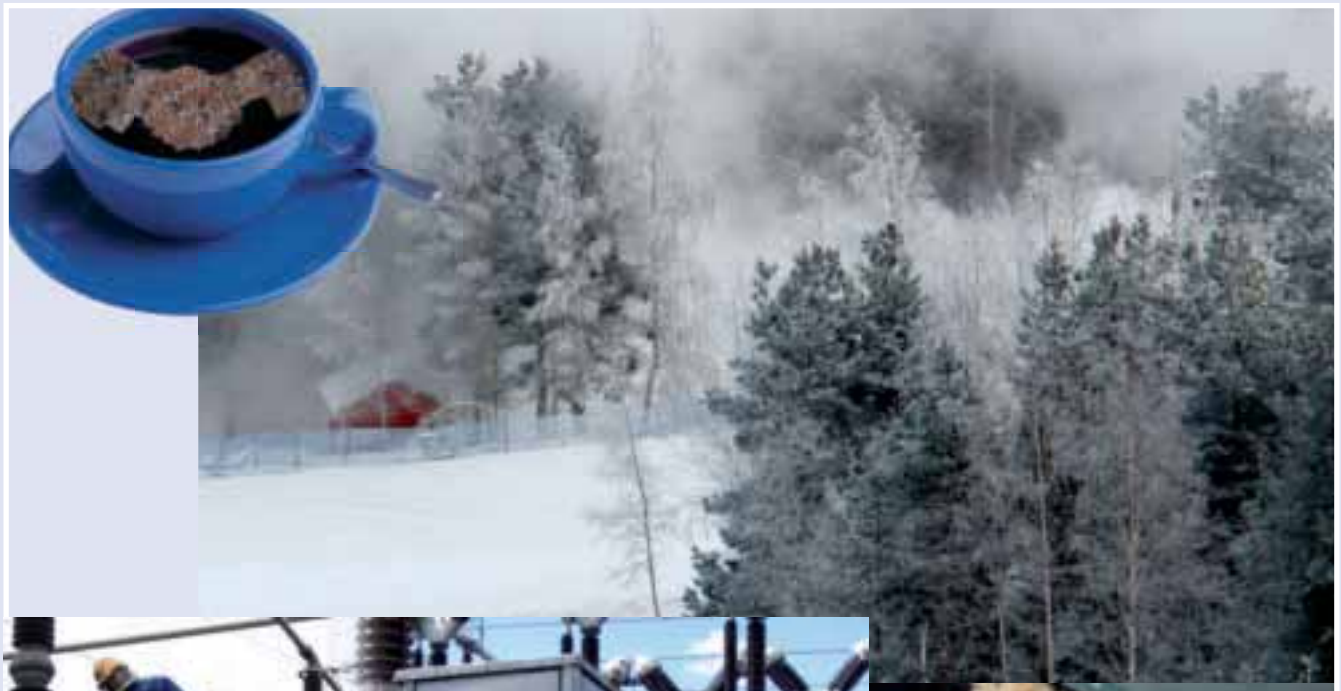
Corporate magazine
Fingrid Oyj
1/2007

# FINGRID

## Finnish co-operation lives on *page 6*

## Electric wonders at Elektra *page 20*



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**Fingrid Oyj**

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**Editorial staff**
**Telephone:** +358 (0)30 395 5000, Fax +358 (0)30 395 5196
**Postal address:** P.O.Box 530, FI-00101 Helsinki, Finland
**Street address:** Arkadiankatu 23 B, Helsinki. www.fingrid.fi
**Editor-in-Chief:** Leni Lustre-Pere, e-mail: leni.lustre-pere@fingrid.fi
**Editorial board:** Jari Helander, Aila Itäpää, Antti Linna, Erkki Stam
**Design by** bbo, Better Business Office Oy / Maria Hallila and Tuija Sorsa
**Translation by** Kielipaja Hannu Hakala

**Cover photograph:** Anniina Riikonen studying Elektra's exhibition. Photograph by Laura Vuoma.

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# In this issue

# On offer: electricity market from Helsinki to Paris – next year!

As an integral part of its energy strategy, the European Union continues to focus on developing a common market for electricity. An efficient market is perceived as the best way in which to provide citizens and industries with electricity in a reliable and environmentally friendly manner and at a competitive price.

The creation of the European electricity market has progressed slowly but steadily. However, it now seems that significant steps are being taken in terms of the opening of the market in Northern Europe.

The Nordic countries have chosen rapid progress from the very beginning, and these countries have been trailblazers in Europe in many issues. The role of a trailblazer is based to a great extent on the good co-operation between the Nordic transmission system operators (TSOs): after all, it is the TSOs who, together with the electricity exchange, create the arena for the wholesale market, where the market players compete with each other. And society benefits from the efficiency brought by competition.

One concrete example of the progressive regional co-operation of the Nordic TSOs is the shared development plan for the Nordic grid. This plan has been drawn up by analysing the benefits given by capital expenditure in the grid to citizens and industries in all Nordic countries. To the other parts of Europe, this grid project package of 1,000 million euros offers an example of true regional co-operation which is only emerging elsewhere in Europe.

The approach of rapid progress adopted by the Nordic countries can already be considered as a success story. The Nordic market has produced distinct welfare to the national economies through increasing efficiency which re-

sults from competition. Competition has enabled the integration of the synergy benefits of hydropower and thermal power in the most efficient way possible. This is reflected to the users of electricity in an inexpensive price of electricity.

Another advantage given by rapid progress will be seen more clearly in the near future. By implementing their own solutions pertaining to the market structure, the Nordic countries have established a market structure which the rest of Europe can follow easily. This process is progressing concretely right now as the integration of the market between the Nordic countries and Continental Europe is well under way.

The Nordic market model, which combines spot trade in the previous day and the intra-day Elbas trade, will turn out victorious in this process. We take all this almost for granted here in the Nordic countries, but when you think about it more closely, it was in no way certain beforehand that for example Germany would have adopted the Nordic model as such. On the other hand, now that Germany is fully involved, the market model carries much more weight. In practice, the market structure has been decided up to a point in time of one hour before the moment of delivery – in accordance with the Nordic model.

The integration of the European electricity market has rested greatly on TSOs and electricity exchanges. Right now, the European market close to us is undergoing a phase of rapid developments. During this and next year, the Nordic countries will be joined by means of market coupling to a market composed of Belgium, Holland, France and Germany.

The market mechanism works pretty much in the same way as Nord Pool's Elspot today. The total size of the integrated market is 1,500 TWh! This process is apt to improve the competitive situation in Europe and will certainly intensify the market mechanisms.

The new situation calls for a reassessment of the situation in all Nordic countries. We need to review the role of Nordic co-operation, taking into account the rapid developments around us. When the wholesale market becomes one, we can no longer create Nordic models which are independent of the remainder of the market area; and now the size of the market is 1,500 TWh, not the safe and familiar Nordic market of 400 TWh. Now that we have gradually become accustomed to co-operation with Norwegian or Danish partners, we will soon meet our French colleagues at a negotiating table.

For this reason, Nordel, the co-operation organisation of the Nordic TSOs, has launched strategy work aiming at considering the new situation in the co-operation conducted between the Nordic TSOs. The basic idea is that matters relating to the functioning of the market will be matters handled mainly on the European level.

The Nordic countries will continue to contribute actively to the development of European models. On the other hand, the shared synchronised grid keeps us bonded with our Nordic colleagues also in the future. In co-operation with our Nordic friends, we will make sure that Finland continues to obtain electricity without disturbance.

Jukka Ruusunen is
Fingrid Oyj's President.

*Pertti Simola thinks that open-minded solutions are among the success factors of a small country. These types of solutions can be created when all parties involved have the will and skill.*

TVO's President & CEO Pertti Simola:

# Finnish model produces INNOVATIVE SOLUTIONS

**Co-operation in the reserve power arrangements for the grid connection of the third nuclear power unit being constructed at Olkiluoto resulted in a win-win outcome.**

Text by Maria Hallila ■ Photographs by Juhani Eskelinen and TVO/Hannu Huovila

Finnish co-operation and a Finnish way of doing things have not disappeared in line with Finland's EU membership and increasing globalisation. On the contrary, they are still vibrant, producing magnificent results.

You really believe this positive message when you listen to **Pertti Simola**, President and CEO of Teollisuuden Voima, when he is describing how co-operation and open-mindedness in the grid connection of the Olkiluoto 3 nuclear power unit led to a unique innovative solution which benefits all parties.

## Largest generator in the world connected to the grid

In line with the completion of the third unit at the Olkiluoto nuclear power plant, the largest single generator in the world, having a power of 1,600 megawatts, will be connected to the Finnish grid. The key issue with its grid connection is related to potential malfunctions: how to secure that the disconnection of the plant unit from the grid does not escalate into a major disturbance in the Finnish and inter-Nordic grid?

Pertti Simola was already involved in tackling this extensive, demanding and difficult technical challenge in his previous position as Senior Vice President for Energy at UPM-Kymmene. At that time, he represented the views of the biggest transmission customer of the grid and also the views of large-scale wood-processing industries. For more than

*The construction site of the third nuclear power plant unit at Olkiluoto is moving over to the installation of main machinery. Work is carried out in three continuous shifts.*

*The third unit at the Olkiluoto nuclear power plant is due to be ready by the turn of 2010 and 2011. For Fingrid, the technical solutions, arrangements and capital investments for connecting the unit to the grid have progressed as planned; the new transmission lines and substations will be complete by the end of 2008.*

three years now, he has examined the operating environment and market of the electricity business from a vanguard position in the energy industry.

## Fingrid on the move in good time

"Fingrid had launched the engineering of the grid arrangements required by the new nuclear power unit before a decision on its location had been made. In other words, the company was moving in good time, like always," Pertti Simola says in referring to the model followed by Fingrid in grid development.

"In terms of the system security and cost efficiency of the grid, it is of utmost importance that Fingrid knows about the customers' plans, needs and wishes as early as possible. This ensures that the grid reinforcements required for example by a power plant project are ready on time. On the other hand, confidential and long-term co-operation helps the transmission system operator to avoid potential misdirected capital investments."

Pertti Simola points out that this type of open and close co-operation is only possible when the parties have full trust towards each other. According to him, Fingrid has deserved the trust of its partners through factors such as comprehensive and in-depth expertise as well as operational reliability and cost-efficiency, as verified by international benchmarking.

Looking back at his own experiences of grid co-operation both in the service of the Finnish wood-processing industry and in his present position, Pertti Simola says that Fingrid has always been as good as its word.

## Unique reserve power arrangement based on collaboration

When Olkiluoto was decided as the location of the new nuclear power unit in Finland in the autumn of 2003, the engineering of technical solutions applied to its grid connection – with reserve power arrangements being the focal issue – started in close co-operation, says Pertti Simola.

One backup system already existed. In accordance with the inter-Nordic burden sharing arrangement, each country supports the system balance by automatically raising hydropower production if a generator trips from the grid.

However, in the case of a 1,600 megawatt generator, this is not sufficient. "More robust means were required, and since there was a positive intent and also competent people on both sides of the negotiating table, such means were found."

Pertti Simola says that the automatic load drop system, which was selected as the solution, is not used anywhere else in the world as far as he can tell. In the arrangement which is based on collaboration, Fingrid's and TVO's partners comprise a host of major electricity users in Finland.

Technically, the solution works so that information on the circuit breaker status caused by the disconnection of the Olkiluoto 3 generator from the grid is forwarded in an instant to transmission customers included in the system. At the same time, an agreed volume of industrial loads – hundreds of megawatts – are disconnected from the grid.

## Gas turbine plant as the third cornerstone in power balance

The innovative solution found for an extensive technical challenge represents, according to Pertti Simola, a Finnish way of doing things, where rationality, will and skills are utilised to benefit all. "The result is a cost-efficient arrangement which benefits not only Fingrid and TVO but the entire Finland."

As an additional example, he also refers to the third cornerstone in the reserve power arrangements for Olkiluoto 3: the gas turbine plant to be constructed in conjunction with the power plant. This 100 megawatt plant due to be ready this summer is a joint project by Fingrid and TVO, with the construction costs of 50 million euros divided in equal proportions by the two companies.

*"The result is a cost-efficient arrangement which benefits not only Fingrid and TVO but the entire Finland."*

The plant is an important part of reserve power capacity which Fingrid needs for potential disturbance situations in the nation-wide power system. On the other hand, alongside other sources of reserve power, it contributes to the supply of auxiliary power to the Olkiluoto plant units in the event of disturbances.

"The win-win principle is at its best in the operating arrangements of the Olkiluoto gas turbine plant: power owned by one party is, whenever necessary, also available to the other," Pertti Simola says.

## Quality issues at Olkiluoto 3 under strict control

For Fingrid, the technical solutions, arrangements and capital investments for connecting the third unit at Olkiluoto to the grid have progressed as planned. **Petri Parviainen**, Fingrid's Customership Manager for grid service, says that the new transmission lines and substations required by the grid connection will be ready by the end of 2008.

Pertti Simola adds that the actual nuclear power plant unit is due to be complete at the turn of 2010 and 2011. "Of course, we are disappointed at the delay in the construction schedule, but there is no doubt that we could not achieve our stringent quality goals in terms of safety, system security and cost efficiency. Once completed, Olkiluoto 3 will represent the pinnacle in its field globally," he assures.

Manpower at the site is approaching 1,500 employees, and TVO's own organisation is making preparations for the installation and commissioning phase. The operating personnel are up against a long period of training.

According to Pertti Simola, the publicity which site deviation reports have attracted in media only shows that the idea of this quality control tool has not been fully understood. "In fact, what the high number of deviation reports indicates is that quality control works well and that all, even small deviations from the extremely carefully specified criteria are noticed," he points out.

"This ensures that the final result is good."

# NEW CONTRACT PERIOD for grid tariff in sight

## Preparations reaching final stages

**Fingrid's goal is to have the unit prices of the new tariff for the grid transmission service for the four-year period 2008 – 2011 ready during the summer. The tariff outlook is primarily influenced by capital expenditure in the grid, which will require more money in the near future than in recent years. However, only a moderate increase is expected in the price of grid service.**

Text by Pertti Kuronen
Photographs by FutureImageBank, Eija Eskelinen and SXC

Capital expenditure in the grid is a way of keeping the electricity market uniform, without bottlenecks, for a greater portion of the time and within a larger geographical area than before. However, the increase in capital expenditure only means a moderate increase in the price of the grid service from the 2007 level. The price during the coming tariff period will remain about at the same level as the present contracts.

## Transmission price down by one third in 10 years

The trend in the transmission price has been decreasing and fairly stable during Fingrid's existence. Fingrid's positive cost trend has enabled the company to transfer part of the profit to improve the balance sheet. Equity ratio has risen from 10 per cent to a level of 25 per cent, which has been deemed sufficient in the present operating environment.

In real terms, the price of grid transmission has decreased by more than one third over the past 10 years. Fingrid's operational efficiency and decreasing interest expenses together with the equity ratio of 25 per cent enabled the price reductions in 2006 and 2007.

Retaining a high credit rating means that the company will continue to have a low margin on its loans and an extensive range of investors both on the international and domestic money and capital markets.

## Capital expenditure in the grid promotes market mechanisms

The transmission grid constitutes the physical market place for electricity trade. Right after system security, grid development must pay attention to promoting the functioning of the electricity market. The objective is that each euro spent by Fingrid in the grid is multiplied by the improved operating conditions available to the electricity market parties.

A good example of this is the Fenno-Skan 2 submarine cable between Finland and Sweden, where the commercial benefit obtained by Fingrid is only about one third of the economic advantage obtained by the electricity market parties.

Fingrid's capital expenditure projects in the early part of this decade have primarily concerned the grid in Finland and amounted to approx. 40 million euros per year. Now the capital expenditure level has risen to more than 60 million euros annually. Capital expenditure in cross-border lines, required by the improved functioning of the electricity market, is elevating the capital expenditure level at the beginning of the next decade twice as high as now.

## Grid capital expenditure gives great benefits to the national economy

Fingrid together with the Government Institute for Economic Research (VATT) has used national economy models to examine what types of consequences grid capital expenditure of a certain magnitude has on the national economy. The analysis took into account all the multiplicative effects of capital expenditure that would be reflected in changes in the gross domestic product. The foremost impacts include an increase in the general capital expenditure level and improved employment figures.

The preliminary results indicated that thanks to the multiplicative effects, the overall impacts of grid capital expenditure on the national economy can elevate the total benefits three times as high as the direct benefits received by consumers and producers.

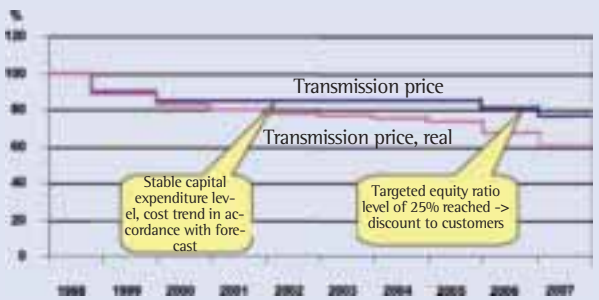
## Direction of cash flow up

Fingrid's cash flow will turn negative as a result of the capital expenditure projects. To counterbalance this negative trend, the accrued income must be raised.

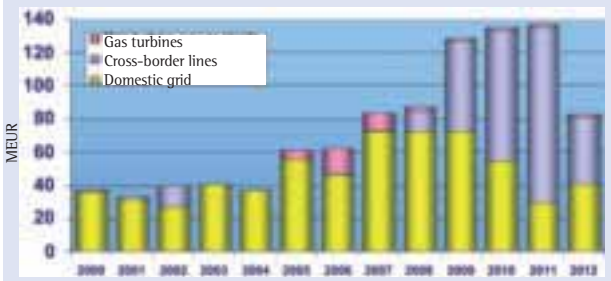
Fingrid's equity ratio will decrease slightly at the peak of capital expenditure but will still remain close to 25 per cent.

The capital expenditure level is raised by the significant rise in the prices of raw materials and construction work especially over the past couple of years.

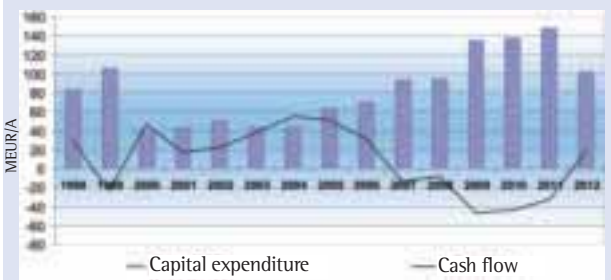
After 2011, capital expenditure will begin to focus more on renovations as the grid structures built in the 1970s, a period of active construction, are reaching




*Trend in transmission price 1998–2007*




*Fingrid's capital expenditure in the grid in 2000–2012*




*Trend in cash flow at the proposed price level after planned capital expenditure projects.*

the end of their life cycle. This concerns substations in particular.

The base load power decisions to be made in the 2010s will also have an impact on capital expenditure in the grid.

### Financial cornerstones as the basis of tariff planning

The planning of the new grid tariff period has been based on the cornerstones of Fingrid's finances as well as on the related primary aspects and objectives:
**Customers** => anticipated and low tariff level for the tariff period.
**Owners** => equity ratio level of 25 per cent is sufficient.
**Sufficient cash flow** => secures the execution of planned capital expenditure projects.
**Retaining the credit rating** = **key figures which determine the debt expenses must be at a sufficient level** => retaining competitiveness in funding.
**Investors/financiers** => retaining an extensive range of investors and keeping Fingrid as an attractive investment for investors.

The goal is to keep the structure of the tariff the same as that of the present tariff which came into force in 2005. In this way, the mutual weighting of the various tariff components would remain roughly the same.

The length of the new contract period will be extended from the present three years to four years, which corresponds to the regulation period of the Finnish Energy Market Authority. However, a longer contract period makes it somewhat more difficult to predict the future financial trends.

### Two alternative price level models

What level of income is required so that Fingrid can retain its present, high credit rating also in the coming tariff period to ensure an inexpensive interest level for the funding of the company?

In the annual theme day arranged by Fingrid for its customers and other stakeholders in the spring, Fingrid presented various alternative models which can be used for adjusting the price level of the grid tariff.

*In the model of stable growth*, the price increases would be divided evenly across the next tariff period, *while in the model of stable tariff*, a sufficient basic adjustment would be made at the beginning of the tariff period, after which the price level would remain unchanged until the end of the period.

For financiers, the latter model would give a better result in view of financial indicators, but customer feedback suggests that the former model would be better suited to the customers.

### Longer contract period adds to uncertainty

The grid contracts have traditionally included provisions for changes which differ from forecasts concerning the operating environment, by taking into account an option for price adjustments of a certain magnitude. The use of this option has been notified separately each year. The increase margin has been 3 per cent per year. As the contract period will now be one year longer than before, there will also be more factors of uncertainty involved in the anticipation of changes.

The foremost factors causing uncertainty in the forecasts include:

- **Capital expenditure level**, which is influenced by changes in the need for capital expenditure projects and/or changes in their timing, and by the price trend of raw materials and construction costs.
- **Procurement of loss energy**, where the most significant risk is composed of changes in the price level of electricity.
- **Consumption forecast of electricity**, according to which the increase in consumption during the contract period is expected to be on average 1.6 per cent. The increase in consumption has been included in the price level analyses of the tariff.
- **Financing costs**. The analyses are based on the assumption that Fingrid's credit rating will remain unchanged.
- **European market place**, where the crucial thing is reaching an agreement on a new arrangement for transit transmissions. The new arrangement will be outlined in more detail before the autumn.
- **Nordic bottleneck revenues**. An agreement on the new distribution model for Nordic bottleneck revenues has been reached between the Nordic TSOs. According to the new distribution model, fifty-fifty distribution will be adopted on each connection within a long period of transition.

The effects of these risk factors will be analysed as carefully as possible, and based on the analyses, Fingrid will pro-


*The tariff structure and preliminary price level of grid service were discussed during Fingrid's theme day arranged for the company's customers and other stakeholders in March. Pertti Kuronen (photograph above), Fingrid's Senior Vice President responsible for grid service, presented the basis of tariff planning to the audience.*

pose potential latitude in the unit prices of the coming contract period.

### Contract negotiations with the customers during the autumn

The new contract period will commence on 1 January 2008. Preparatory work for the pricing was launched in the summer of 2006 when the development needs were presented to Fingrid's Advisory Committee and Board of Directors. The tariff structure and preliminary price level were discussed during the theme day and among the Advisory Committee in March.

Before a proposal concerning the new unit prices is submitted, Fingrid will conduct a host of preparatory discussions with specific customer groups. After this, the matter will again be discussed within the Advisory Committee.

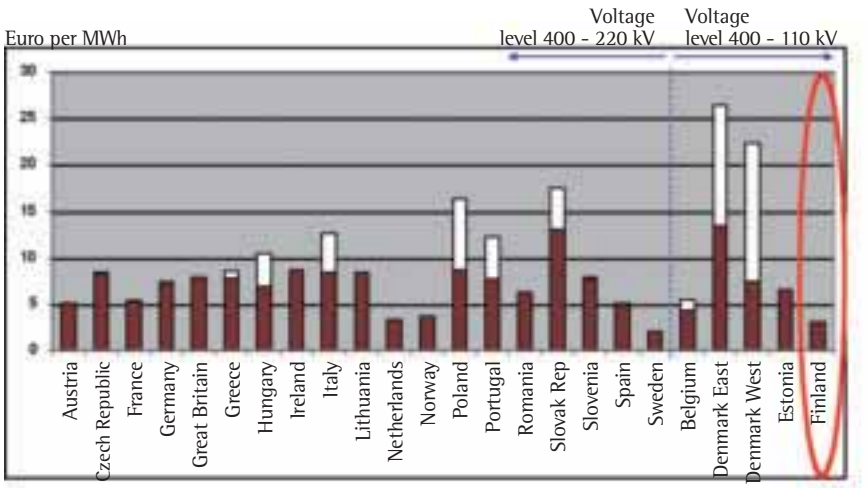
After handling by the Board of Directors, the Energy Market Authority will confirm the terms and conditions of the grid service during the autumn. Contract negotiations with all customers will take place during the autumn.

## Maillot jaune – objective also in the future

Fingrid's grid pricing has been highly competitive within the European ETSO area. In the most recent comparison in 2005, Fingrid's grid tariff was the most inexpensive when considering the scope of service.

"The price of our service covers not only the 400 kV and 220 kV grids, but also the costs of the 110 kV grid, with these costs being almost half of the costs of electricity transmission," says **Pertti Kuronen**, Senior Vice President for Fingrid's grid service.

"Keeping the leader's maillot jaune also in the future will be our goal," he promises.




■ Costs connected to TSO activities: infrastructure (capital and all operation charges), losses, system services, congestion.

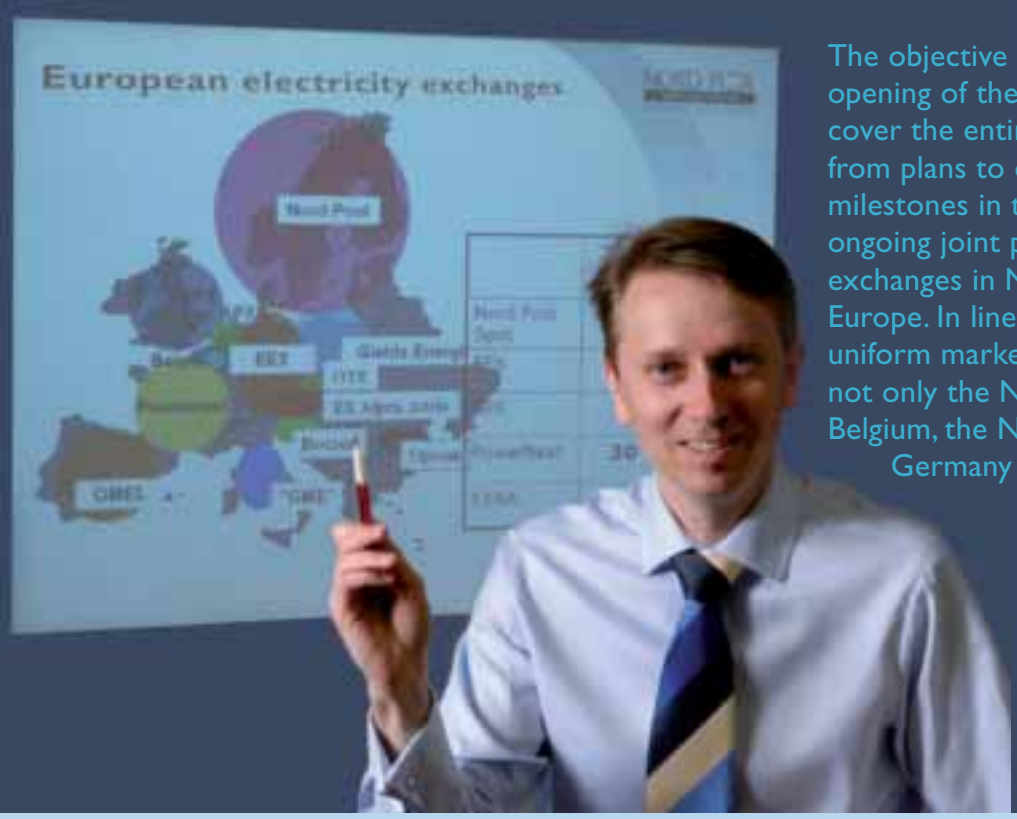
□ Other burdens not directly related to transmission costs: stranded costs, public interest contribution, renewable energy and other.

**General information notes:**
The example taken for this comparison is the base case, that is:
- for a utilization time of 5000 h, for a maximum power of 40 MW
- average value for countries with location tariff
• For any customer connected to the highest voltage level in each country

*ETSO's tariff comparison in 2005.*

# Electricity market opening up in Europe

## Market coupling used for seeking growth benefits




The objective of the European Union, opening of the electricity market to cover the entire Europe, has progressed from plans to concrete action. Important milestones in this process include the ongoing joint projects by electricity exchanges in Northern and Continental Europe. In line with these projects, the uniform market area will expand to cover not only the Nordic countries but also Belgium, the Netherlands, France and Germany by the end of next year.

Text by Maria Hallila
Photographs by
Juhani Eskelinen

"The European Market Coupling project aims at achieving a market area which is geographically larger than before. The first phase is to turn the national electricity markets into multinational markets. The multinational Nordic market is already progressing towards a North European market," says **Karri Mäkelä**, Director of Nord Pool Finland Oy.

"We are gradually moving via regional markets to a market covering the entire Europe. In accordance with the ultimate objective, this market will have an as uniform European electricity price as possible."

### Nord Pool – pioneer in electricity trade

Electricity exchanges have been established in Europe since the 1990s. Their establishment has been expedited by the EU directive according to which the member states must open their electricity and gas markets as of the beginning of July 2007. At the moment, there are 15 exchanges in the European electricity market.

*"The larger the market, the better it works," is how Karri Mäkelä summarises the basic rationale of European electricity market integration.*

Nord Pool in the Nordic countries is a pioneer in this field and the first electricity exchange in the world operating in the area of several countries. It has the highest market share in its area of opera-

tion. “We account for about 63 per cent of the total market in our area. The market shares of most other electricity exchanges are less than 10 per cent,” Karri Mäkelä says.

The total volume of the physical market in Nord Pool in 2006 was approx. 250 terawatt hours (TWh). The second biggest electricity exchange is the German EEX (87 TWh) and the third biggest is the British APX (19 TWh).

## Market mechanism à la Nordic

As the opening of the electricity market in Europe has progressed further, electricity exchanges have become more and more interested in co-operating with their neighbours. “The benefits given by an expanding market bring the market players in a certain region to the same negotiating table and suppress the local interests and political interests, which in many cases can be quite considerable,” Karri Mäkelä says.

He adds that the pioneering and progressive Nordic approach has been an example in Europe in co-operation between both electricity exchanges and transmission system operators.

“In the European Market Coupling projects, which aim at establishing increasingly larger European market areas, the price mechanism and model of operations follow the example set by Nord Pool’s Elspot and Elbas market places.”

The Elspot market is for day-ahead trade. The purchase and sales bids are made daily by 12 o´clock (CET) for each hour of operation in the next day.

Elbas market is for intra-day trade. It is continuous trade and takes place 24 hours a day. The last trading option is one hour before delivery.

## Strong links under preparation

The first European Market Coupling project concerning the Nordic countries was launched when preparations for the construction of the NorNed electricity transmission cable between Norway and the Netherlands commenced at the beginning of 2005. The cable is due to be ready by the end of this year. It will link the electricity markets in the Nordic countries and Continental Europe even more closely to each other.

“This project was initiated by transmission system operators in the Netherlands and Norway. Later on, it also involved the Nordic electricity exchange Nord Pool Spot and the APX exchange operating in the Netherlands and Great Britain”, Karri Mäkelä says.

Once completed, NorNed will be the longest submarine cable in the world with a length of 580 kilometres. The transmission capacity of this HVDC cable laid between Kvinesdal in Norway and Eemshaven in the Netherlands is at least 600 megawatts.

There is also an ongoing co-operation project between the Nordic countries and Germany aiming to improve present capacity optimisation between Denmark and Germany.

The parties involved in this project are the Danish and German transmission system operators Energinet.dk, Vattenfall Europe Transmission and E.ON Netz as well as electricity exchanges Nord Pool and EEX in Germany.

“The goal is to have market coupling up and running towards the end of this year. Allocation of cross-border transmission capacity presently takes place partially by means separate auctioning procedures. The new model will mean that allocation of interconnector capacity is integrated into energy trade through co-operation between the electricity exchanges. This results in more efficient market mechanisms.”

## Benefits to national economies and consumers

According to Karri Mäkelä, the biggest benefits from the integration of a market with thermal power production in Continental Europe and the hydropower-based market in the Nordic countries are derived from increased efficiency and smaller price peaks.

“The national economies in the countries involved draw the greatest benefits. We all know that the larger the market, the better it works.”

Karri Mäkelä thinks that over the long term, consumers will also benefit from the expansion of the market area. “In the uniform European electricity market, electricity is always transmitted from a cheaper price area to a more expensive one, never the other way around.”

In 2006, the direction of electricity trade was mainly from north to south according to Karri Mäkelä. However, there is a distinct need for reverse electricity transmissions.

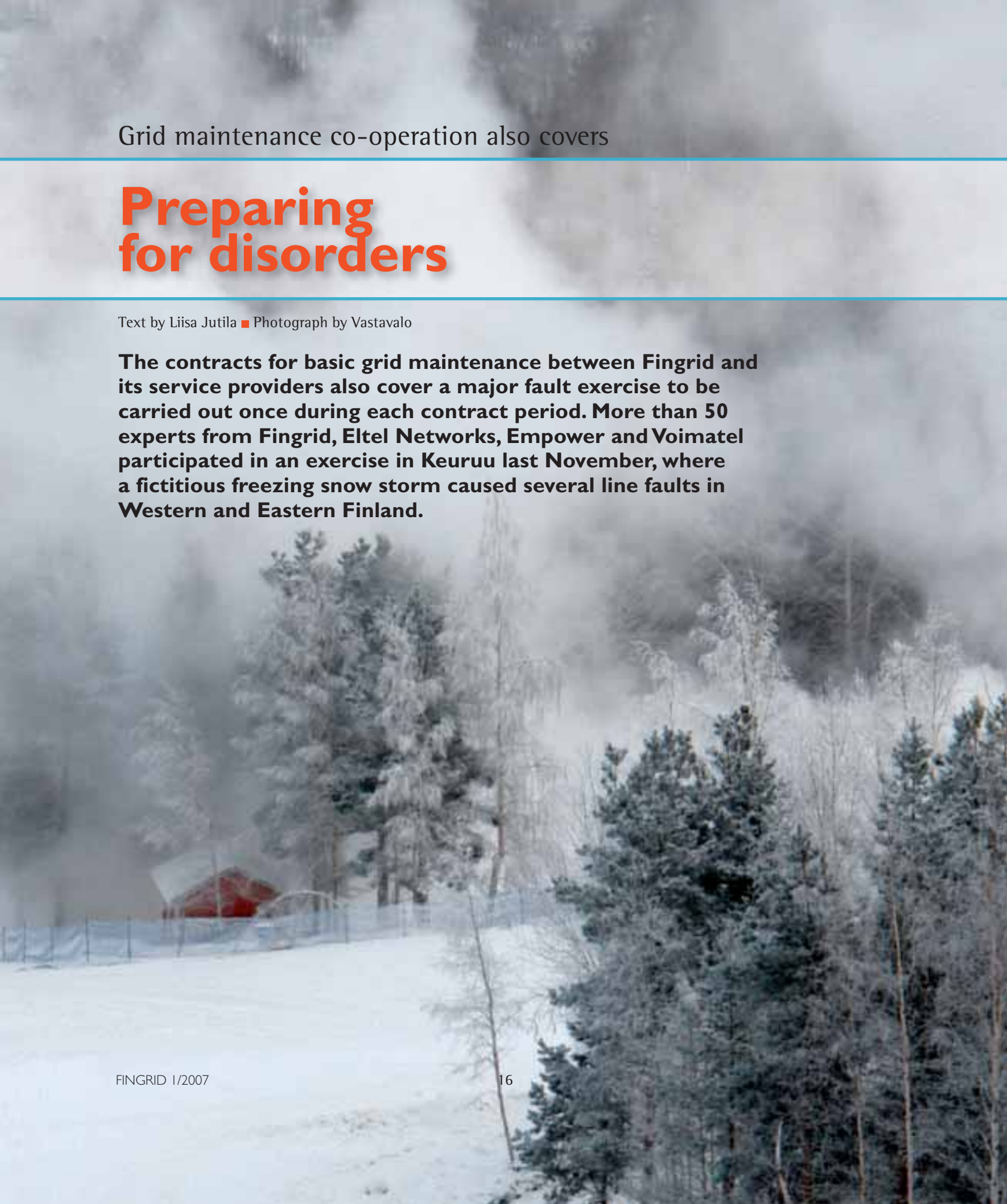
“And of course, a larger market area is not only an efficiency factor but also a security factor,” Karri Mäkelä points out.

Grid maintenance co-operation also covers

# Preparing for disorders

Text by Liisa Jutila ■ Photograph by Vastavalo

**The contracts for basic grid maintenance between Fingrid and its service providers also cover a major fault exercise to be carried out once during each contract period. More than 50 experts from Fingrid, Eltel Networks, Empower and Voimatel participated in an exercise in Keuruu last November, where a fictitious freezing snow storm caused several line faults in Western and Eastern Finland.**



"The preparations of the exercise started in August, and they required much work from many Fingrid employees," says **Ari Levula**, Fingrid's Maintenance Manager for transmission lines, who served as the "main architect" of the exercise.

The exercise in Keuruu focused on the clearing and repair of several simultaneous line faults as well as grid operation and other measures required by the faults. Another important component was to test how management, co-operation and communications work when there are several parties to "clear the same mess".

On the first day of the exercise, the participants also visited the Central Finland Engineer Regiment in Keuruu and received information on the equipment and executive assistance provided by the Finnish Defence Forces.

## Things really got done

**Kimmo Kuusinen**, head of Fingrid's Network Control Centre in Hämeenlinna, belonged to the 11-member jury of team work assignments. He says that the various parties especially seemed to share the view that the exercise was really useful and matched the expectations.

The theme was practicing the work of specific teams – such as various service providers – and communications between the teams.

"Even though the exercise was carried out as a desk exercise, the workplaces of the teams were full of activity, because the 'freezing snow storm' caused one fault after another," Kimmo Kuusinen said after the exercise.

*"All in all, the useful exercise left a positive feeling."*

He says that most of the functions were carried out well. "However, when reflecting on the actual situation, maybe some of the assessments made were even too optimistic. For example, there was sufficient repair material and personnel available now, and the communications worked without glitches. In reality, a widespread disturbance like the one imagined in the exercise would certainly complicate these things. However, the organisers had decided in advance that for example communications work all the time."

According to Kimmo Kuusinen, the exercise revealed a need to update certain instructions and rethink some procedures. Some teams also felt that communications should be improved.

"If we ever repeat this exercise, we need to think more closely what initial information is given to the various parties so that the teams would have an identical view of the situation. It would be easier to carry out the exercise so that people work at their own offices, because then they would have access to all necessary tools. On the other hand, this would deprive the exercise of one of its dimensions – when you assemble in a single place, you can meet with people with whom you talk on the phone almost daily."

"All in all, the useful exercise left a positive feeling," Kimmo Kuusinen summarised his impression.

## Demanding but realistic assignments

**Panu Tuhkanen**, who heads Empower Oy's transmission line unit, remembers the exercise for the eager and activity of the participants.

"The event was very successful, because the participants came from many different companies. However, they had a clear shared goal – to pull through the exercise," Panu Tuhkanen said.

He says that the exercise revealed some bottlenecks – just like it was supposed to. As an example, Empower made further specifications to internal communications after the exercise. "The communications experiences gained from the exercise were soon put into practice in conjunction with the repair of a fault on the Tahkoluoto - Ulvila 400 kV line," Panu Tuhkanen says.

He thinks that the exercise assignments were demanding but still imaginable in a serious grid disturbance.

"It was very positive that the exercise was implemented in co-operation between Fingrid's organisations and service providers. In this way, the various parties will have a better understanding of each others' performance if there is an actual disturbance situation. I hope that the exercise will be followed by another part where we could go through the shortcomings detected and agree on potential further action," Panu Tuhkanen says.

*Substation training was headed by Project Manager Sami Mäki from Fingrid's substation investments group.*

*In the foreground instructors Patrik Lindblad (on the left) and Lauri Koivisto.*

# FINGRID'S SUBSTATION TRAINING

## gathers professionals to the source of knowledge

Text by Sami Mäki ■ Photographs by Eija Eskelinen

**Almost 90 professionals working with the Finnish transmission grid assembled in a training session arranged by Fingrid on 19 April. The training focused on relay protection and related plant testing and commissioning testing experiences. The training was part of the substation training package launched by Fingrid in 2006. The high number of participants indicated that there is a need to augment knowledge.**

In addition to Fingrid's own personnel, the event was also intended for the personnel of service providers.

The instructors in the training, which received good feedback from the participants, were **Patrik Lindblad** and **Lauri Koivisto** of Fingrid.

### Goal: to expand and advance knowledge and expertise

The objective of the training package is to increase the knowledge of the company and its service providers of the processes involved in substation projects and to advance expertise in this crucial special area. Another objective is to harmonise the procedures applied by Fingrid and its suppliers and to arouse a discussion of the contents of specifications and of the ways in which things should be run in general.

In the structure of the training, the substation project and its technical aspects have been broken down into parts. The training aims to shed light on Fingrid's special requirements and background of specifications, not so much on the details of standards and calculations. The primary target group of the training is composed of persons who work in substation projects on a full-time basis.

### Fingrid's own specialists and other experts as instructors

The training programme is headed by Project Manager **Sami Mäki** from Fingrid's substation investment group, assisted by a control group consisting of **Risto Ryynänen, Martti Heinonen, Patrik Lindblad** and **Jari Helander**. Fingrid's own specialists, specialists of service providers and other electricity experts serve as the actual instructors.

Some of the training sessions arranged two to four times a year are Fingrid's internal sessions while some are arranged together with service providers. The training topics covered so far have included construction specifications and good installation procedures.

The next training event on **1 November 2007** will deal with Fingrid's control, monitoring and measurement systems. The head of training and the control group welcome suggestions concerning the topics of training to be arranged in 2008.


*From the left: Christian Mack (Siemens AG), Mika Väärämäki (Fingrid), Christian Ebert (Siemens AG), Martti Kohtanen (Siemens Osakeyhtiö), Jukka Ruusunen (Fingrid), Jyrki Penttilä (Siemens Osakeyhtiö) and Kari Kuusela (Fingrid).*

# Fingrid ordered five new power transformers

■ Fingrid has ordered five new power transformers from Siemens AG. The total costs of the project are almost 20 million euros.

The transformers to be placed in different parts of Finland will add to the system security of the grid and reduce electricity transmission losses. The transformers will be delivered between 2008 and 2010.

The transformers will be manufactured at Siemens' Nuremberg factory in Germany. About 40 corresponding transformers are already in use at Fingrid's different substations in Finland.

## Alapitkä substation expanded by outgoing bay and main busbar

■ Fingrid is expanding the Alapitkä 400/110/20 kilovolt substation by adding another 110 kilovolt main busbar and one outgoing bay.

The expansion will improve the transmission reliability of the grid in North Karelia. Construction work at the substation will begin in the summer of 2007, and the work will be ready in 2008.

The turnkey contractor in the project is Fortum Power and Heat Oy.

## Vuolijoki substation upgraded by one outgoing bay

■ Fingrid will expand the Vuolijoki 400/110/20 kilovolt substation by one 110 kilovolt outgoing bay.

The construction of the bay is related to a mining project in Talvivaara. The expansion work will be carried out by Voimatel Oy on a turnkey basis. Construction work in Vuolijoki will commence during the spring, and the project will be ready during the early part of 2008.

*Eero Niemi and Santeri Riikonen working out the wonders of electricity.*

# ELEKTRA
# Who invented electricity?

## Summer exhibition of Electricity Museum Elektra offers things to see for all

Electricity Museum Elektra in Finland is a place for the whole family, offering an opportunity to learn more about electricity from various viewpoints. Among other things, the museum tour takes the visitor to the early stages of electrical engineering to meet a gentleman by the name of **Nikola Tesla**. Children are instructed by the electric rabbit Voltti, who helps in understanding the various electric phenomena.

Text by Leni Lustre-Pere ■ Photograph by Laura Vuoma

Nikola Tesla, born in 1856 in the area of the present Croatia, was an acclaimed and controversial expert in electrotechnology and the man who practically "invented electricity". Tesla was a theoretical and practical genius who apparently knew more about electricity than anyone else before him – and so far also after him.

Tesla invented things like alternating current, polyphase system, a flying machine and the so-called Tesla coil. He was also one of the early developers of the radio, even though this invention is usually credited to **Marconi**. However, in the USA the radio was patented by Tesla. The unit for magnetic flux density, tesla, is named after Nikola Tesla.

**Research by this multitalented genius** is said to have promoted the development of robotics, remote control, radar and computer technology and also contributed to achievements in ballistics, nuclear physics and theoretical physics.

**Nikola Tesla took some of the secrets** behind his inventions with him to the grave. One of these is the so-called black box, which, according to Tesla, took energy from ether. His black box was not just theory, because in 1931 he removed the petrol motor from his Pierce Arrow car and installed the black box in its place. To everyone's amazement and surprise, Tesla drove his car for about a week without any visible or external source of energy. At the end of the test drive, Tesla drove his car into the garage and dismantled the mysterious box. It is still not known how the car generated the electricity needed.

**Electricity Museum Elektra** now offers an opportunity to get to know this universal genius and pioneer in electrical engineering. The museum also houses a functioning Tesla coil, a device from the early days of electricity, which produces arc discharge more than 50 centimetres in length.

**Elektra's permanent exhibition** takes the visitor to a tour across the history of electrification. Settings from bygone decades describe how electricity came into homes, factories and towns. The exhibition integrates electricity production, electrical engineering and industrial development into everyday life.

The Electrotherapy section of the exhibition shows that the wonder gadgets advertised on TV shops are no new phenomenon. Electrotherapy appliances have been marketed as a miracle cure ever since man learned how to control electricity.

Elektra has not forgotten children, either. The children's corner shows how the force field of a magnet is created, what a circuit is, and how an electric motor works. Electric rabbit Voltti instructs how to make safe experiments with electricity.

Electricity Museum Elektra, Valvomotie 11, FI-13110 Hämeenlinna, Finland. • Open Tue–Fri 12–18, Sat 11–17. Closed Sun-Mon.
Inquiries and reservations +358 (0)30 395 4326, +358 (0)400 205 361, Kimmo Kyllönen. • See also: www.elektra.fi

Photograh by Eero Honkavaara

## Discoloured Blue Cranes were given a new coat of paint

■ The landmark at a multi-level junction in Espoo, a set of transmission line towers on Fingrid's 400 kilovolt line, referred to as Sinikurjet (Blue Cranes), were given a new coat of blue paint to brighten their surface which had been discoloured by the sun.

The set of three transmission line towers at the intersection of the road to Turku and Ring Road III was designed by Professor **Antti Nurmesniemi** in 1995. Weather conditions, mainly sunshine, have faded the deep blue colour of the towers, which was now rejuvenated.

In the three-week painting job, the towers were cleaned, painted and lacquered with two coats. This treatment is believed to keep the colour bright for the next 15 years.

The painting contract was carried out by FSP Finnish Steel Painting Oy.

*Representatives of Nokian Capacitors and Fingrid signing the procurement contract for the SVC unit. Back row from the left: Jyrki Virtanen, Aki Leinonen, Bo Wikström, Matti Lahtinen and Hannu Heikkinen. Front row from the left: Jouni Mälkönen, Kari Tuomala, Jukka Ruusunen and Kari Kuusela.*

## Nokian Capacitors to supply Fingrid with SVC unit

■ Nokian Capacitors Oy will supply Fingrid with a Static Var Compensator (SVC) for the Kangasala substation in Central Finland.

The SVC unit improves the damping of low frequency power oscillations in the grid and supports voltage, hence increasing the disturbance resistance and system security of the grid.

SVC construction will commence in the autumn. Electrical installations will begin in the spring of 2008, and the unit will be commissioned in the winter of 2009.

The value of the contract is approx. 8 million euros. Fingrid has ordered the transformer required by the unit as a separate purchase.

## Environmental impact assessment for the Petäjäskoski - Kaukonen - Vajukoski transmission line completed

■ Fingrid has completed the environmental impact assessment (EIA) process for the new 239 kilometre long 220 kilovolt transmission line in Lapland.

The route of the line will run from the Petäjäskoski substation in Rovaniemi via Kaukonen in Kittilä to the substation located at the Vajukoski hydropower station in Sodankylä. The project will continue with the survey of the line route from Kaukonen to Vajukoski. The planned line project will improve the transmission capacity and power system security in the region well into the future.

In accordance with the main route option presented in the EIA process, the new transmission line will be located parallel with the present transmission lines from Petäjäskoski to Kaukonen. From Kaukonen to the northeast side of Rajala, the transmission line will be placed in a new right-of-way over a distance of 60 kilometres. From Rajala to Vajukoski, the line will run again parallel with existing lines.

The location of the new line parallel with the existing 110 kilovolt line has been specified further at Kuolavaara and Jääskö in Rovaniemi as well as in Ranta-Vaimasluoma in Kittilä. These specifications were made so as to mitigate disadvantages revealed by the EIA process, concerning housing and the natural environment as well as valuable scenic areas.

Preparations for the coming directive launched

# Measurements of exposure to electric fields at substations and on transmission lines

**A new EU directive on the exposure of employees to electromagnetic fields will come into force in May 2008. Fingrid used extensive measurements to study the exposure of its own personnel and personnel of service providers in various types of maintenance and service duties in the summers of 2005 and 2006. According to the studies, the limit values laid down in the directive are not exceeded at substations, in transmission line work or in the clearing of rights-of-ways.**

Text by Harri Kuisti and Jarmo Elovaara ■ Photographs by Juhani Eskelinen

Finnish legislation concerning exposure to electromagnetic fields is based on the EU directive on the exposure of workers to electromagnetic fields and on the recommendation of the Council of Europe on the limits applied to the exposure of the general public. Both of these, in turn, are based on the recommendations of the ICNIRP* expert group.

In accordance with ICNIRP's recommendations, in occupational exposure the densities of currents induced by electric and magnetic fields in people must be less than 1/10 of the levels which create harmfully intense nerve stimulation, and less than 1/50 of these levels in exposure of the general public.

The Finnish Decree on limiting the exposure of the general public to non-ionising radiation, which became effective in 2002, has a status of a recommendation within the extremely low frequency (ELF) range. In the case of Fingrid, exposure to ELF fields (50 Hz) is the main consideration. The Decree gives two sets of recommended maximum values for electric and magnetic fields depending on the length of exposure to the fields.

If the exposure lasts for a considerable period of time (for example when a person lives close to a transmission line), the electric field limit is 5 kV/m and the magnetic field limit is 100 µT. If the exposure does not last for a considerable period of time (for example when a person picks berries or works on a field under a transmission line), the electric field limit is 15 kV/m and the magnetic field limit is 500 µT.

## New obligations to network operators

Fingrid's goal is naturally that the above exposure limits of the general public are not exceeded. A new obligation of the company is to make sure that the occupational exposure of its own employees or service providers' employees does not exceed the prescribed limits.

**ICNIRP = International Commission of Non-Ionizing Radiation Protection.*

**All electric appliances at home and work** cause electric and magnetic fields in their surroundings. In most cases, the strength of these fields is so weak that people do not even notice their existence without meters.

However, in people the electric and magnetic fields induce currents which increase as the fields become stronger. The complex human organism also involves electric phenomena which are influenced by the currents induced by the external fields. A generally known example of this is the direct effect of the currents on the nervous system (nerve stimulation), which is manifested as a sensation of feeling at current densities in excess of 10–100 mA/m$^2$, and as muscular cramps at current densities in excess of 100–1,000 mA/m$^2$. Disturbances in vision may also occur in a strong electric or magnetic field.

Legislation aims to eliminate the occurrence of harmfully intense nerve stimulation.

In addition to the known acute impacts of electric and magnetic fields, their potential long-term effects have also been studied extensively. However, there is no undisputed medical evidence of these effects, and legislation generally does not aim to restrict them.

The EU directive 2004/40/EC "On the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields)" was published in 2004, and from May 2008 onwards it needs to be considered in the national legislation of the member states.

The said EU directive imposes certain action values for extremely low frequency electric and magnetic fields and for the so-called contact current flowing through a person who for example touches a grounded object in the presence of the electric field. If the employer can prove that the actual values are below the action values in all tasks and locations, it is considered that the EU directive is fulfilled.

The action value of the above EU directive is 10 kV/m for the electric field, 500 µT for the magnetic field and 1 mA for the steady-state part of the contact current. If the action values are exceeded, the employer must verify that the current densities in people induced by electric and magnetic fields do not exceed the limit values. A limit value of 10 mA/m$^2$ for current density is applied to 50 Hz electricity. If this limit value is also exceeded, the working conditions, work methods and/or the employees' protective equipment must be changed so that the limit value is no longer exceeded.

## Central nervous system the main issue

The essential thing is that the limit value for current density is not exceeded in the area of the central nervous system. The neck is the narrowest point in the human body in terms of the route of the central nervous system, and therefore it is important to ascertain the current density at the neck.

Since earlier measurements at Fingrid's substations have revealed values of electric and magnetic fields in excess of the action values, Fingrid is required to take further action. The best solution in terms of magnetic fields is for example to move the protection fences of air-core shunt reactors, which generate great magnetic fields, a little further at some substations so that the action value of 500 µT is not exceeded.

Going below the action value is the only possibility in the case of magnetic fields, because it is not possible to measure the currents induced by them in people. However, it can be estimated that in practical situations the currents induced by magnetic fields in people are smaller than the currents induced by the electric fields at the same place.

Currents induced by electric fields in people can be measured to some extent. Such measurements were carried out by the Tampere University of Technology at Fingrid's substations in the summer of 2005 and on the transmission lines in the summer of 2006.

## No limit values exceeded in substation work

The voluntary testees participating in the measurements comprised Fortum Service's and ELTEL Networks' electricians. In the summer of 2005, there were measurements at seven 400 kilovolt substations. The measurements imitated working positions related to a total of 125 different tasks carried out during actual work. The measurements are highly representative of Fingrid's all 400 kilovolt substations in that the most extensive exposures have probably been discovered.

However, since the goal was to choose such work locations where greater exposure than normal was assumed to occur, the current densities in practice are probably most often below the maximum values measured. Even though the highest measured field strength was well above the action value of 10 kV/m in many measured locations at substations, the maximum values of current density were

## SPECIFIC MEASUREMENT EQUIPMENT DEVELOPED FOR THE RESEARCH

There were no commercially available tools for the measurement of current induced by an electric field in people. This is why **Matti Kuussaari** of Fortum Service Oy, who served as a consultant in the measurement project, developed and calibrated equipment suitable for this purpose.

The main part of the equipment is a helmet coated with conducting foil, with a conductor going from the helmet to the current meters (in the bum bag in the photograph) and further to the ground. A conductive and transparent visor can be connected to the helmet to measure more accurately the current collected by the human head in the horizontal direction. One meter registers the current collected by the helmet and the visor, and the other the current flowing through the body to the ground.

During the measurements, the helmet protects the person so that the current which would otherwise flow through the head and neck now flows through the helmet and its ground conductor. The helmet is larger than a human head and hence collects a higher current than a head.

When the visor of the helmet is in place, the current collected by the helmet is actually higher than that flowing through a normal-size head. This is taken into account by means of calibration coefficients defined in laboratory.

The total current induced in the human body is measured by means of a medical electrode fastened to the hand, and the testee who wears insulating footwear is grounded by this electrode. The current thus measured corresponds to the steady-state contact current referred to in the EU's occupational safety directive.

below 7 mA/m², in other words clearly under the limit value of 10 mA/m².

### Below permitted values also on transmission lines

Measurements carried out on transmission lines in the summer of 2006 were divided into measurements carried out in conjunction with climbing up towers and clearing of vegetation. Live line work is not carried out in Fingrid's overhead line network and such tasks were hence not included in the study. Climbing measurements were performed on 400, 220 and 110 kilovolt lines, and the clearing measurements focused on the clearing of a 400 kilovolt right-of-way, which creates the highest exposure.

For these measurements, the measuring instruments had to be modified in terms of grounding. Some of the clearing measurements also measured the magnitude of the current flowing from the tree to the person via the clearing saw. However, most of the instruments were the same as in the substation measurements in the summer of 2005.

The analysis of the transmission line measurements is not yet complete, but it can be stated that the measured values for total current and neck current density were clearly below those given in the occupational safety directive in situations permitted by electrical safety, which were naturally imitated in the measurements. When climbing up towers of 400 kilovolt lines, it is often possible to reach the height of the phase conductor and go even beyond it. Still, the highest measured total current flowing through a testee was about half of the value permitted by the directive.

On 220 and 110 kilovolt lines, the tested person only climbed as high as per-

mitted by safety distances to live parts. In this case, the total current flowing through the person was clearly below that permitted by the directive.

When a person climbs up a tower, the person's position in relation to the electric field is different from the position in most types of substation work. This is why the neck current densities were lower in climbing. During clearing work under a transmission line, the electric field is exerted on a person in a vertical direction, which means that the neck current may be significant. Despite this, the measured values came nowhere close to the current densities allowed by the directive.

### Present work methods fulfil the new conditions

The measurement results obtained in 2005 and 2006 strongly suggest that even though the action value of 10 kV/m imposed by the occupational safety directive for the electric field strength is exceeded locally quite much, the measured values were clearly below the limit values of the directive for the contact current and for the density of the current flowing through a person. Based on this, it hence appears that there is no need to change the work procedures and methods in substation and transmission line work even after the Finnish decree based on the EU directive becomes effective in the spring of 2008.

The new decree does not take a stand on the transient contact current, which may cause unpleasant sensations. However, these as well as their steady-state values can be eliminated simply by connecting the worker to the same potential with the work object.


Illustration by Tuija Sorsa

# Look out for resource thieves!

In the past, some people living next door to a spirits plant had drawn a line of their own from the plant, supplying them with booze for several years. Even today, some people tap an oil pipe for their own personal use. There are many ways in which you can exploit things that belong to other people.

That is obviously stealing. If the booze or oil was yours, you would not put up with the exploitation. You would alert the police to restore order.

But when a colleague of yours once again stops at your desk to jabber even though you indicate clearly that you are busy and the boss is waiting. But when you once again notice that you are in a meeting where some people arrive late, some leave before the meeting is over and where nobody sticks to the agenda, if it ever had one. But when your company mobile phone starts to ring just when your children have picked the bedtime story and are waiting for you to start reading.

But when you are stolen some of your most precious assets, you do not put up resistance.

There is much talk about resources, but not so much of those who steal resources.

Still, nobody plants beautiful and expensive flowers if the ground is untreated and conquered by weeds. Not even the best efforts yield results in an environment where their counterforces can rage freely.

If your workplace swarms with resource thieves, even the best time management systems and operational rationalisation plans go to waste. In fact, they are like cashmere to clothes moths or like a tourist to pickpockets: they are sure to be hit first.

A resource thief is a time thief.

A resource thief takes your present moment. Very often, you inadvertently help the thief.

You consent to waiting for the same people, spare parts, telephone calls. The day's work does not get done, the results are delayed, and people become angry. You continue the disturbed working hours with your own hours. You are good at coming up with excuses: "He's always like that." "She is a pro when she chooses to be." "She seems to have it difficult at home again." "Well, he's my superior."

When you are busy, you cannot estimate your own strength correctly. You get tired. And the resource thief takes the credit for your work, if there is any credit left.

It is likely that you are more merciful with the resource thief than with yourself. You let the haste get to you, or you join the thief in his efforts.

A resource thief takes your future. Actually, you have sold your future to the resource thief, at half price.

If you don't look out, you cannot start your own life next week, next month or even next year. When autumn comes, you notice that you have committed yourself to so many projects that all you have left between them is shredded time, which just cannot be used sensibly. Sometimes the resource thief can be found at the workplace, sometimes at home, and sometimes inside your own head.

The end result is always the same: you're living everyone else's life but your own.

A resource thief takes your past. Finnish gloominess is its best ally.

You can use incredibly much energy on brooding over the past. It is easier to allure your colleagues to reminisce past mistakes – made by others – than to create refreshing plans for the future.

Even the appraisal interview process used in Finnish workplaces resembles a talking-to in the headmaster's office rather than a genuine encounter between two adults for the setting and evaluation of reasonable objectives. You're always dead beat after it. It is good to learn from experiences, but speculating over alternative solutions for past events, repenting of them or feeling bitter about them are sure to take you to an early and lonely old age.

The best way to resist the resource thief is to live through past things in a calm manner and to leave them behind.

The summer is ahead, which makes the resource thieves active. Have you already burdened your after-holiday life so that you know that you will continue to be important and needed? Have you programmed the holiday of your family to such a tight schedule that you are sure to understand that you are on holiday, not just lazying about? Have you made sure that you will receive your customary dose of anxiety on potential negotiations concerning redundancies at your workplace, the outrageously high prices of charcoal and climate change also while you are on holiday?

Your energy is diminishing at an accelerating pace. You just wish that you make it to the beginning of your holiday.

You will make it there, and beyond. A resource thief cannot manage on his own; that is why he steals and parasitizes. He is afraid of exposure and attempts to run from being exposed. So, take a good grip of the thief and yank his mask off. You are sure to identify him.

Let the time thief off duty. Start living your own life. And you will have energy to be put into reserve.



*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."*

Photograph by SXC

# FINGRID OYJ


Arkadiankatu 23 B, P.O.Box 530, FI-00101 Helsinki • Tel +358 30 395 5000 • Fax +358 30 395 5196 • www.fingrid.fi

**Helsinki**
P.O.Box 530
FI-00101 Helsinki
Finland
Tel. +358 30 395 5000
Fax +358 30 395 5196

**Hämeenlinna**
Valvomotie 11
FI-13110 Hämeenlinna
Finland
Tel. +358 30 395 5000
Fax +358 30 395 5336

**Oulu**
Lentokatu 2
FI-90460 Oulunsalo
Finland
Tel. +358 30 395 5000
Fax + 358 30 395 5711

**Petäjävesi**
Sähkötie 24
FI-41900 Petäjävesi
Finland
Tel. +358 30 395 5000
Fax +358 30 395 5524

**Varkaus**
Wredenkatu 2
FI-78250 Varkaus
Finland
Tel. +358 30 395 5000
Fax +358 30 395 5611