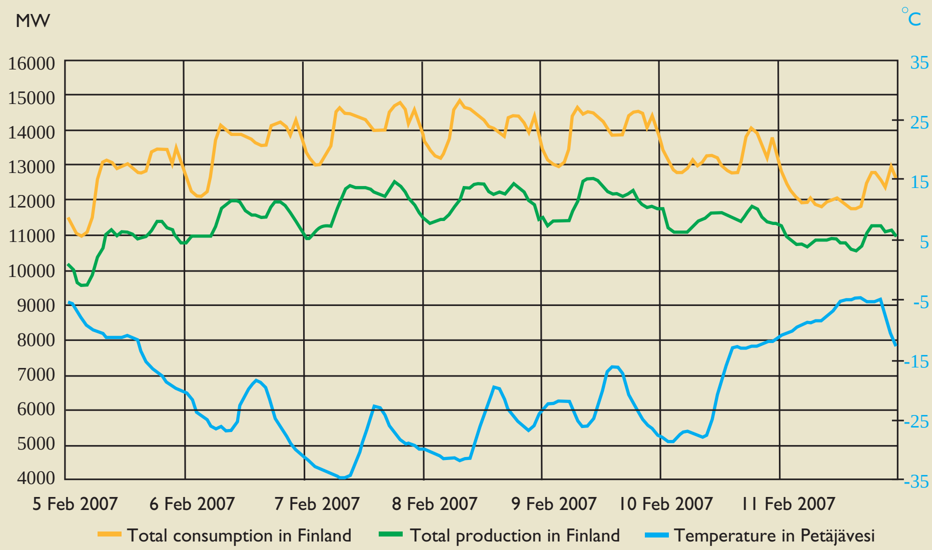
The early winter was very mild in the Nordic countries, but the latter part of the winter was normal for that time of the year. Electricity prices were high temporarily, but this did not raise imports from outside the Nordic area. Scant water reservoirs in particular increased the price of electricity.

The Nordic countries depend on electricity imports from Russia and from the other EU countries especially during very cold weather when the consumption figures are high.

The early part of the winter was very warm in Denmark like in the other Nordic countries, and weather conditions which favoured wind power increased the production of this form of electricity generation. There was excess production in Western Denmark in early January, which is why the production of power plants, including wind power stations, had to be restricted. The transmission capacity from Denmark to Norway and Sweden was in almost full use. On the other hand, Denmark could not export any more electricity to Germany because of a similar production situation there. The transmission options were also restricted by a cable fault on the Kontek connection between Zealand and Germany. Cold weather in February caused freezing problems on the transmission lines and short-term interruptions in electricity supply.

In Norway, the water reservoirs were very low at the beginning of the winter period. The summer of 2006 was very dry, and even the previous winter had left less snow than normally in the mountains. Since electricity production

Total consumption and total production in Finland and temperature in Petäjävesi in Central Finland 5 Feb - 11 Feb 2007



The all-time high consumption peak in Finland was recorded on 8 February. Fingrid used for the first time the production capacity based on the Power Reserve Act.

in Norway consists exclusively of hydropower, low water reservoirs made Norway dependant on electricity imports from Sweden and Denmark. From November onwards, the water reservoirs started to fill up and the situation became normal during the winter.

Operating disturbances in nuclear power plants in Sweden increased the need for imports and reduced the opportunities to export electricity. The heavy storm in January caused many problems in regional networks but only few disturbance situations in the main grid.

In Finland, the winter was exceptionally short. Because of the mild winter, electricity consumption in Finland during the first three months was 1.9 per cent smaller than in the corresponding period a year before. There were no significant problems in electricity production. The all-time high consumption peak (some 14,900 MW) was reached in Finland in February during a period of very cold weather.

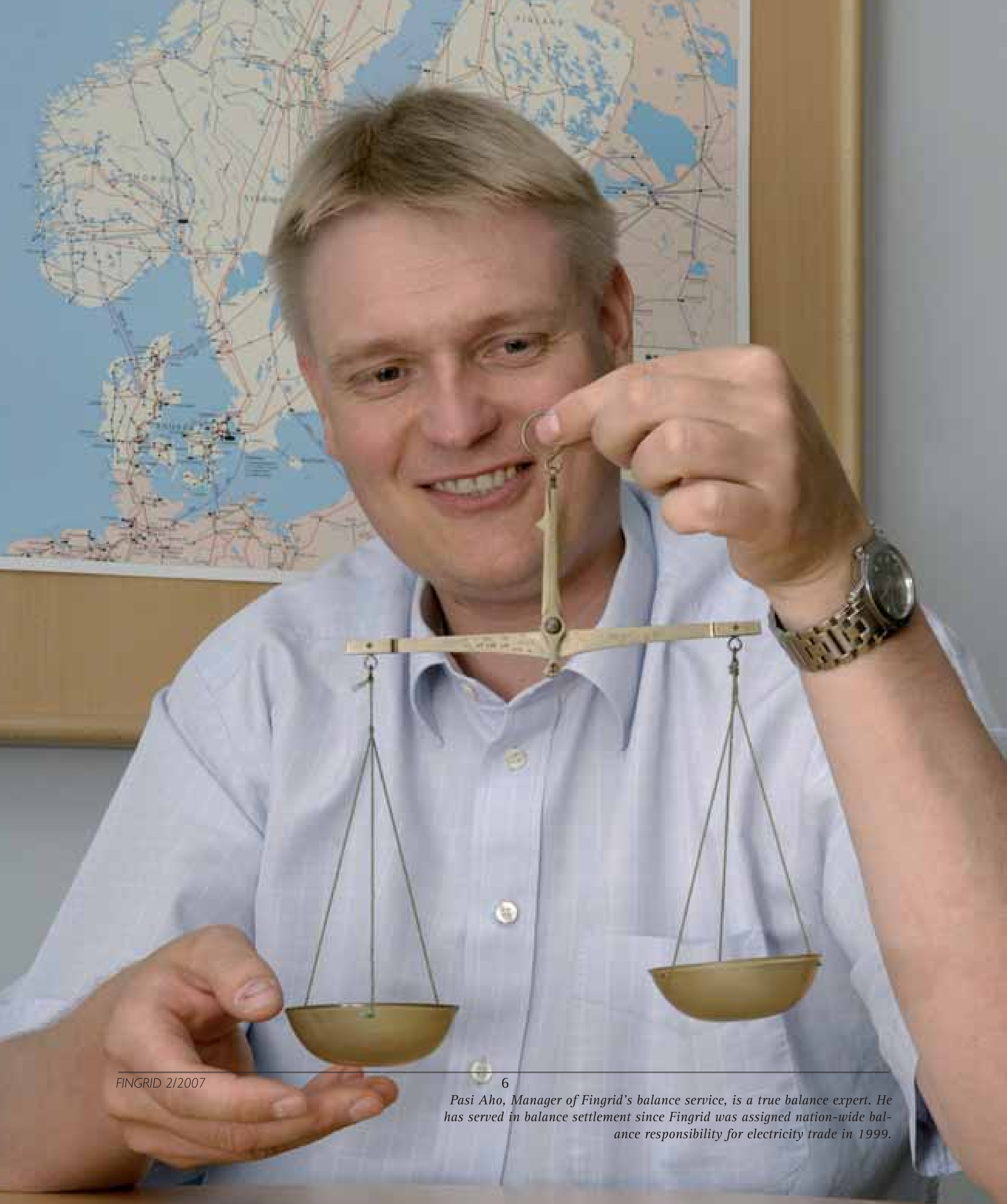
During the peak consumption, Fingrid used for the first time the production capacity based on the new Power Reserve Act, starting one power plant at minimum power just to be on the safe side if problems had occurred on the import connections or in production.

The only significant electricity transmission disturbance took place when the 550 MW Fenno-Skan cable was damaged in early December. The connection could not be repaired until February. Transmission capacity between Finland and Sweden had to be restricted for the duration of the repairs.

The most important transmission addition was the introduction of the 350 MW Estlink connection between Finland and Estonia. This cable connection inaugurated in December enables electricity imports and exports between Finland and Estonia.

In most parts of Europe, electricity demand remained smaller than anticipated because of the mild winter. The Kyrill storm which raged in mid-January did not affect the electricity transmission system very much. Cross-border transmissions of electricity were occasionally large due to unexpected electricity production interruptions and abundant wind power production in Germany. However, the sufficiency of electricity production was not threatened in Continental Europe.

In November, the system in Continental Europe experienced a disturbance the effects of which were reflected in several countries. As a result of the disturbance, about 15 million inhabitants were without electricity for several hours.



Pasi Aho, Manager of Fingrid's balance service, is a true balance expert. He has served in balance settlement since Fingrid was assigned nation-wide balance responsibility for electricity trade in 1999.

New Nordic balance service model to be introduced at the beginning of 2009

Nordel has been examining Nordic harmonisation of balance service, and found a shared approach last year as a result of lengthy efforts. The new Nordic balance service model due to enter into force at the beginning of 2009 will pave the way for a shared end consumer market which works even better than now. Moreover, it will guarantee that all Nordic market players will be treated equally and transparently both in terms of the pricing of balance deviation and the cost principles of balance service.

Text by Pasi Aho ■ Photographs by Juhani Eskelinen and SXC

The present balance service model was introduced in 1999, when Fingrid's system responsibility was supplemented by balance responsibility, and balance management and balance settlement were assigned to the company.

In the year 2000, the so-called window model which had been in use until then was replaced by the present model where consumption, production and electricity transactions by a balance provider are added together in a single balance and where a two-price system is applied to potential balance deviations.

After this, up until these days, the same balance service model has been used, and only small changes and improvements which have facilitated the practical matters have been made to it.

Seeking a shared Nordic approach

Nordic harmonisation of balance service has been boosted in this decade. The first Nordel task force on this issue began its work in 2002, aiming to find a balance service model that could be shared by all Nordic countries.

Last year, the third task force finally came up with a shared approach and reached a compromise on the new Nordic balance service model.

Before the matter was subjected to the Board of Nordel, transmission system operators in each of the Nordic countries inquired the opinions of electricity market parties in their respective countries about the new model. The mostly positive response obtained facilitated the decision made by Nordel's Board on 7 February 2007 to accept the proposal of the task force to be used as the new balance service model as of 1 January 2009.

Fingrid and balance service

Fingrid is responsible for maintaining a power balance in Finland and for the nation-wide balance settlement.

Each party operating on the electricity market must take continuous care of its electricity balance. This means that each party must maintain a power balance between electricity production/procurement and consumption/sales. In practice, no party can do this by itself because of momentary variations in consumption and production, which is why each party must have an open supplier which balances the party's power balance. A party whose open supplier is Fingrid is referred to as a balance provider.

An open delivery between Fingrid and a balance provider is agreed by means of a balance service agreement the terms of which are public and equal to all. After signing the balance service agreement, a balance provider obtains an open delivery and also the services relating to balance settlement between the balance provider and Fingrid as well as an opportunity to participate in the regulating power market.

IN BRIEF

Border tariffs abolished from electricity trade between Finland and Estonia

Estonia has joined the European mechanism which compensates transit costs caused by power transmission between countries. Fingrid has consequently removed the fees on electricity imports and exports over the Estlink cable as of 1 June.

The Estonian TSO Põhivõrk joined the transit compensation mechanism of European TSO association ETSO at the beginning of June. The purpose of the mechanism is to compensate costs to those TSOs which host transits through their networks.

The operators pay fees to a joint fund and receive remuneration from it according to how much the countries cause transit to each other. The transit mechanism has allowed the abolition of export, import and transit fees from the borders of most EU countries.

Now the border tariffs have been abolished from electricity trade between Finland and Estonia. The other Baltic countries, Latvia and Lithuania, did not join the system yet.

"The removal of cross-border fees is an important step towards the integration of Nordic and Baltic electricity markets, and it also needs to be seen as part of European integration", says **Jukka Ruusunen**, CEO of Fingrid.

"The opening of the Baltic electricity market is still at an early phase but wholesale trade between and through the countries functions reasonably well. Market integration needs to be developed further, and TSO co-operation in the region plays a key role here."

Estlink, the new sea cable between Finland and Estonia, became operative at the beginning of this year. Up to 350 megawatts of power can be transmitted over the link in both directions. The link is a merchant line owned by a group of Finnish and Baltic power companies. It does not provide other market players with an open access to its capacity. Therefore imports and exports over Estlink continue to be subject to the same grid fees payable to Fingrid as production and consumption in Finland. Such fees are not charged on the open Nordic interconnectors.

Why the change?

Balance service has its own important role on the electricity market, from the wholesale market all the way to the end consumers.

The objectives of the Nordic authorities include the development of a shared end consumer market, and balance service principles must also be harmonised on the way to this objective.

Moreover, an identical balance service in all Nordic countries will treat the market players equally and transparently both in terms of the pricing of balance deviation and the costs of balance service.

Development and harmonisation of balance service belongs to the domain of transmission system operators while the end consumer market is included in the scope of authorities. The new balance service model due to become effective at the beginning of 2009 will pave the way for an increasingly well-functioning Nordic end consumer market.

costs in balance service. Here, reserves refer to reserves required by the maintenance of grid frequency and system security by the TSO.

The model allocates various types of reserves, using the matching principle, both to balance service and to other TSO services – primarily grid service – so that the costs of frequency-controlled normal operation reserve belong to balance service and the disturbance reserves (frequency-controlled disturbance reserve and fast disturbance reserve) belong both to balance service and other services.

In Finland, the new allocation of reserves between the various services means that the reserve costs in balance service will rise and on the other hand that they will decrease in grid services.

Three main issues in harmonisation

When contemplating on the new model, Nordel focused on three main areas:
1) harmonisation of reserve costs included in balance service,
2) introduction of a new model of two balances in the Nordic countries, and
3) harmonisation of rules for electricity trade taking place close to the specific hour.

Harmonisation of reserve costs included in balance service

One of the basic ideas in the new model is to harmonise the cost basis of balance service. Transmission system operator's reserve costs account for the highest

Two balances

Another main idea in the new model is that the balances are divided into two instead of the present single balance. At the moment, a balance provider's production, purchases, sales and consumption are all added together in a single balance, and a two-price model is applied to the resulting balance deviation. In other words, there is a different price for the purchase and sales of balance power.

In the new model, production is included in one balance, and purchases, sales and consumption in another. Moreover, a separate price is applied to the balance deviation existing in the production and consumption balances, i.e. to balance power. A so-called two-price model is calculated for the balance deviation in the production balance, and a so-called single-price model is calculated for the balance deviation in the consumption balance. In other words, there is the same price for the purchase and sales of balance power. A production plan from the production balance before the beginning of the specific hour benefits the consumption balance in the balance settlement procedure. The table below describes the model in more detail.

Production balance

(Actual production - production plan)

Two-price system for balance deviation

+

production fee on measured production

1/3 of costs

Consumption balance

(Production plan +/- fixed trades - actual consumption)

One-price system for balance deviation

+ volume fee on balance deviation

0.1–0.5 €/MWh

+

consumption fee on measured consumption, 2/3 of costs

Moreover, it has been agreed that a separate fee be levied on actual measured production and consumption in order to cover costs caused by a rise in reserve costs. The reason for this is that the revenues accumulating in balance service from balance deviations between the production and consumption balance and from the price systems applied to them are not sufficient to cover the costs of balance service. The production fee covers one third of the costs of balance service and the consumption fee covers the rest.

Electricity trade close to the specific hour

In conjunction with the model, Nordel agreed on the deadlines of electricity trade close to the specific hour of operation. This means that the electricity market parties have an opportunity to electricity trade, for example on the Elbas market, up to one hour before the specific hour.

Moreover, the balance providers must submit their production plans and bids to the inter-Nordic regulating power market 45 minutes before the specific hour. In this way, the TSOs will have ample time to forecast the power and operating situation during the commencing hour and to carry out potential adjustments before the beginning of the hour and during it.

Balance service forum facilitating preparations for changes

The new balance service model will involve many changes affecting balance settlement in Finland. Two balances and related reporting of production plans and actual production are significant reforms, as is the launching of a single-price system in Finland. Moreover, agreeing on many other details will require much work and reaching an understanding with the balance providers.

Fingrid has established a specific group of the representatives of balance providers and other electricity market parties to prepare the introduction of the new model and to discuss its details. The group includes experts with in-depth knowledge of balance settlement, balance management, reporting and energy measurements.

The group is primarily a discussion forum. Fingrid summons the group, and the goal is to have approximately one meeting per month after the start-up meeting.

Minutes are kept of the meetings, and the minutes will be sent for information to all balance providers and members of Fingrid's Power System Committee, and they will also be published on Fingrid's balance service Extranet. In this way, Fingrid's close interaction with the balance providers is natural and continuous.

Which came first, the chicken or the egg? – This question makes Tuija and Hannu smile. – "Basically, it would have to be the egg, but that's not possible," they answer with a laughter.

Electricity supply of hen house secured

"ANIMALS CANNOT COPE WITHOUT ELECTRICITY"

Text by Tiina Miettinen
Photographs by Juhani Eskelinen and FutureImageBank

Electricity is a lifeline in farming. "People can always manage during a power failure, but it could easily mean the end of the world for animals." This is how **Tuija** and **Hannu Miettinen**, owners of a traditional battery hen farm, summarise the importance of reliable electricity supply at their farm.

The Miettinen farm is situated in Humppila in Western Finland. The family has been engaged in farming for several generations. Tuija and Hannu took over the farm at the end of the 1980s.

"First, we had a piggery but we changed to hens in the mid-1990s. Egg production and field farming are pres-

"Even though the work is automated, people are needed constantly to make sure that everything works properly and that the hens are doing alright."

ently our sources of income. Reliable supply of electricity is vital to us in this work. Luckily, we have only had very few long-lasting power failures in this region," Hannu Miettinen says with satisfaction.

The Miettinen hen house is dependant on electricity, because all operations are automated. Feeding of hens, egg collection and manure removal take place automatically powered by electricity. The egg collection machine transports the eggs to the packing machine, fodder is carried into feeding chutes, and moving manure conveyors sweep hen manure out of the building. Electricity is naturally also used for illuminating and air conditioning the hen house. Heating is carried out by means of wood, but the circulating water pump needs electricity.

"Even though the work is automated, people are needed constantly to make sure that everything works properly and that the hens are doing alright. The eating and weight of hens must be monitored especially carefully. There has to be pure water, fodder and ample room. You have to take good care of the hens or egg production may be disturbed," Hannu Miettinen says in describing how the hen house is operated.

"The hen house has 14 hours of light and 10 hours of darkness. The hens actually sleep more than I," Hannu says with a smile.

A city dweller is surprised at how dim it is inside the hen house. The light bulbs are only 25 watts each. The explanation is clear: hens see better than people in dark, and sudden bright lights might frighten poultry. The photographer's flashlight creates panic among the hens. An incredibly loud sigh of the wings progresses in the hen house from one end to the other like a wave created by the spectators in a football stand.

"You should not scare hens because they may lay rubber eggs. Hens are very sensitive to everything sudden. They don't like low-flying aeroplanes, either," Tuija says.

"Gentle" packing machine

The Miettinen hen house is home for some 16,000 hens. Almost as many eggs are laid each day. The eggs are stored on pallets in a cold store cooled by a refrigerating machine. One pallet always contains 8,640 eggs which await transport to Munakunta, a co-operative of Finnish egg producers.

Before storage, collection belts carry the

In addition to egg production, the Miettinen farm is specialised in field farming.

Fingrid at the Farmari Agricultural Fair

Fingrid will participate in the Farmari Agricultural Fair to be arranged in Kuopio at the Sorsasalo race track from 26 to 29 July. In the agricultural fair, country life and urban life meet each other in a setting of laid-back togetherness and versatile programmes. There are many things to see from domestic animals to various types of machines. Forest and energy also have a prominent role. Fingrid is one of the main partners of the fair.

The annual Farmari fair is a familiar event to **Tuija** and **Hannu Miettinen**. This year, too, they will probably include a trip to the fair in their holiday tour. On the other hand, Fingrid is not directly that familiar to the egg producers, because they are supplied with electricity from Vattenfall's regional network.

So that Fingrid would become more familiar, the Miettinen family and the 80,000 other fair guests are welcome to visit Fingrid's stand at the Farmari fair. The transmission grid operator has a natural link to the countryside. Fingrid is responsible for high-voltage electricity transmission in the nation-wide grid. Major power plants, industrial plants and distribution networks are connected to the grid. It is Fingrid's duty to secure the supply security of electricity in the transmission grid in order to keep the lights on in the whole of Finland – including the dim hen house. But the most important reason for Fingrid's presence in the Farmari fair is that we wish to meet land owners and forest owners whose land areas host 14,000 kilometres of transmission lines. Welcome to meet us!

eggs from the hen house to the packing machine situated adjacent to the cold store. Anyone who has ever handled eggs can only admire the machine which sorts the eggs into egg cartons. The eggs remain intact, and the machine also turns the eggs the right way up based on weight.

"This machine is gentler than people," Hannu says.

Electrification and technological advancements have facilitated manual work at farms. In line with these developments, farming has also become increasingly dependent on the supply security of electricity. A long-term power failure might jeopardise the sustainability of a poultry farm. Power failures re-

You do not really believe how gentle the egg packing machine can be until you see one in action.

sulting from storm damage, reported in news a few years ago, encouraged Hannu and Tuija to purchase an aggregate of their own for a potential power cut.

"The aggregate which uses fuel oil starts automatically in 7 seconds after a power cut. Backup power secures that air can flow in the hen house also when it is very hot in the summer. Animals just cannot survive without electricity," Tuija points out.

The Miettinen farm consumes some 30,000 kilowatt hours (kWh) of electricity in a year. This is slightly below the average consumption of Finnish farms. Statistics by the Finnish Central Union of Agricultural Producers and Forest Owners (MTK) indicate that there are great differences in electricity consumption between farms. Large dairy farms may use over 200,000 kWh annually and large pig farms as much as 500,000 kWh or more. On the other hand, small grain farms of 20 to 30 hectares can go below 10,000 kWh per year. Agricultural production and private consumption in the countryside account for about 3 per cent of all electricity consumption in Finland.

The increase in electricity consumption by agriculture is likely to remain moderate. According to an estimate by MTK, electricity consumption will rise by approx. 1 percentage unit per year. An increasing number of farms have ancillary operations relating to farming or independent of it. One out of three farms are already engaged in operations other than agricultural production: processing, farm tourism, machine contracting etc. These are apt to increase electricity consumption in the countryside.

Electricity supply to the Miettinen hen house is secured by an aggregate which uses fuel oil. The aggregate starts automatically in 7 seconds after a power cut.

Research project finding

TRANSMISSION LINE AREAS FAVOURED BY MEADOW SPECIES

Text by Maria Hallila ■ Photographs by Janne Heliölä and Mikko Kuussaari

Cat's-foot, red German catchfly, bristled bellflower, maiden pink and many other meadow flowers were still common in Finland just a few decades ago. As a result of the rapid disappearance of natural meadows, meadow flowers have also become increasingly rare, and some are actually endangered.

However, some meadow species have found new habitats in transmission line areas. These valuable areas are now searched in a research project which Fingrid has ordered from the Finnish Environment Institute.

The Finnish Environment Institute (SYKE) has earlier studied the significance of transmission line areas to butterflies and vascular plants. The present meadow plant project is headed by SYKE's **Janne Heliölä**. The study is carried out mainly as a desk study, utilising geographic information systems and various types of map material.

"Because of the large amount of transmission lines, it is impossible to carry out an extensive field investigation on them. This is why we aim to identify potentially valuable transmission line areas on the basis of existing information," Janne Heliölä says.

Geographically, the project is limited to the regions of Uusimaa and Pirkanmaa in Southern Finland, but if the method works, it can be applied in other parts of Finland, too.

As farming has become increasingly efficient, natural meadows have decreased to a fraction from the former area. However, transmission line areas provide partly replacing habitats for the traditional meadow species. The wild pansy prefers open rocky areas.

The meadow study continues Fingrid's projects carried out in recent years together with various experts. According to **Sami Kuitunen**, who heads Fingrid's environmental unit, these projects have indicated that transmission line areas have an important role in terms of the environment.

Clearing gives more room for meadow species

The importance of transmission line areas to Fingrid is primarily related to the company's foremost duty: as the transmission system operator, Fingrid carries main responsibility for the functioning of the power system in Finland. However, Sami Kuitunen says that environmental matters have gained more and more focus within the company in recent years.

"Biodiversity together with the identification and promotion of the positive impacts of transmission line areas are, alongside technical issues, one of our primary areas of research and development," he says.

The total length of Fingrid's transmission lines is approx. 14,000 kilometres. Regular and appropriate clearing of vegetation from the transmission line areas is a crucial part of efforts aiming to ensure the system security of the grid.

"The transmission line areas are cleared at intervals of 5 to 6 years in Southern Finland and every 5 to 8 years elsewhere," says Sami Kuitunen. The total area cleared is about 33,000 hectares.

The present clearing intervals have turned out to be sufficient in terms of the reliability of electricity transmission and operational safety of transmission lines. However, Janne Heliölä says that meadow plants and insects would benefit from more frequent clearing.

"If the clearing interval was shorter, the growth of coppice which suffocates other plants and takes up their living space could be prevented. Insects dependent on meadow plants also favour openness as well as heat and light brought by it," he says.

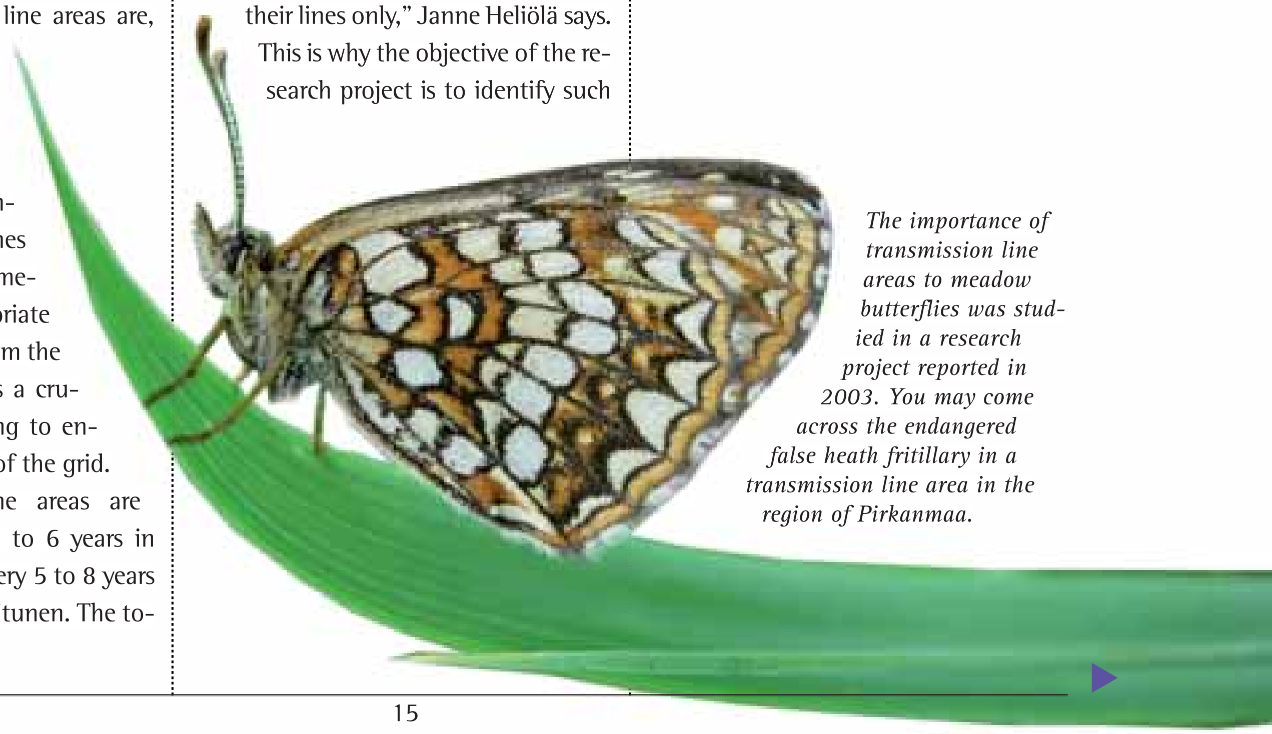
Farmers as partners in clearing work?

"Because clearing work is expensive, power line operators can commission more frequent clearing for nature management purposes on a small part of their lines only," Janne Heliölä says. This is why the objective of the research project is to identify such parts of the lines where additional clearing would give an optimum benefit to meadow species.

"When we know such valuable areas, their management could be offered for example to farmers or local nature societies by using the environmental subsidy available to agriculture. It would be a handy arrangement if a farmer would clear a transmission line area close to his grazing land and join the transmission line area as part of the grazing land."

According to Janne Heliölä, there are already some experiences of similar co-operation with farmers in the management of traditional biotopes, i.e. various types of meadows and forest pastures.

Janne Heliölä believes that at least part of the clearing costs of particularly valuable transmission line areas could be covered by the environmental subsidy of agriculture. However, he adds that



The importance of transmission line areas to meadow butterflies was studied in a research project reported in 2003. You may come across the endangered false heath fritillary in a transmission line area in the region of Pirkanmaa.

it is a challenge to find farmers who are willing to co-operate in the management work.

Rock areas potential substitutes for natural meadows

Just before summer, SYKE's and Fingrid's research project had progressed to a phase where transmission line areas which fulfil the agreed criteria had been screened on the basis of geographic information. Some of these area will be investigated on site during the summer.

"Most of the selected areas are rocky sites, and about one third are various types of gravel and sand slopes. Rocky, dry and warm slopes may be suited to species inhabiting meadows and rocky meadows. These species have degenerated especially rapidly," Janne Heliölä says.

In the summer, 30 pre-selected areas will be studied on site in the regions of Uusimaa and Pirkanmaa, and 20 random transmission line areas have been chosen for reference studies.

"The field studies are used for assessing how well the selection method used can differentiate areas, which are more suitable than average for meadow species, from ordinary areas," Janne Heliölä says.

The results of the research will be ready during the coming autumn, and they will be published as a report in the early part of 2008. The report also contains suggestions concerning means with which valuable meadow-like transmission line areas could be managed through public funding.

Butterflies led to transmission line areas

Janne Heliölä is satisfied with the recent trend which renders environmental matters an increasingly important component of the construction of transmission lines and other infrastructure.

His own speciality and interest are butterflies. It is through butterflies that he first came into contact with transmission line areas as replacing habitats for meadow species.

"The most vibrant populations of the endangered false heath fritillary can be found in my home region of Pirkanmaa, and many of its remaining populations live on abandoned meadows located in transmission line areas. The only reason why these areas have stayed open is regular clearing of vegetation. This has made us see that some endangered meadow species can really thrive in these areas."

"If our research project succeeds in attaining its objective, Fingrid's limited nature management resources can be allocated to areas where they benefit biodiversity in the optimum manner," says Janne Heliölä who heads the research project.

Route of electricity. The boys have made electricity flow from the power plant into homes via the grid.

Voltti the rabbit arrived at Electricity Museum Elektra

Children's department offers electric experiences to support school education

In May, school pupils had an opportunity to test the new children's department of Electricity Museum Elektra, where the electric rabbit Voltti instructs children in making experiments with the basic phenomena of electricity. The museum also has a Tesla room. It presents the Tesla coil named after its inventor Nikola Tesla. The coil produces arc discharge more than 50 centimetres in length. Some 200 pupils came to see the new departments before the school summer holidays began.

Text by Riia Kemppainen ■ Photographs by Kimmo Kyllönen

Since 1998, Electricity Museum Elektra in Hämeenlinna has invited visitors to a journey through the history of electrification. In recent years, the museum has attracted especially families and school groups. There are visitors from near and far.

"What a pleasant place this is!" is a frequently heard comment from those arriving at Elektra. **Minna Pussinen**, who teaches class 4 B at the Suorama School in Kangasala, shares this first impression.

The teacher is followed into the museum by an energetic and loud group of pupils. The boys and girls seem to have power left in them after the 80-kilometre bus ride; it will be interesting to see how much power they have gathered by the end of the electricity museum tour!

Repetition of things learned at school

The fourth graders at the Suorama school have headed for Hämeenlinna and Electricity Museum Elektra on their spring outing. Before the trip, Minna Pussinen searched suitable attractions through the website of the town of Hämeenlinna.

"The pages of the Electricity Museum impressed me," she says.

Elektra was chosen as one stop in the programme because the new chil-

Circuit. The girls are studying the magnitude of the current flowing through the bulb when the lamp is lit. Teacher Minna Pussinen follows magnetism experiments at the adjacent table.

Kitchen view. Assistant Riia Kemppainen telling the children how homes were electrified in Finland in the 1930s. Some children had seen certain kitchen items in their grandmother's house.

dren's department supports the teaching of environmental and natural sciences, which include sections in physics and hence also theory of electricity. Before the visit to Elektra, the pupils had built circuits and tested insulators and conductors. In other words, the group can use the electricity laboratory of Voltti the rabbit to rehearse and test what they have learned at school.

In the olden days…

The museum tour begins with the home settings of the permanent exhibition. The pupils listen to the guide telling how electricity came into Finnish homes. The first charming view is of a living room from the 1910s, with interior decoration and furniture typical of that era.

Naturally, the room is equipped with contemporary electric appliances. Some of these are familiar to modern children while others, such as the cigar lighter or electric stove, are rarer nowadays.

Corresponding rooms from various decades continue the permanent exhibition to the 1970s. The rooms present days which none of the four graders of the Suorama school has seen in real life.

The expressions on the faces of the pupils range from amazement to amusement when the guide tells how clumsy people were in the use of electricity in the early decades of the 20th century. There are bursts of laughter when the guide says that signs were needed in public premises to state that no matches are needed for lighting light bulbs.

Amazement and enchantment

During this 30-minute tour, the ampere levels of the pupils are fairly low and there are no power surges. Minna Pussinen thanks the guide for presenting the permanent exhibition. One of the reasons why the children had the patience to listen was that the presentation was concrete and did not go too deep into the theory of electrical engineering.

However, the children are beginning to be a bit restless, and the guide releases the energy by urging the children to do their own experiments in the children's department. And the children are ready for that!

The kids are particularly interested in the large scenery painted on the wall, showing the route of electricity from a power plant to the consumers. Switching between the various locations is carried out from the control desk. Lights of different colours come on based on where electricity travels at any given moment.

"This is really great!" says one girl who makes the Ferris wheel turn, accompanied by music. The Ferris wheel is also admired by the other pupils.

When the museum guide asks the children whether it was worth their while to visit the museum, the pupils cry out in one voice: "Yes!". And upon leaving, someone says: "Thank you, museum!".

"Aku, come and see, I made this move," says a boy at another table. He has created a static charge in two carbon rods and is now spinning one rod in a rack with the other. "It's really moving fast – look!" the same boy continues with enthusiasm. Children at the next table are studying magnetism, and those standing in the back row are already impatient: "Can we try, too?"

"Thank you, museum!"

Minna Pussinen looks at her pupils with satisfaction. The museum visit has fulfilled her expectations. Alongside the informational offering, she highlights the experiences that the pupils have had. "This was a very good visit for us, and everything was presented in a suitable manner in view of the target group," she states.

Towards the end of the visit, some children would not want to leave at all. Instead, they would like to keep on experimenting with the various gadgets.

When you ask children of this age what the best part of the museum was, it is not difficult to guess that the answer is the children's department. It seems to be important for children to try the devices themselves and at the same time experience their own impact on the creation of electric phenomena.

The board showing the route of electricity is by far the most popular item. Many also remember the arc discharge at the end of the museum tour as an extraordinary phenomenon.

When the museum guide asks the children whether it was worth their while to visit the museum, the pupils cry out in one voice: "Yes!". And upon leaving, someone says: "Thank you, museum!".

Grid ABC

This article series deals with the main operating principles, equipment units and components in the main grid. The earlier articles have dealt with substation equipment, power and instrument transformers, switching devices, operation control system, relay protection, and direct current transmission.

Text by Mikko Jalonen
Photographs by Juhani Eskelinen

TRANSMISSION LINES ARE FOCAL PART OF THE ELECTRICITY TRANSMISSION SYSTEM

Two self-supporting double circuit towers.

Electricity could not be transmitted over long distances if there were no transmission lines. For most people, transmission lines are the most familiar and visible part of the power transmission system.

The Finnish power transmission system is built around a nation-wide transmission grid owned by Fingrid. The voltage levels of transmission lines in the grid are 400, 220 and 110 kilovolts (kV). In addition to these, regional network companies own approximately half of the length of the 110 kV network in Finland.

The voltage level used on a line depends on the volume of power transmitted and on the transmission distance. The higher the power and the longer the distance, the higher the voltage that should be used.

Transmission lines can be either overhead lines or cables which are usually placed underground. Based on technical, economic and system security aspects, the Finnish grid uses overhead lines.

All conductors in the structures used are bare, without a surrounding insulation around them, but with a sufficient air gap that serves as the insulation. Such lines are referred to as bare conductor overhead lines.

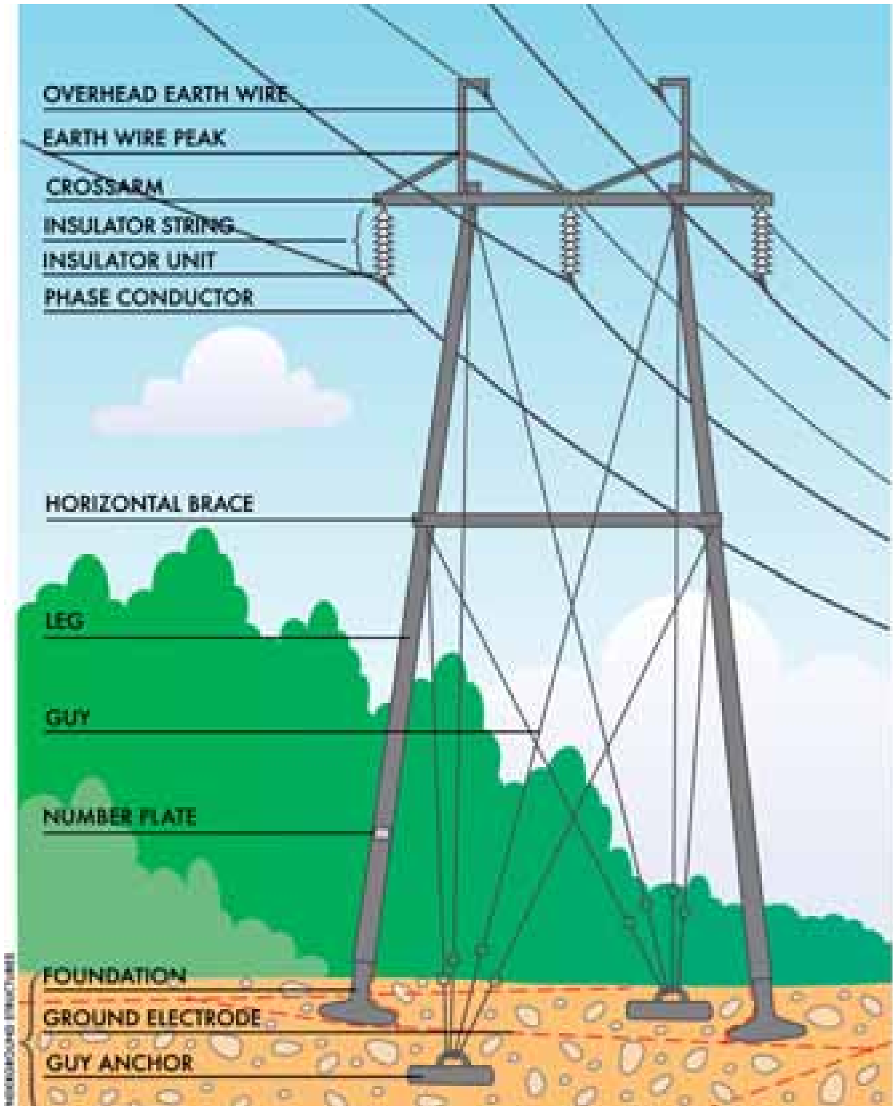


Figure 1. Structural parts of a guyed portal support.

On a bare conductor overhead line, the conductors are fastened to insulators. The conductor with its insulators and support structures form the overhead line. The support structures are almost always supports standing on concrete foundations.

Overhead lines have been used for transmitting high powers over long distances for quite some time, which is why conductor and support manufacturers have developed much technology relating to this transmission method. Overhead lines have hence obtained a purposeful and cost-efficient structure, with every component having its own important role.

Most of the supports of transmission lines are guyed portal supports, although there are also some self-supporting steel towers with no guys. Figure 1 shows the structure of a guyed support and its various parts.

The conductor is naturally the most important part of a transmission line in terms of electricity transmission. The important criteria in the selection of the conductor include sufficient transmission capacity and mechanical strength. Present-day conductors are mainly steel-reinforced aluminium conductors. Aluminium and aluminium alloy conductors are also used to some extent.

There are always at least three conductors in a three-phase system. The basic idea is that the thicker the conductor, the higher its transmission capacity. Depending on the necessary transmission capacity and voltage used, it is often technically and economically viable to use several sub-conductors in each phase. As an example, 110 kV lines in the Finnish grid typically have two sub-conductors and 400 kV lines have three sub-conductors. These sub-conductors are joined together by spacers which prevent the conductors from hitting each other and keep an advantageously even distance between the sub-conductors over the entire span, i.e. distance between two towers.

Near supports, there are often small dumbbell-like items attached to the conductors. The purpose of these vibration dampers is to prevent vibration in the line caused by wind. This vibration would cause mechanical stress in the conductors and their fastening points.

All presently used conductor materials have a common feature: they resist the flow of current. By the effect of current, this resistance of the conductor results in losses which heat up the conductor. Together with changes in ambient temperature, they cause thermal expansion in the conductor material. Because of the consequent elongation of the conductor, the height of the conductors from the ground changes by the effect of ambient temperature and the load current, i.e. transmitted power, which flows in the conductor.

Variations in the height of conductors are a familiar phenomenon to many. During the summer when it is hot, some of the conductors may hang very low as compared to the colder seasons of the year. The engineering of the line has paid attention to this height variation for example in terms of support heights so that a line can never hang so low that it would cause a risk to the environment. On the other hand, the line must not be exposed to excessive mechanical stress when the conductor has reached its minimum length.

Air serves as the insulating material in bare conductor overhead lines. Since air has a poor mechanical strength, a solid and mechanically strong insulator must also be used. On transmission lines, an insulator string composed of individual insulator units serves as such insulation.

The units in the insulator string can be of porcelain or glass. Glass units are used exclusively nowadays for example because their breakage can be noticed more easily. In recent years, composite insulators made from materials such as silicone rubber have been used to a growing extent to replace insulator strings.

In other words, insulators are used for separating the live conductors from the structural parts of the support which are in contact with the ground. The length of the insulator string depends on the voltage level used. The length of the insulator string is the best way in which a layman can identify the voltage level of the line (see Figure 2).

Voltage level of transmission line kV	Length of insulator string	Number of insulator units
110	approx. 1 metre	6–8
220	approx. 2 metres	10–12
400	approx. 4 metres	18–21

Figure 2. Lengths of insulator strings at various voltage levels of transmission lines.

The ground wires, which are located highest in the transmission line structure, have a focal role in how disturbance-free electricity transmission is. They protect the conductors from direct strokes of lightning thus reducing electricity transmission disturbances caused by thunder.

On some lines, one of the ground wires contains an optical fibre which can be used for transmitting data on the grid and also for general telecommunications needs.

The ground wires have a conductive connection to copper ground electrodes buried underground. If lighting strikes the ground wire, the lightning current flows along the grounding system into the ground, preventing the creation of dangerous voltages in the support structures and in the environment of the support.

Grounding also serves as an integral part of line protection. If the voltage of the conductor accesses the support structure for some reason, such as when insulation fails, the ground electrode leads the fault current created into the ground. This activates immediately the protection system of the line at a substation, and the line is de-energised.

The ground electrodes usually extend dozens of metres from the support, which must be taken into account if excavation work needs to be carried out in the transmission line area.

In addition to the electric parts of a transmission line, support structures with a sufficient strength are needed to keep the conductors up. These structures are built on concrete foundations which provide a sturdy base for the support legs.

Most of the transmission line supports in Finland are guyed supports where the guys keep the support in the correct position. A majority of the support legs of 110 kV and 220 kV lines are made of impregnated wood while the supports of 400 kV lines are of steel. The steel supports may have a pipe or lattice structure. The crossarm located at the top of the support legs is made of steel also with wooden supports.

If the line needs to have an abrupt angle or if the width of the transmission line area is not sufficient for a guyed portal support, so-called self-supporting towers made of steel are used. Self-supporting towers can also be used as double circuit supports in situations where two lines need to be placed on the same right-of-way (see photograph on page 19).

On such supports, horizontal forces are transmitted through the actual support to the foundation causing great torques both in the support and its foundation. This is why self-supporting towers have a robust structure and are hence much more expensive than guyed portal supports.

The height of the support is influenced by factors such as the conductor used, terrain contours, and long span required by an obstacle, for instance a waterway which needs to be crossed.

If two supports are located very far from each other, the sag of the conductors is great. This is why safety considerations may require the use of supports which are taller than normally. Greater support height is restricted not only by mechanical strength but also by potential air traffic in the vicinity of the line. This imposes certain maximum heights on supports in such areas. The supports may also have to be painted with high-visibility colours and provided with anti-collision lights. Moreover, power line markers may sometimes be installed on the ground wires for birds and air traffic.

Since transmission lines are constructed as bare conductor overhead line lines, disturbance-free electricity transmission requires that the conductors cannot come into contact with each other or the ground. In practice, this means that the conductors must be prevented from touching trees or other structures with a conductive connection to the ground.

In order to reduce the risk of ground contact, the transmission line area and right-of-way must be sufficiently wide so that even if the tallest trees at the edge of the right-of-way fall, they cannot touch the conductors. This distance, i.e. the width of the right-of-way, is determined by the tower height and above all by the span length and by the free space required by the largest possible swing of the edge conductor, enabled by the span length. Figure 3 shows a schematic illustration of the transmission line area.

The transmission line area is composed of the right-of-way and of border zones on its each side. In conjunction with the construction of a line, the grid operator expropriates a limited right of use to the land area, with this right of use restricting the use of the line area by the landowner.

The right-of-way is kept clear of trees by means of regular clearing. The length of trees in the border zone is monitored by means of line inspections carried out at prescribed intervals. If the inspection reveals border zone trees that can reach a conductor if they fall, such trees are recorded and removed later.

If the entire border zone has grown too long, the only sensible way is to fell all trees in the border zone. In such cases, the felling of trees is agreed upon with the landowner.

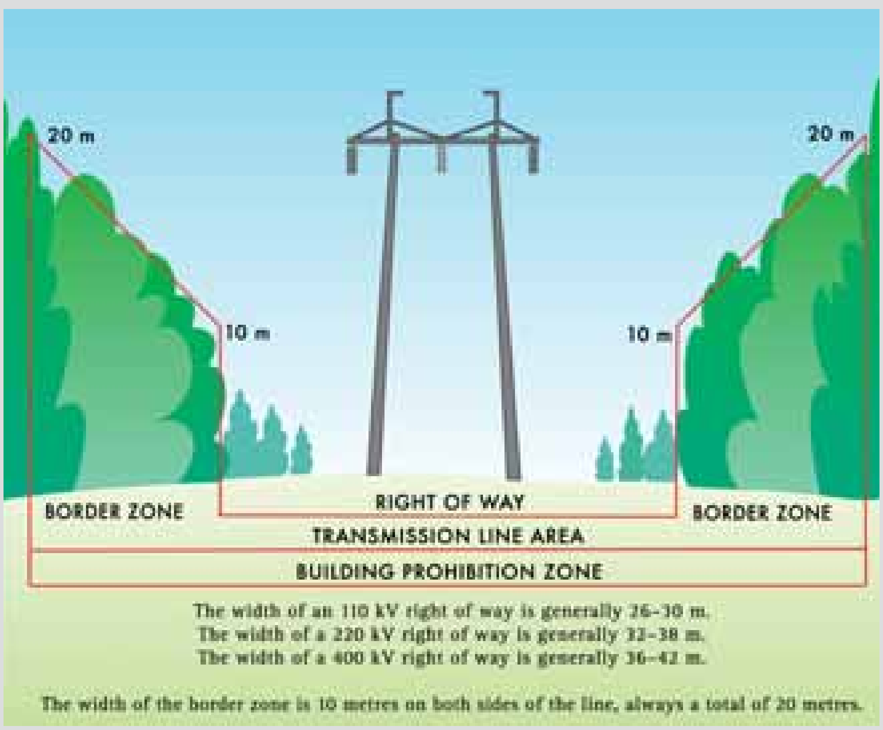


Figure 3. Schematic illustration of the transmission line area. The right-of-way is that area which is kept clear of trees. In the border zone, the trees are shaped so that if they fall, they cannot reach the conductors. All types of construction are prohibited in the building prohibition zone.

Electricity is blue

Electricity – something invisible, boring, colourless and technical men's stuff? Not at all! Electricity startles.

Electricity is blue! Electric blue is one of the oldest and wildest colours there are. It has obtained its name from lightning, the ruler of all divinities. It is the colour of kings and peacocks, the colour of power and self-consciousness. Azure is the mother of all blue.

Blue, like all colours, carries a mighty symbolic meaning. The ancient Romans underrated blue. This was probably due to the fact that the eyes of the undervalued barbarians were blue. It was not until the victorious Medieval French kings adopted blue, the colour of St Mary, in their shields that blue became acceptable. Blue has the undertone of force and triumph.

This is why blue has a special role whenever a leader marks his turf with his own colour that often differs from the official colour of the community. When a blue wave starts to spread from the corner room to the open-plan office, everyone in the company knows that there is a power struggle going on.

What do I do with this piece of information? My landscape is office grey, screensaver grey, commuting grey, paper grey? I, whose only blue appears on my overalls, every day, and sky-blue, on those rare occasions that I get to see it?

But the entire you live your life. Your whole body, all senses. Work does not need to be an all-absorbing calling; it is OK to take work just as work. You only torment yourself if you put on an asbestos-surfaced or teflon-surfaced work-me when you leave home for work.That's a deadlock.

Under mental stress, you get wound up as you try to press just a little bit more capacity from your head. Gradually, only your overheated head goes to work; the rest of the body just drags along and becomes even more deteriorated.

Under physical stress, your muscles moan and your field of vision tapers. Your head becomes void, and your only thought is that repeated by your weary body: One more time, gogogo.

In both cases, what comes home is a tired, colourless person.

It takes its time to be able to sense and observe things, to fill up and rejuvenate. The tenser your life, the more intense signals and more ferocious experiences are needed to arouse just any reaction. A busy person can only discern black and light. A busy person cannot be stopped by touch; he has to run against a wall to be stopped. The shades disappear.

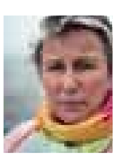
Many people say that a necessary change came to their life like in a stroke of lightning. After lightning, the air is filled with new kind of energy, smell of ozone and burning, and a strange kind of listening silence. After being frightened and dazzled by the blue, everything is quite different for a while. He who seizes the opportunity is truly wise.

Electric blue reminds us of the need for having energy in life. It is no wonder that Finns, tired by the long winter and burdened by their heroic work morale, tend to choose blue as their favourite colour. We see and sing about blue dreams, we spend blue moments, in our wild youth we ordered beer with a blue label on the bottle, and now we still eat chocolate wrapped in blue paper.

Blue is a good colour to remind us that people should have dreams and time to nurture them. Dreams do not just benefit the private life. They can also be inspiring goals and plans related to work, and they can gain a more comprehensive meaning in a group of friends.

Dreams are an indication of hope; a hopeless person withers. Blue electrifies and opens new perspectives.

Hilkka Olkinuora



Hilkka Olkinuora is the columnist of the Fingrid magazine. She presents herself as follows: "Minister and journalist from Tampere, wrote earlier of economy, nowadays also again a student. Also works at workplaces, and discusses electric encounters in this magazine."