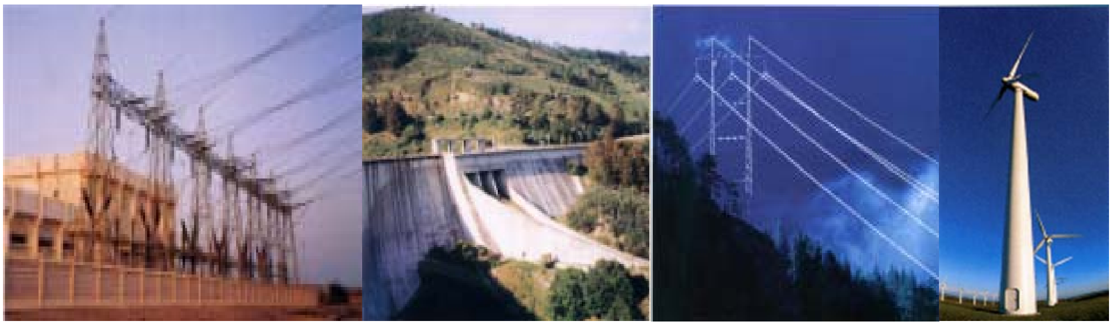
# Nordic Country Report



**Innovative Electricity Markets to Incorporate Variable Production**

**to**

**IEA – Renewable Energy Technology Deployment**

**May 2008**


**IPA Energy + Water Consulting**

**COWI A/S**

**SGA Energy**

# Innovative Electricity Markets to Incorporate Variable Production

**to**

# IEA – Renewable Energy Technology Deployment

IPA Energy + Water Economics
41 Manor Place
Edinburgh
EH3 7EB
Scotland

Tel: +44 (0) 131 240 0840
Fax: +44 (0) 131 220 6440
Email: contact@ipaeconomics.com
web: www.ipaeconomics.com

# TABLE OF CONTENTS

# 1 MARKET MECHANISMS

This section provides an overview of the operation of renewable generation within the common Nordic power market comprising Denmark, Finland, Norway and Sweden[1].

## 1.1 Renewable Generation Capacity

In the Nordic power market, the production system differs greatly from one country to another. Denmark uses conventional thermal power and increasing proportion of wind power. Norway has hydro power, whilst Finland and Sweden have a mix of different systems, mostly hydro and nuclear power.

The most important renewable energy (RE) sources in the Nordic power market with regard to their energy potential are hydro energy, bio energy, wind energy and solar energy.

Hydro energy has been used for many decades in Finland, Norway and Sweden, but there is still a tremendous potential to increase the efficiency of old plants. Bio fuels including peat are mainly used in Finland and Sweden, where it is used in combined heat and power (CHP) plants. Wind power is mainly used in Denmark, but also in the other Nordic countries where large potential has been identified, and in all countries there are plans for establishing new large wind farms. To date, solar energy has not been used for power generation to any appreciable extent. There is a technical potential for solar energy in the Nordic countries, even though it is of course lower than in the Southern European countries, but until now the solar technologies for electricity generation have been to costly. Apart from the most important RE sources as mentioned above, there is also a use of waste (municipal waste and others) for energy production in the Nordic countries which among others is used in CHP plants.

The total installed power capacity in the four countries today is 92,330 MW, of which 58,155 MW is from renewable power sources. The installed capacity by main energy source is shown in the table below.

[1] Iceland is also part of the Nordic countries but is not part of the common Nordic power marked.

**Table 1: Installed capacity by main energy source on 31 December 2006, MW**

| | Denmark | Finland | Norway | Sweden | Total |
|---|---|---|---|---|---|
| **Nuclear power** | **-** | **2,671** | **-** | **8,965** | **11,636** |
| **Fossil fuels** | **8,934** | **8,409** | **64** | **5,132** | **22,539** |
| **Renewables** | **3,765** | **5,464** | **29,204** | **19,722** | **58,155** |
| - Hydro power | 10 | 3,044 | 28,691 | 16,180 | 47,925 |
| - Bio fuel | 294 | 2,190 | 96 | 2,715 | 5295 |
| - Waste | 326 | 144 | 84 | 247 | 801 |
| - Wind power | 3,135 | 86 | 333 | 580 | 4134 |
| **Total capacity** | **12,699** | **16,544** | **29,268** | **33,819** | **92,330** |

Source: Nordel (2006) [11]

It can be seen from the table that hydro power is without comparison the most dominant renewable energy source with an installed capacity of more than 50% of total Nordic capacity. In Norway, where the share of hydropower is largest, hydropower counts for 98% of installed capacity. Bio fuel and wind power count for approximately 5% each of total Nordic capacity.

In respect of installed capacity, renewable energy sources counts for approximately 63% of the total Nordic capacity. However, the number of equivalent full load hours is lower than average generation. In 2006, the electricity generation from renewable energy sources was 224.1 TWh of a total electricity generation of 383.8 GWh corresponding to a share of approximately 58%.

## 1.2 Renewable Generation Size

Regarding connection to the grid, there are different technical regulations to be complied with in each country depending on for instance the type of production and the voltage level on which the production unit is connected. In Denmark, for instance, the technical regulations for wind turbines depend on whether the wind turbines are connected to grids with a voltage level above or below 100 kV. Typically, on-land wind turbines are connected to voltage levels below 100 kV and off-shore wind turbines are connected to voltage levels above 100 kV. The technical regulations are to some extend harmonised in the Nordic grid code (see section 3.2.2), and furthermore a coordination takes place with the UCTE[2].

One big issue in the Nordic countries at the moment is distributed generation, e.g. micro CHP units. Such units may for instance have a capacity of 1 to 3 kW, and clustered in large numbers, they will change the transmission patterns of the network and possibly require some network changes. Some of the large advantages are that distributed generation can contribute to an increasing share of renewable energy in the system as well as an increased share of combined heat and power generation. Furthermore, it can reduce network losses due to the fact that it

[2] "The Union for the Co-ordination of Transmission of Electricity" (UCTE) is the association of transmission system operators in continental Europe.

removes energy production to places where it is needed. In Norway, distributed generation may even be a solution on how to supply remote areas with electricity and thereby save expensive extensions in the network.

All sizes of generation have to pay the costs associated with transmission.

## 1.3 Renewable Generation and Power Markets

There are no special arrangements in the Nordic power market for renewable generation, other than additional financial support as mentioned under section 1.5. In other respects, renewable generation is treated the same way as conventional generation, and has to interact with and operate within the rules of the power market.

### 1.3.1 Players on the Nordic power market

Several types of players are active on the Nordic electricity market, and in practice a player often has two or more roles, operating simultaneously as producer, end customer, electricity supplier and balance responsible party (BRP).

**The producer** generates electricity and sells it prior to the delivery hour to the supplier (electricity trader) or to Nord Pool. In the actual delivery hour, the producer sells/buys electricity to/from the transmission system operator on the regulating power market.

**The electricity supplier** (electricity trader) buys electricity from the producer, from Nord Pool or from another supplier and resells it to the end customers.

**The end customer** uses the electricity purchased from the electricity supplier.

**The balance responsible party (BRP)** is a player who has concluded an agreement on balance responsibility with the transmission system operator.

**The grid company** operates the distribution networks and performs all metering work. The grid company submits the metered consumption and production data for each individual BRP to the transmission system operator, who uses the data for settling imbalances.

**The company with a supply obligation** is a supplier licensed to supply end consumers not exercising their right to freely choose another supplier (market access).

**The transmission system operator** is responsible for the security of supply of the electricity system, including the safeguarding of the physical balance, and for the drawing up of market rules that will ensure a well-functioning electricity market. The system operators are (one in each country) Energinet.dk (Denmark), Fingrid (Finland), Statnett (Norway) and Svenska Kraftnät (Sweden).

**Nord Pool** is the common Nordic electricity exchange, which operates the two physical market places, Elspot and Elbas (see next section) and provides financial products which give market players an opportunity to manage their own risk (hedging).

## 1.3.2 Market places

The actors in the electricity market can trade either bilaterally or via the common Nordic electricity exchange, Nord Pool. Furthermore, they can enter into agreements with the TSO's regarding upward and downward regulation as well as on providing available reserve capacity in case of outages.

Nord Pool has divided the Nordic market into several bidding areas. Nord Pool uses the concept implicit auction, by which transfer capacity is allocated concurrently with electricity being traded. This means that all trade between bidding areas must take place via Nord Pool.

**Elspot**

Electricity for delivery the next day is traded on Elspot. The trade results in a price that may be characterised as the market price on electricity in the Nordic countries. The trade via Elspot follows the time schedule below:

- Every day by 10:00, the Nordic transmission operators make guaranteed transfer capacity between the bidding areas available to Elspot for the following day of operation.
- 12:00 is the players' bidding deadline for trade in electricity for the following day of operation (buying and selling bids).
- Subsequently, Nord Pool calculates the price. Initially, Nord Pool adds up all the buying and selling bids arriving at a price (system price) that strikes a balance between purchase and sale in the whole area. If sufficient transfer capacity between the areas is available, a common market price equal to the system price will become effective in all the areas. This is seldom the case, however.
- In situations of insufficient transfer capacity (congestion), the Nordic countries are divided into different price areas. A bidding area's price is called the area price.
- At 13:00, Nord Pool announces the traded volumes and prices for the following day of operation.

**Elbas**

- On Elbas (Nord Pool's intraday market), electricity can be traded up to one hour before the delivery hour. The purpose of Elbas is to make it possible for players to buy and sell as required in order to ensure balance right up the delivery hour, e.g. in case of outages.
- Apart from being able to ensure balance by appropriate buying and selling on Elbas, the players can also make bilateral transactions up to one hour before the delivery hour. Bilateral transactions can only be made within each individual bidding area.

**The regulating power market**

- As described further in section 1.10, the TSO is committed to maintaining the balance in the delivery hour. This is achieved by buying upward and downward regulation reserves on the regulating power market.

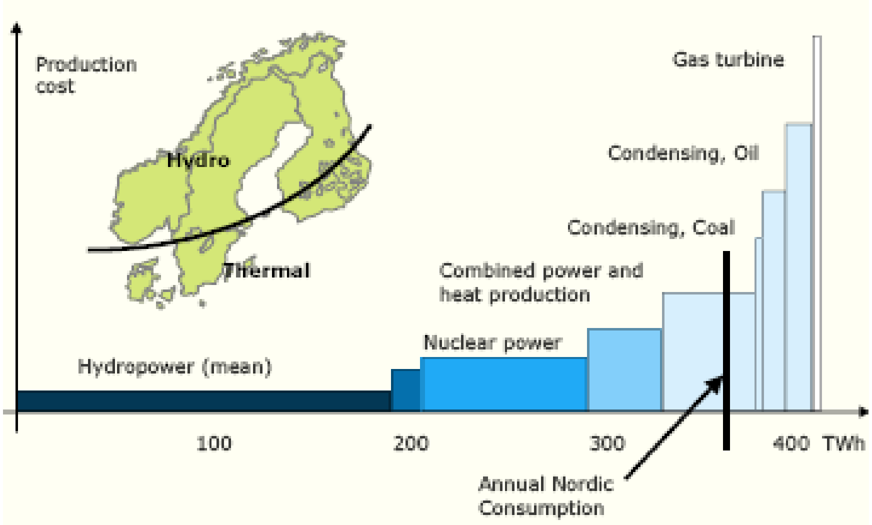
**The reserve capacity market**

- Via Nordel each TSO is subject to internationally established requirements in relation to the availability of sufficient reserve capacity to cover the possible outage of the largest unit (by largest unit is meant a production unit or an international connection).
- To ensure that sufficient reserve capacity is available on the regulating power market, the TSOs therefore conclude reserve capacity agreements. If, by way of example, a producer has concluded a monthly capacity agreement with a TSO, he is committed to submitting bids to the regulating power market for each hour of the relevant month.

To participate in the Nord Pool market, participants can choose whether to pay an annual fee plus a lower per MWh or a single higher per MWh fee, allowing flexibility for smaller participants.

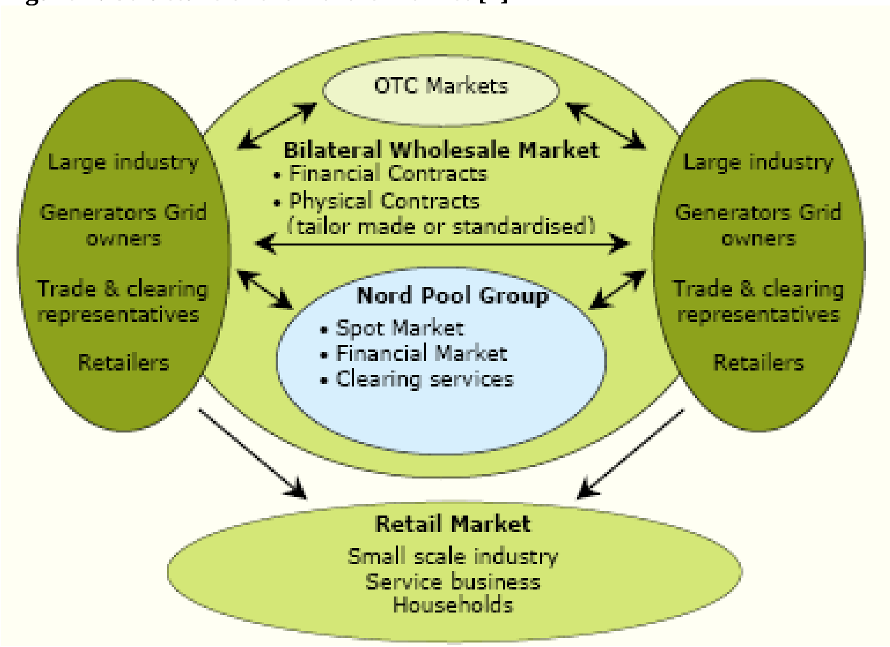
The Nord Pool market is designed to lead to the most efficient use of generation resources. Normally, the cheapest forms of generated electricity are used first, while more expensive forms are not used until required by demand. This market pricing ensures that every electricity generation plant is covered for at least its variable cost for electricity generation. Wind power, hydro power, nuclear power and combined heat and power plants have the lowest variable costs in the Nordic region. When these resources are inadequate, fossil condensation power must be drawn upon. In the Nordic countries, pricing is primarily dictated by water supply. However, capacity development, fuel prices, temperature and the price of CO2 emission allowances also affect the price of electricity. In many other countries, such as in Germany, the merit order curve is considerably flatter, resulting in narrower price variations.

**Figure 1: Production capacity in the Nordic Market [1]**




Prior to Nord Pool, market concentration was high in many Nordic markets. Following its introduction there is less dominance by single market players. Vattenfall has the highest share of the Nordic market at 23%, followed by Fortum at 12%, Statkraft at 11%, E.On Sweden at 8% and Elsam/DONG at 5%. Other participants make up the remaining 41% of the market [2].

**Figure 2: Structure of the Nordic Market [1]**




## 1.4 Degree of Centralisation

There is no central agency within the Nordic power market managing the development, operation or marketing of renewable generation projects. It is the responsibility of individual private developers to identify suitable sites for renewable generation, obtain relevant approvals to allow construction and develop and operate the site. The scheduling and trading of generation output is the responsibility of the operator. As a result renewable energy generators take the responsibility for the short and long term trading of their generation output.

## 1.5 Support Mechanisms

In order to promote the use of renewable energy sources, different types of support mechanisms are used in the Nordic countries. Examples of support mechanisms used are feed in tariffs, green certificates, investment support and operation support. The Nordic countries all use at least one of these mechanisms.

The support level of course affects the investment climate for new renewable power in different countries, but it should be noted that there are several other factors that are important when taking investment decisions, e.g. local physical conditions for renewables, production taxes or environmentally related taxes such as carbon, or fossil fuel taxes. (In Norway in principle all electricity production is based on renewable energy sources, in spite of the fact that support levels are low.).

Issues regarding support mechanisms for renewable electricity are important because they fundamentally influence the liberalised Nordic electricity market, and because both the support schemes and their consequences are complex.

Below is a short description of the support in each of the Nordic countries.

### 1.5.1 Denmark

The significant increase in wind power in Denmark has been reached primarily due to large subsidies in the late nineties. This was however changed by 1 January 2003. Since then, the subsidy has been 100 DKK/MWh on top of the market price of electricity (2007).

There is also a "decommissioning arrangement" for on-land wind turbines; a system which gives a mark-up on the electricity price of 120 DKK/MWh for substitution of wind turbines (from old and small wind turbines to new and more efficient wind turbines). However, from 2004 to 2006, this scheme has only contributed to 12 MW of new capacity.

Furthermore, the building of two new wind farms (2 x 200 MW) has recently gone through tender processes. The result of the first tender was made public at the end of June 2005, and the guaranteed price was fixed at 518 DKK/MWh (market price plus subsidy) for the generation of an electricity amount corresponding to 50,000 full load hours (equivalent to approximately 12 years of production).

For renewable energy sources other than wind (e.g. biomass and biogas), the subsidy is considerably higher as the price is set at 600 DKK/MWh including the market price on electricity the first ten years of operation and

400 DKK/MWh for the next ten years (2007). It is, however, at the current stage still not sufficient to stimulate the construction of new plants.

The Danish transmission system operator Energinet.dk funds research and development (R&D) projects within environmentally friendly electricity production technologies by means of a special PSO tariff of 0.0004 DKK/kWh[3]. The tariff is paid by all electricity consumers via their electricity bills.

- ***Planned changes to supporting scheme structure***
  On 19 January 2007, the Danish government published the paper "A visionary Danish energy policy" which describes the targets for the Danish energy policy towards 2025. The paper is part of the government's long term policy aim of making Denmark independent of fossil fuels such as coal, oil and natural gas, and it includes among others a target of increasing the share of renewable energy from the present 15% to 30% in 2025. Furthermore, the paper points out that in the coming years, great effort should be made to further development and commercialise the Danish positions of strength within among others large and highly effective wind turbines.

  It is expected that the new and more ambitious energy policy targets will lead to some changes in the supporting scheme structure. However, there is nothing concrete on that at the moment.

### 1.5.2 Finland

According to the current National Energy and Climate Strategy, the main measures to reduce Finland's $CO_2$ emissions are promotion of renewable energy and efficient use of energy, and reduction of carbon intensity in energy production. In addition to reduction of $CO_2$ emissions, reduction of other environmental emissions, improvement of self-sufficiency, employment, regional development and development of new energy technology have also been reasons to promote renewable energy in Finland.

Renewable energy sources are supported by investment aid and by taxation. Funds are also granted for technology development and commercialisation of renewable energy technologies.

Power plants that use renewable energy can get aid to their investments depending on the technology used and the size of the power plant. At maximum, the support can be 30-40% of investments for wind power plants. For larger power plants which combust wood fuels, the support has typically been limited to 5-10% of investments. New large hydro power larger than 10 MW are excluded from the support scheme. Aid can also be granted to investments related to production of renewable fuels.

[3] PSO stands for Public Service Obligation

Electricity produced from renewable energy sources can get direct support (tax refund).

- ***Planned changes to supporting scheme structure***
  The National Climate and Energy Strategy, which was introduced by the Government in November 2005, proposes some remarkable changes to RES support policy in Finland. The strategy does not propose any new support instruments but changes to existing ones. As EU emission trading system has increased the market price of electricity and thereby increased the competitiveness of $CO_2$-free power generation (e.g. from renewable sources) there is not anymore such a strong reason to support renewable power generation within the emission trading sector. That is why the strategy proposes that the investment aid should be directed to new technology and to sectors outside the emission-trading scheme. The strategy also proposes the abolishment of tax refund for electricity from industrial wood waste and residues. However, there still remain other reasons for RES support, such as security of energy supply and employment.

### 1.5.3 Norway

Even though most power generation in Norway today is based on renewable energy (hydropower), there is an established goal of introducing minimum 3 TWh wind power by 2010. This target was originally supplemented by a support scheme based on a combination of production support and investment support. The wind power support scheme was used only for a few wind projects. In 2004 the production support was terminated, as only 8 GWh of wind production claimed eligible to support.

Initially a mandatory green certificate system was proposed in cooperation with Sweden. This system should cover all new capacity based on renewable energy. The government presented a white paper about this in August 2004, and a proposal for a new law introducing the certificate system was presented in November 2004, with the intention of starting a common Norwegian-Swedish certificate system in 2006. However, as close cooperation with Swedish authorities was required and the Swedish process was delayed, the Norwegian certificate system was postponed until 2007. In February 2006, the negotiations broke down. Currently, there is no prospect for a common certificate market.

Instead, from 2008 the government introduced feed-in tariff support on top of the market price. Wind power producers will receive NOK 0.08 per kWh electricity produced. Producers of electricity using immature technologies, and producers of electricity based on biomass will receive NOK 0.10 per kWh. Hydropower producers will receive NOK 0.04 per kWh for production representing the first 3 MW of the installed capacity. Support will be paid for 15 years. Owners of existing hydropower plants will also receive support for upgrading the production capacity.

### 1.5.4 Sweden

In May 2003, Sweden introduced its electricity certificates system in order to meet their targets for the production of electricity from renewable energy sources. The objective of the system was to increase the production of electricity from renewable energy sources by 10 TWh by 2010, relative to the corresponding production in 2002. In subsequent years, the objective of the legislation has been expanded, so that it now also includes encouragement of the production of electricity from peat as a fuel in combined heat and power plants.

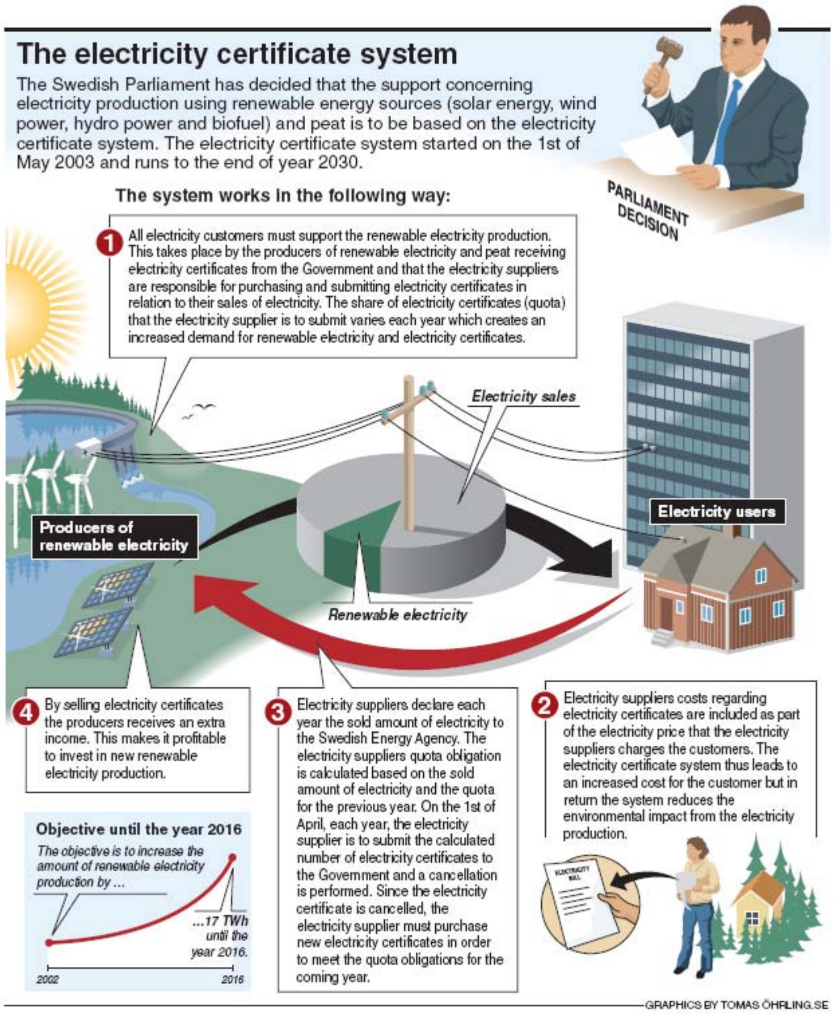
The Electricity Certificates Act amended by Parliament on the 14 June 2006 has raised the target level. With effect from 1 January 2007, the target of the act is now to increase the production of electricity from renewable sources by 17 TWh in 2016, relative to 2002.

The electricity certificate system is a market based support system to assist the expansion of electricity production in Sweden from renewable energy sources and peat. The principle of the system is that there are sellers and purchasers of certificates and a market to bring them together. One electricity certificate unit is issued to each approved producer for each produced and metered MWh of electricity from the following energy sources:

- Wind power
- Solar energy
- Wave energy
- Geothermal energy
- Biofuels
- Peat, when burnt in combined heat and power plants
- Hydro power:
  - *small scale hydro power which, at the end of April 2003, had a maximum installed capacity of 1,500 kW per production unit*
  - *new plants*
  - *resumed operation from plants that had been closed*
  - *increased production capacity from existing plants*
  - *plants that can no longer operate in an economically viable manner due to decisions by the authorities or to extensive rebuilding.*

The principle of the system is illustrated in the figure below:

**Figure 3: The Swedish electricity certificate system**




Source: Swedish Energy Agency (2007) [12]

In 2006 the quota obligation charge was 278 SEK per certificate (MWh).

When the system was introduced, it replaced all other support schemes, except one "environmental bonus" to wind power.

- ***Planned changes to supporting scheme structure***
  The electricity certificate system has recently been changed with effect from 1 January 2007.

### 1.5.5 EU Emission Trading System (ETS)

Denmark, Finland and Sweden are all members of the EU and thereby comprised by the EU emission trading system (ETS). The system sets quotas for the total $CO_2$ emission in EU, and it allows market players to trade quotas with each others. The system gives an incitement to generate electricity at power sources with low $CO_2$ emissions, and thereby the system gives a competitive advantage to RE sources such as for instance wind power, hydro power and biomass. From Nord Pool's web page, www.nordpool.com, it can be seen, that the present price on $CO_2$ quotas regarding the year 2008 is in the level of 22 EUR/ton.

## 1.6 Trading

Since the 1980s, there has been a trend towards free competition both in the EU and elsewhere in the world, but the trend has developed most rapidly in the Nordic countries. Among other things, the world's first international electric power exchange, Nord Pool, was launched here in 1996.

As written in section 1.3.2, there is two physical markets for sale of electricity as well as some financial products within Nord Pool. The physical market includes Elspot, Elbas and the regulating power market.

The key features of the Nordic Elspot market concept are:

- **Implicit auction**. The Elspot concept is based on bids for purchase and sale of hourly contracts using three different bidding types: hourly bids, block bids and flexible hourly bids tat cover some or all of the 24 hours of the next day.
- **Grid congestion management**. At the interconnections between the Nordic countries and within Norway, price mechanisms are used to relieve grid congestion (bottlenecks), by introducing different Elspot area prices. Within Sweden, Finland, and Denmark, grid congestion is managed by counter-trade purchases the based on bids from generators.
- **Area price**. The total geographic market is divided into bidding areas; these may become separate price areas if the contractual flow of power between bid areas exceeds the capacity allocated for Elspot contracts by the transmission system operators. When such grid congestion develops, two or more area prices are created.
- **System price**. The Elspot market's system price is also denoted "the unconstrained market clearing price". This is because the system price is the price that balances sale and purchase in the exchange area while not considering any transmission constraints. When there actually are no constraints between the bidding areas, the area price are all equal to the system price.

The time span between the day's Elspot price-fixing and the actual delivery hour of the concluded contracts is quite long (36 hours at the most). As consumption and production situations change, market players may find a need for trade during these 36 hours.

The Elbas market enables continuous trading with contract that lead to physical delivery for the hours that have been traded on the Elspot market and are more than one hour from delivery. The Elbas market is open around the clock every day of the year.

The financial market at Nord Pool gives market players an opportunity to mange their own risk, and at present the contract types traded comprise of power derivates, electricity certificates, carbon dioxide allowances, and as a new thing from June 2007 also CER's (which is a global carbon product in form of a standardised certified emission reduction contract). The derivates are base and peak load futures, options, and contracts for difference. The reference price for these contracts is the system price of the total Nordic power market. The maximum trading time horizon is currently five years. There is no physical delivery of financial market electricity contracts. Cash settlement is made throughout the trading- and/or the delivery period, starting at the due date of each contract (depending on whether the product is a future or forward).

Apart from trading via Nord Pool, the market players can also trade bilaterally with each others. However, in 2006 Nord Pool's physical market accounted for 63% of the total value of the Nordic region's power consumption.

## 1.7 Despatch

Counterparties (generators and suppliers) decide individually how much power they physically plan to inject and withdraw from the system.

Generators typically have firm transmission access which means that renewable generators will typically plan to inject all available generation on to the system (assuming normal operating conditions and no transmission constraints in the system).

## 1.8 Notification

There are different rules regarding notification in the Nordic countries. The overall principle is the same, but the rules differ with respect to time for gate closures.

In Denmark the deadlines for submitting notifications are as specified below. Unless otherwise stated, all times refer to the 24-hour period before the day of operation for which the notifications contain data. Such times are deadlines, but submission by BRP's must be made as soon as possible in practice, just as confirmation reports will be sent as soon as Energinet.dk is able to do so. In other words, a hard deadline may occur sooner than described below if all notifications balance, however not sooner than 15:00.

**15:00 Soft deadline**. The BRP must submit a notification for the next day of operation before this time. The hard deadline may be activated immediately after the soft deadline provided that all notifications balance and all trades match.

**16:00 Hard deadline**. Notifications that do not yet balance and trades that do not match must be changed. At the request of the system operator, the hard deadline may be postponed to a specified time.

**Delivery hour - 45 minutes**. This deadline applies to the submission of notifications including intraday trades, by BRP's.

As mentioned above, these times of gate closures differ from country to country, but presently the four TSO's are working on a harmonisation. The deadline for submission of notifications including intraday trades, i.e., the deadline of forty five minutes before delivery hour, is however already today the same in all four countries.

## 1.9 Imbalance Settlement

Elbas provides a mechanism for market players to balance their own portfolio on the day of delivery. Market players have financial incentives to manage the balancing of their position as the TSOs distribute the costs of buying regulating power (which have been bought during the day of operation) among the BRPs relative to their individual deviation.

After the day of operation, meter data on consumption and production is collected. If consumption exceeds the purchased volume (negative imbalance), the difference is bought from the transmission system operator. If less electricity has been consumed than scheduled (positive imbalance), the surplus is sold to the transmission system operator. Electricity traded in this way is called balancing power.

If variable power production is higher than the bid, other producers will have to regulate down or consumption must increase in order to maintain power balance. In this case, the variable producer will get a lower price for the excess electricity produced than the spot market price.

If variable production is lower than the bid, other producers will have to regulate up to secure the power supply, or consumption must be reduced. These other producers will obtain a price above the spot market price for the extra electricity produced, an additional cost, which has to be borne by the variable producer.

The costs for contracting for reserve power are mainly socialised through a "system tariff" paid by the electricity consumers. The system tariff covers the TSO's costs relating to reserve capacity, system operation, etc. However, in Sweden and Finland, a smaller part of the costs for reserve power is paid by the balance responsible parties themselves. From 2009 this system will be implemented in all four countries. The largest part of the costs for reserve power will, however, still be socialised through the system tariff.

The costs for balancing power are paid fully by the balance responsible parties themselves. Dual imbalance pricing for balance responsible parties is used in Sweden, Finland and Denmark, and single imbalance pricing in Norway.

- ***Norway***

Norway has a single-price settlement for imbalances on a total balance. The total balance is calculated as the sum of actual figures both for production, consumption and trade. The BRPs imbalance is priced with the same price (the regulation price) independent of which direction the imbalance is in with respect to the system in total. In a situation when the system has been up-regulated the BRP with a positive imbalance will receive the regulation price for its imbalance while the BRP with a negative imbalance and subsequently has to buy balance power is charged the regulation price. There are no additional economic incentives to the BRPs in order for them to keep their balance after submitting their production plans to the system operator at 7 p.m. the day ahead.

Statnett has added a system for administrative monitoring, also called market surveillance, as a non-economic incentive towards the BRPs. The Market Settlement Department controls BRPs trade on NordPool Spot with reference to the requested collaterals that are determined weekly based on statistics from historical trade. The BRPs must put up collaterals both to NordPool Spot and Statnett, due to different assumption of risk. On average collateral of about NOK 300 million is put up to Statnett weekly.

The overall balance for the Norwegian system is considered more important than the balance of each party. This is intended to give a higher socioeconomic benefit than leaving the responsibility for keeping the balance with the BRPs on individual basis, due to the fact that the TSO handles the total amount of imbalance, the regulation will always be done with the entities offering the lowest bid on the regulating market. It is believed that allowing the BRP to handle their imbalance up to gate closure does not always ensure lowest marginal price will be selected. The Norwegian system is also designed with the aim of simplicity and of not discriminating against smaller players in comparison to the big vertically integrated companies and keeps a low entry barrier for new participants. In Norway there are approximately 135 BRPs, which indicates that the system has succeeded in that respect.

The fees consist of a volume fee for buying and selling regulating power and balance power in addition to some fixed fees related to bilateral contracts, buying and selling regulating power. In addition there are some special fees for extra services provided by the TSO for some BRPs.

- ***Finland***

In Finland one total balance is used in the settlement model and the balance is calculated as in Norway, but a dual price system is used in Finland as well as in Denmark and Sweden.

In Finland a balance provider is responsible for their own balance, including both the planning phase and the operating hour. The balance provider has the option to trade electricity as near the operational hour as possible and change their own production balance during the operating hour, i.e. to self regulate, to improve their balance.

TSO makes the necessary regulations for the system balance. The main focus is on cost correlation, strong economical steering signals of the total imbalance and on real time balance. The two-price settlement gives an income to the TSOs as imbalances in the “wrong” direction are charged the regulation price while the spot price is applied on imbalances helping the system. The difference comprises a surplus for the TSOs.

In Finland, the legislation states that balance management and grid should be separated, i.e. no subsidies are allowed. From this follows that the cost base for balance management in Finland includes administrative costs for balance settlement and regulation as well as a minor part of the costs for the reserve.

- ***Denmark and Sweden***

In Denmark and Sweden the two-price settlement model is applied together with three separate balances for production, consumption and planned balance. Some years ago, one total balance was used in all the Nordic countries. The input, (production and purchase) was compared to output (consumption and sales). However, a new model was introduced in both Denmark and Sweden about 5-6 years ago where the three balances are:

1. Production plans and measured production
2. Consumption forecast and measured consumption.
3. Planned balance – calculated from production plans, consumption forecasts and trade.

The motives for dividing the balance are to make balance regulation more efficient, i.e. to remove the incentive to self-regulate during the delivery hour in order to balance variations in consumption. Producers therefore should have no reason to hold back reserve production from the regulation-bidding process. If the balance management controls all regulation in the operational phase, the risk for counter regulation should be reduced or eliminated. Another motive was to equalize conditions for players with and without production so that producers would not have the advantage over players without production of being able to compensate for consumption variations during the delivery hour.

The three balances also lead to better quality of the production plans and consumption forecasts, since as the plans are used in the settlement process there is an incentive to submit better plans and keep them updated.

In Sweden, Svenska Kraftnät separates costs that are related to system services and grid service as no subsidies are allowed. Therefore the cost base for balance management in Sweden includes administrative costs for balance settlement and regulation as well as certain reserve costs that are not included in the other Nordic countries. To cover these costs a fee for financing part of the costs has been introduced and it is levied on consumption and production.

In Denmark, all costs for system operation including reserve capacity are separated from the costs of the grid and PSO´s (Public Service Obligation) in a special account and tariff ("systemtariff"). Excluding the costs for the reserve capacity the balance management in general has a surplus due to the two-price price income and the fixed fees. Including the costs for the reserve capacity there is a large deficit financed by the "systemtariff".

Under a dual pricing system, the costs of imbalance are calculated from the size of the imbalance in MWh multiplied by the the spot price or the regulation price (in EUR/MWh. The imbalance charges depend on whether there is a need for up- or down regulation in the specific hour.

Upward regulation:

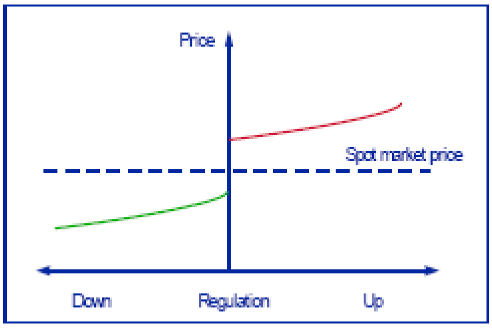
- Those who have had a negative imbalance (produced less than expected) will have to pay the upward regulation price
- Those who have had a positive imbalance (produced more than expected) will get the spot price (generally lower than the upward regulation price).
- Therefore, those who help the system actively (by selling upward regulation at the regulation price) receive a higher price than those who help the system "by a mistake" and receive the spot price.

Downward regulation:

- Those who have had a positive imbalance (produced more than expected) will get the downward regulation price.
- Those who have had a negative imbalance (produced less than expected) will have to pay the spot price (generally higher than the downward regulation price)

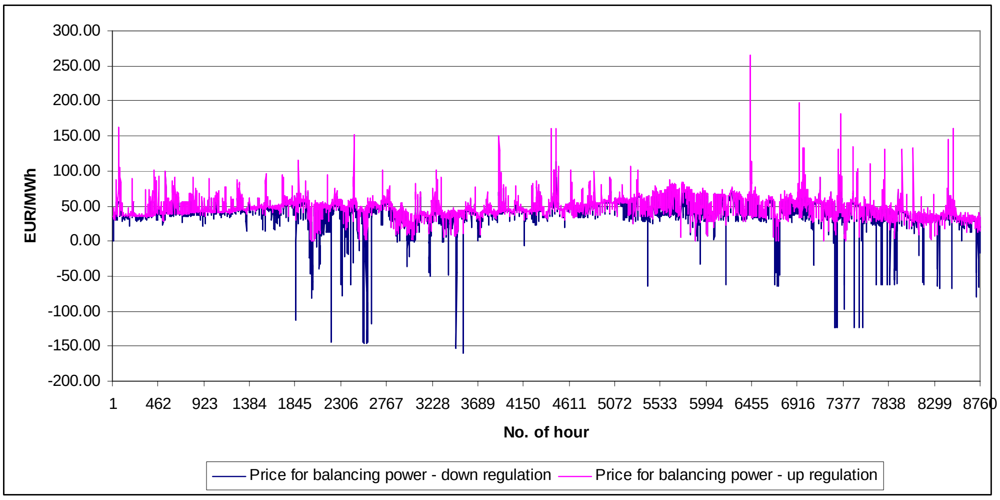
The more that variable production is off track, the higher the premium is expected to be, as shown in the figure below by the difference from the regulatory curves to the stipulated spot market price.

**Figure 4: The spot market price [3]**




As an example, the price for balancing power, down and up regulation, in Western Denmark in 2006 is shown in the figure below.

**Figure 5: Prices for balancing power, down and up regulation, DK-West, 2006**




The average price for down regulation in 2006 was 39.78 EUR/MWh and the average price for up regulation was 47.44 EUR/MWh. It appears from the figure that in some situations, the price for down regulation was actually negative.

In countries with limited regulation resources (mixed production as in Finland, Denmark and Sweden) it has been considered important to give the players a strong economical incentive to keep their balance. In the two-price system the incentive is stronger than in the one-price system since imbalances which contribute to the total imbalances are charged the regulating price, whereas the spot-market price is applied for imbalances which apparently help to balance the system. Players then have a greater incentive to keep their balances by trade or production adjustments close to delivery.

The two price system thus reduces the imbalances by introducing stronger economic incentives. Common statistics from Nordel show that when comparing imbalance figures (regulating power excluded) Norway has higher imbalance figures than the rest of the Nordic countries. Part of the difference can probably be attributed to the one price system but can also be explained by the fact that the Norwegian BRPs lack the possibility to change their plans closer to the operational hour.

Nordel presented a proposal for harmonising parts of the balance management in April 2006 which in a modified form was approved by the Nordel board in February 2007. Nordel hopes to introduce the new system from 2009. Nordel proposes to introduce two balances, one for production and one for consumption & trade, which for convenience is called the consumption balance. A dual price system will apply to the production balance while a single price system will apply to the consumption balance.

## 1.10 System Balancing

### 1.10.1 Responsibility

The responsibility for balancing supply and demand is arguably split between the Transmission System Operator (TSO) and the market players. The TSOs have the national balance responsibility within the operating hour as one of their core duties. However, market players are responsible for ensuring that their procurement meets their commercial commitments, even in peak load hours. On Elbas (Nord Pool's intraday market), electricity can be traded up to one hour before the delivery hour, and thereby the market players can buy and sell as required in order to ensure balance right up to the delivery hour, e.g. in case of outages.

In case of imbalances in the operation hour, the TSO handle these by buying "ancillary services" in the form of upward or downward regulation, which are required to handle frequency and voltage variations, deviations from forecasts and trips of production and grid installations. The need for ancillary services will in reality vary according to the operating situation and the mix of electricity production and electricity exchange. The need for ancillary services is determined on the basis of:

- Choice of design criteria with regard of security of supply (n-1)
- Design contingency and regulation scenarios
- UCTE rules and Nordel's System Operation Agreement
- Any agreements with neighboring TSOs

It is up to the individual players if and when they choose to be active on the regulating power market, provided they have not concluded an agreement about reserve capacity with the TSO. If this is the situation, they are committed to submit bids to the regulating power market for each hour of the relevant period.

Apart from producers, consumers are also entitled to submit bids for upward and downward regulation.

### 1.10.2 Nordic regulating power market

Since 2002 there have been a common Nordic regulating power market which is a compilation of bids delivered to the four Nordic national balancing markets, and is used for balancing and frequency control. The Nordic regulation market differs from the markets at Nord Pool. Whereas, the Nord Pool markets are organized as a common market place with common member agreements and bidding rules, the Nordic regulating market is on the other hand a compilation of bids given to the national balancing market places, i.e., the TSOs under rules and agreements set by the TSOs. The Nordic regulation market has some Nordic rules given in the

Nordic system agreement, but the rules for bidding and payments are primarily given in the national balancing markets.

### 1.10.3 Capacity balances

In order to ensure that there is enough capacity available in the operating hour, also on a longer term, the TSOs monitor the power balances closely in each area. The power balances do not include contributions from wind power to cover maximum consumption as there will often not be much wind on a winter's day with heavy frost and thereby no wind power generation. With a view to improve the power balances, the TSOs are engaged in promoting demand response, activating emergency supply units and - in a longer term - providing the psychical possibilities and market incentives for constructing new production capacity.

## 1.11 Summary

The Nordic countries have large amounts of renewable energy, mainly in form of hydro power, bio fuels and wind power. There are different support schemes within each country promoting the use of RE. Apart from these support schemes, which in some cases guarantee a certain price for RE electricity, there are not special arrangements for renewable generation.

For variable renewable generators that are not guarantied a certain price, however, the risk of actively participating in the market are much greater that for conventional generators with a predictable output pattern. The generators have to predict their generation up to 36 hours before the delivery hour when they produce their bid on Elspot. In case of imbalances, they can trade on the intraday market, Elbas, but in case they have given a bid on Elspot and need to counter-trade at Elbas immediately before the delivery hour, they may very well lose some money.

So whilst the market mechanisms do not restrict variable generators from actively participating in the market, the relative nature of the market (apart from the support mechanisms) does not attract variable generators to participate within it.

# 2 CROSS BORDER TRADING

Within the Nordic power market comprising Denmark, Finland, Norway and Sweden, there are strong electricity interconnections. Trade between the countries is encouraged by the variation in generation technology; hydro, wind power, nuclear, fossil fuels (with and without district heating) and biomass. Each technology has its strengths and weaknesses, which can be offset by trade.

In addition to the interconnections within the Nordic power market, there are also transmission links to neighbouring countries, i.e. Germany, Poland, Estonia and Russia (see Figure 6 below).

**Figure 6: The transmission grid in the Nordic countries**

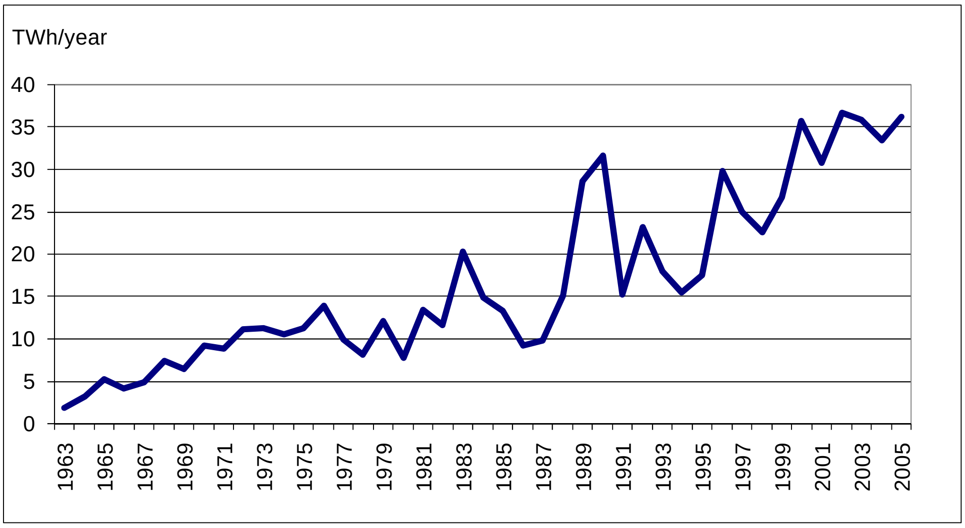

## 2.1 Current Cross Border Flows

### 2.1.1 Development in power exchange

The exchange of power between the Nordic countries has taken place for 100 years, but has increased steadily for the past 40 years (see Figure 7 below). While the Nordic electricity demand has doubled since 1975, the exchange of electricity has increased by a factor 3.5. The drivers behind this development have been new transmission lines (internal, between the Nordic countries as well as lines to the continental Europe), the change in generation technology (nuclear power and wind power) as well as the liberalisation of the electricity market.

In 2006, the internal Nordic power exchange corresponded to approximately 8.4% of the electricity consumption in Norway, Denmark, Sweden and Finland of 395.5 TWh.

**Figure 7: Exchange of power in the Nordic system.**
*The curve shows the sum of the flows between the four countries. E.g. from Sweden to Finland, from Finland to Sweden, from Norway to Denmark, from Denmark to Norway etc. Power exchange with neighbouring countries is not included.*




### 2.1.2 Existing cross-border interconnections within the Nordic power market and to other countries

The existing interconnections between the Nordic countries are shown in Figure 8 below.

**Figure 8: Interconnections between the Nordic countries, 2006**

| Countries / Stations | Transmission capacity, MW | | Total length of line, km | Of which cable, km |
|---|---|---|---|---|
| **Denmark - Norway** | **From Denmark** | **To Denmark** | | |
| - Tjele - Kristianssand | 1000 | 1000 | 240 | 127 |
| **Denmark - Sweden** | **From Sweden** | **To Sweden** | | |
| - Teglstrupgaard - Mörap | 1350 (all three lines) | 1750 (all three lines) | 23 | 10 |
| - Gørløsegård - Söderåsen | | | 70 | 8 |
| - Hovegård - Söderåsen | | | 91 | 8 |
| - Hasle - Boreby | 60 | 60 | 48 | 43 |
| - Vester Hassing - Stenkul. | 290 | 270 | 176 | 88 |
| - Vester Hassing - Lindome | 740 | 740 | 149 | 87 |
| **Finland - Norway** | **From Finland** | **To Finland** | | |
| - Ivalo - Varangerbotn | 100 | 100 | 228 | - |
| **Finland - Sweden** | **From Sweden** | **To Sweden** | | |
| - Ossauskoski - Kalix | 1600 (all three lines) | 1200 (all three lines) | 93 | - |
| - Petäjäskoski - Letsi | | | 230 | - |
| - Keminmaa - Svartbyn | | | 134 | - |
| - Raumo - Forsmark | 550 | 550 | 233 | 200 |
| - Tingsbacka - Senneby | 80 | 80 | 81 | 60 |
| **Norway - Sweden** | **From Sweden** | **To Sweden** | | |
| - Sidvik - Tornehamn | 1000 (all four lines) | 1300 (all four lines) | 39 | - |
| - Ofoten - Ritsem | | | 58 | - |
| - Røssåga - Ajaure | | | 117 | - |
| - Nea - Järpströmmen | | | 100 | - |
| - Linnvasselv, transformator | 50 | 50 | - | - |
| - Lutufallet - Höljes | 40 | 20 | 18 | - |
| - Eidskog - Charlottenberg | 100 | 100 | 13 | - |
| - Halse - Borgvik | 2150 (both lines) | 2150 (both lines) | 106 | - |
| - Halden - Skogssäter | | | 135 | - |

Source: Nordel (2006a) [7]

The existing interconnections between the Nordic countries and other countries are shown in Figure 9 below.

**Figure 9: Interconnections between the Nordic countries and other countries, 2006**

| Countries / Stations | Transmission capacity, MW | | Total length of line, km | Of which cable, km |
|---|---|---|---|---|
| **Denmark - Germany** | **From Nordel** | **To Nordel** | | |
| - Kassø - Audorf | 1200 (all three lines) | 800 (all three lines) | 107 | - |
| - Kassø - Flensburg | | | 40 | - |
| - Ensted - Flensburg | | | 34 | - |
| - Ensted - Flensburg | 150 | 150 | 26 | 5 |
| - Bjæverskov - Rostock | 600 | 600 | 166 | 166 |
| **Finland - Russia** | **From Nordel** | **To Nordel** | | |
| - Imatra - GES 10 | - | 100 | 20 | - |
| - Yllikkälä - Viborg | - (both lines) | 1400 (both lines) | 2 * 67 | - |
| - Kymi - Viborg | | | 132 | - |
| - Nellimö - Kaitakoski | - | 60 | 50 | - |
| **Finland - Estonia** | **From Nordel** | **To Nordel** | | |
| - Espoo - Harko | 350 | 350 | 105 | 105 |
| **Norway - Russia** | **From Nordel** | **To Nordel** | | |
| - Kirkenes - Boris Gleb | 50 | 50 | 10 | - |
| **Sweden - Germany** | **From Nordel** | **To Nordel** | | |
| - Västra K. - Herrenwyk | 600 | 600 | 269 | 257 |
| **Sweden - Poland** | **From Nordel** | **To Nordel** | | |
| - Stärnö - Slupsk | 600 | 600 | 256 | 256 |

Source: Nordel (2006a) [7]

The interconnections are in general owned jointly by the Transmission System Operators on each side of the link.

Western Denmark is operating synchronously with the UCTE system (continental Europe), whereas the other part of common Nordic power market, i.e., Eastern Denmark, Sweden, Norway and Finland is operated as one separate synchronous area.

## 2.1.3 Future Cross Border Interconnector Capacity

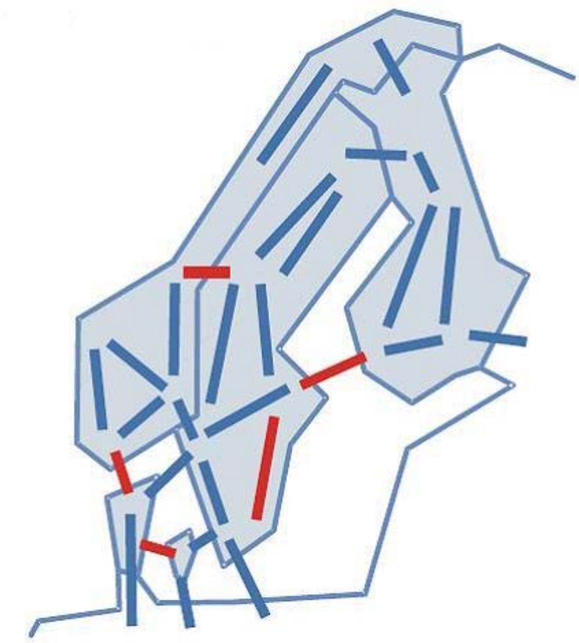
The role of the transmission connections is to exchange energy and power in an efficient international market and also to enable cooperation on production reserves. This makes it possible to exploit the differences in the electricity system in the best possible way and to make allowances for fluctuations resulting from market-based trading or variations in precipitation and wind.

In 2004, the organisation of the Nordic system operators (Nordel) carried out joint Nordic analyses of important cross-sections in the Nordic power market. The starting point for the analyses was that the Nordel area will, from an overall point of view, have an energy deficit in 2010. It is a challenge to determine how much of this energy and power balance must be managed through expanding production capacity and price-elastic electricity consumption as well as internal grid expansions for an optimal utilisation of this, and how much must be managed through grid expansion to neighbouring countries.
From the analyses, Nordel identified the following five cross-sections which can be expanded beneficially:

- Cross-section 4 in Sweden
- The Fennoskan interconnection between Sweden and Finland
- The Great Belt connection in Denmark
- The local cross-section Nea-Järpströmmen between Norway and Sweden
- The Skagerrak interconnection between Norway and Denmark

Not all of these cross-sections are actually cross-border interconnectors. However, the expansion of the cross-section 4 in Sweden and the Great Belt connection in Denmark helps to reinforce the transport channels between the Nordic countries and the Continent and helps on strengthening trade between areas dominated by thermal/wind power and by hydropower.

**Figure 10: The five prioritised internal Nordel cross-sections**



Source: Nordel

Apart from these five prioritised internal Nordel cross-sections, of which the first four already have been decided, it has also been decided to establish a link between Norway and the Netherlands. Regarding the Skagerrak interconnection between Norway and Denmark, a decision is to be made in 2007/2008.

Figure 11 below shows the main characteristics and the status these in total six new lines.

**Figure 11: Important interconnections and grid reinforcements**

| Cross-section | Capacity, MW | Total length of line, km | Of which cable, km | Expected year of com. | Status |
|---|---|---|---|---|---|
| Cross-section 4 in Sweden | - | 400 | - | 2012 | Decided |
| Fennoskan between Sweden and Finland | 800 | 300 | 200 | 2010 | Decided and under construction |
| Great Belt connection in Denmark | 600 | 58 | 58 | 2010 | Decided |
| Nea-Järpströmmen between Norway and Sweden | 750 | 100 | 0 | 2009 | Decided |
| Skagerrak between Norway and Denmark | 600 | 215.3 | 130.5 | - | Decision to be made in 2007/2008 |
| NorNed between Norway and the Nethrelands | 700 | 580 | 580 | 2007 | Decided and under construction |

## 2.2 Cross Border Capacity Mechanisms and Trading

In this section, the cross border capacity mechanisms and cross border trading are described, both regarding the links within the Nordic countries and regarding the links to other countries.

### 2.2.1 Within the Nordic countries

Regarding trade within the Nordic countries, Nord Pool uses the concept **implicit auction** in form of **market splitting**[4], by which transfer capacity is allocated concurrently with electricity being traded.

The use of market splitting as the cross border and congestion management method in the Nordic system means that the market balance between supply and demand per bidding area is automatically determined by the combination of bids/offers in all bidding areas and utilisation of the

[4] Implicit auction can also be in form of "market coupling" which is based on the same general principles as market splitting, but with the main difference that it is organised between two or more separate market operators.

available capacity between the various bidding areas. In other words, in market splitting, a price mechanism assures that all bidding area prices reflect both the price of energy and capacity.

This market splitting is carried out by the market place operator Nord Pool Spot based on an agreement among all the Nordic TSOs to provide all cross border capacity between bidding areas to the Elspot market.

The use of this system means that all trade between bidding areas must take place via Nord Pool.

The management of the transmission lines takes place in a three-step approach:

- The TSOs (system operators) make an *ex ante* evaluation of the secure use of transmission lines. Then they submit the available transmission capacity to Nord Pool in every hour of the following day. In many cases, this leads to a reduction in available capacity on certain transmission lines. Since the evaluation takes place before bids for the day-ahead market, it is based on an estimate of the next day's production patterns (which is influenced by the prices later obtained in the day ahead market) and on security standards like the (n-1) rule[5]. This information is published each day at 9:30.
- Bids for demand and generation in the spot market are submitted to Nord Pool before 12:00 noon every day. The day-ahead market allocates production to each price area in a way which ensures that the use of the transmission lines is below the announced available capacity. Whether congestion and price differences occur depends on a combination of the available capacity and the bids to the market.
- In the operating hour, the TSOs activate regulating power if deviation from the planned power flow threatens to exceed the capacity of the transmission lines. However, the changes in actual power flow can also result in higher capacities: Often, the *ex ante* evaluation of the maximum power flow is relaxed in the operating hour, due to the more accurate information now being available. In the operation hour, detailed plans describing power flows exist for demand and generation. Unused capacity can e.g. be used to transport regulating power.

The capacity allocated to the market and announced by the TSO for day-ahead trading is called net transfer capacity (NTC) which is defined as:

$$NTC = TTC - TRM$$

TTC is the maximum exchange programme between two areas compatible with operational security standards applicable at each system if future

[5] (n-1) is an expression of a level of system security entailing that a power system can handle loss of any single component (production units, lines, transformers, bus bars, consumption etc.). For faults having the largest impact on the power system, the term dimensioning faults is used.

network conditions, generation and load pattern were perfectly known in advance.

TRM is a security margin that copes with uncertainties on the computed TTC values arising from:

- Unintended deviations of physical flows during operations due to physical functioning of load-frequency regulation
- Emergency exchanges between TSOs to cope with unexpected unbalanced situations in real time
- Inaccuracies, e.g., in data collection and measurements

When determining the capacity on the interconnection between two subsystems, the capacity is calculated by the TSOs on each side of the connection by using computer programs based on coordinated network models. If the values differ, the lowest value is used. The objective is to give the market as high capacity for energy trade as possible taking into account outages and faults in the network. The NTC values between all the subsystems are given to Nord Pool Spot for day-ahead trading (Elspot) in its entirety. The TSOs guarantee the NTC value given for Elspot trading. The available transfer capacity (ATC), which remains available after day-ahead trading, is used for further commercial activities, i.e., the Elbas-market[6] and the regulation power market.[7]

That the net transfer capacity (NTC) is often reduced significant under the capacity as per design rules can be seen from the two figures below showing the net transfer capacity in 2006 from Norway to Denmark West (Figure 12) and from Denmark East to Sweden (Figure 13). The hours in each figure are sorted after decreasing capacity.

[6] On Elbas (Nord Pool's intraday market), electricity can be traded up to one hour before the delivery hour. The purpose of Elbas is to make it possible for players to buy and sell as required in order to ensure balance right up the delivery hour, e.g., in case of outages.
[7] Since 2002 there have been a common Nordic regulating power market which is a compilation of bids delivered to the four Nordic national balancing markets, and is used for balancing and frequency control.

**Figure 12: Net transfer capacity from Norway to Denmark West in 2006 (1000 MW link)**

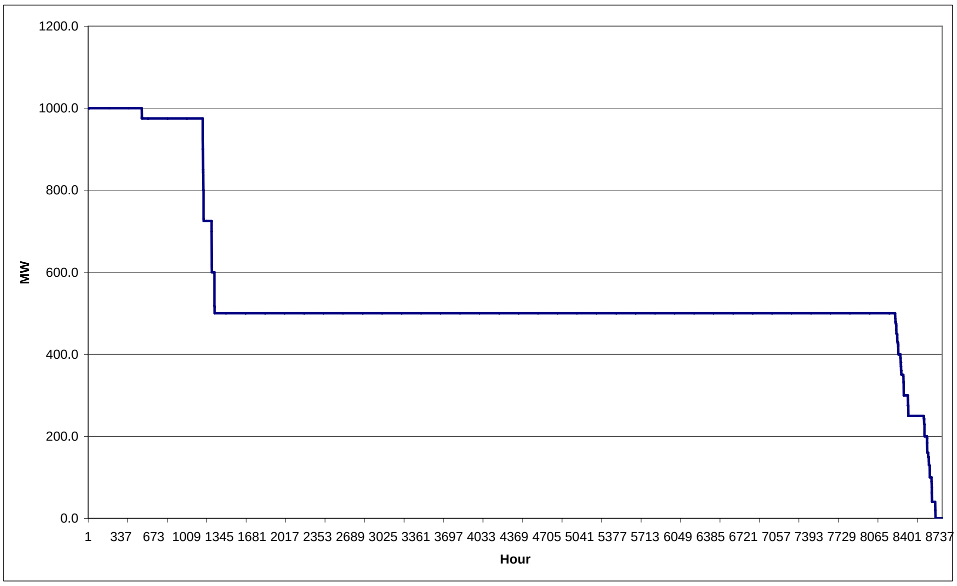
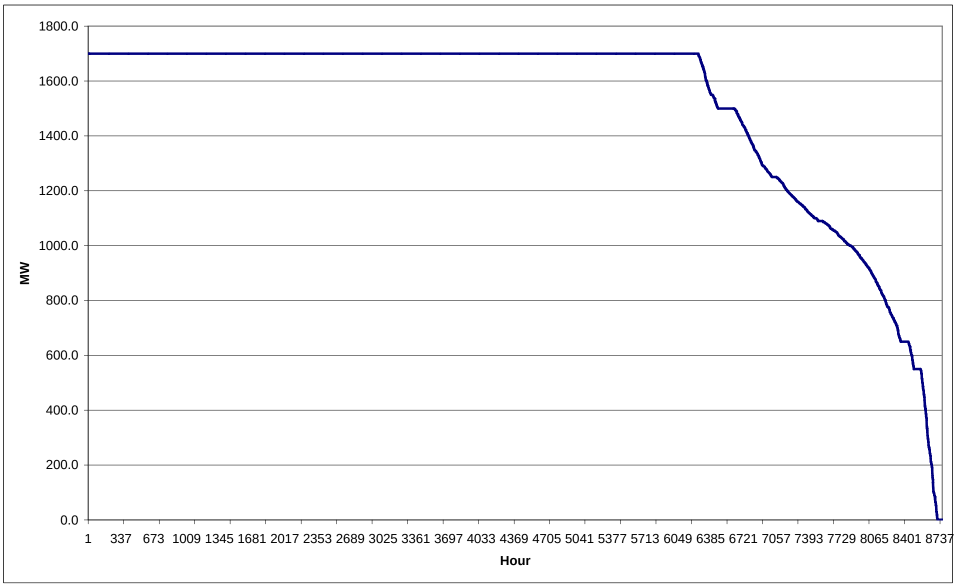



**Figure 13: Net transfer capacity from Denmark East to Sweden in 2006 (1750 MW link)**




It appears from the two figures that in 2006 the net transfer capacity from Norway to Denmark was reduced under its maximum in more than 8,000 hours and the that the net transfer capacity from Denmark East to Sweden was reduced under its maximum in approximately 2,500 hours.

### 2.2.2 Denmark - Germany

The interconnection between Eastern Denmark and Germany is operated according to the same principles as the one applying to the interconnections within the Nordic countries as described in section 2.2.1. This came into force on the 5th of October 2005 where Nord Pool Spot opened a price quotation in Germany. The Nordic Exchange area was then expanded to include also a bidding area in Germany named KONTEK. Thereby the implicit auction has replaced daily and monthly auctions on the Kontek cable that were operated by the Danish TSO prior to the opening of the KONTEK bidding area. Thus the Nordic and the German markets are linked for the first time through the implicit auction mechanism used in the Nordic market. This development is among others in line with the EU strategy for the future development of the European energy market.

On the interconnection between Western Denmark and Germany, daily, monthly and annual auctioning of capacity is still used. The German transmission system operator, E.ON Netz, is in charge of the auctions. The terms applying to the auctions can be found of the website "Auctions on the Danish/German border" [26] and are continuously updated. Players buying capacity on the border at the auction are free to make the capacity available to the market, handing it over to Nord Pool. The purpose is to improve trade on the border. Nord Pool's service is called "Cross Border Optimisation" (CBO).

### 2.2.3 Sweden - Germany

The transmission link between Sweden and Germany is owned and operated by Baltic Cable AB [27], which is owned by E.ON Sverige AB (1/3 of the shares) in Sweden and Statkraft Energi AS (2/3) of the shares) in Norway.

Baltic Cable (BC) offers, in case of free physical capacity, on request, transmission short term on the link on a day-by-day basis. In order for Third Party to be able to use the link following conditions must be fulfilled:

- The customer must be approved balance responsible and a counter party to Svenska Kraftnät and E.ON Netz ,i.e., a Balansansvarsavtal (with Svenska Kraftnät) and a Bilanzkreisvertrag (with E.ON Netz) must be signed.
- The customer must also be approved counter party to Baltic Cable AB

The tariffs for using the link consist of a transmission fee and additional fees. The transmission fee is:

| | |
|---|---|
| Day subscription | 110.29 EUR/MW |
| Hour subscription | 11.03 EUR/MW |

Day subscription means that the same amount of transmission capacity is allocated for a whole day (00.00-24.00).

The additional fees are costs related and cover the energy losses on the link itself as well as the connection fees to the Swedish transmission net (Svenska Kraftnät). The connection fees consist of both capacity and energy charges and are also depending on power direction, season and time according to Svenaka Kraftnät's point-of-connection-tariff in Arrie.

Figure 14: Transmission fees, Sweden - Germany (EUR/MWh)

| Time/Power direction | South (Swe to Ger) | North (Ger to Swe) |
|---|---|---|
| High load, working day | 4.18 | 0.53 |
| High load, other day | 3.87 | 0.84 |
| Low load, working day | 3.97 | 0.74 |
| Low load, other day | 3.52 | 1.18 |

### 2.2.4 Sweden - Poland

SwePol Link AB is a subsidiary company of Svenska Kraftnät and owns the Swedish and the international parts of the transmission link between Sweden and Poland. The commercial conditions for the link are set by SwePol Link AB [28].

There are some fixed tariffs for using the link and available transmission capacity in bunches of 50 MW are offered on a "first come - first served" basis.

The fixed fee for 50 MW per year is 14.3 million SEK (1.5 million EUR). The fixed fee includes a variable fee up to 75,000 MWh. The variable fee for energy in excess of 75,000 MWh is 6.56 SEK/MWh (0.71 EUR/MWh) in both north-bound and south-bound direction.

### 2.2.5 Finland - Russia

The link between Finland and Russia is owned by the Finish TSO Fingrid and is only used for import purposes to Finland. The transmission service is intended for a fixed-type import of electricity. When making an agreement on transmission service, the customer reserves a transmission right for a time period to be separately agreed upon. The smallest unit for transmission that can be reserved is 50 MW.

If the total volume of reservations received by Fingrid is larger than the transmission capacity offered, the available capacity will be distributed annually in proportion to the reservations made, unless those making the reservations or some of them reach some other agreements between themselves or with the seller of electricity. A customer can waive his reservation if his full reservation cannot be confirmed.

The determination of the available cross-border capacity for the coming day and the daily handling as well as the confirmation of the hour by hour transmission programme is scheduled so that the customer can take imports from Russia into account when trading on the Nordic electricity exchange.

Fingrid can restrict the transmission service for the needs of securing the management of the Nordic power system as well as in the event of disorders in the grid on the Russian or Finnish side of the border and during other outages affecting the transmission capacity of the connection.

For the transmission service, the customer pays transmission service fees which are invoiced monthly.

**Figure 15: Transmission fees, Finland - Russia**

| *Capacity fee* | *500 EUR/MW, month* |
|---|---|
| Use of grid, input | 0.30 EUR/MWh |
| Market border fee | 1.00 EUR/MWh |
| ETSO fee | 1.41 EUR/MWh |
| Peak power fee | 0.40 EUR/MWh |

### 2.2.6 Finland - Estonia

The connector between Finland and Estonia is owned by the company AS Nordic Energy Link (NEL) and is jointly operated by Põhivõrk and Fingrid. The interconnector allows electricity trading in both directions.

Under decision 108708 of 27 April 2005, the EC Directorate-General for Energy and Transport granted an exemption to NEL which means that until the 2009-2013, the capacity will be used by the parties connected to the project (of establishing the link) according to the use-it-or-loose-it principle. At a moment later to be specified, the ownership of the interconnection is intended to be transferred to Fingrid and the transmission system operators in the Baltic States. The transmission capacity will then be opened to third parties without a preference clause relating to the capacity.

Even though project parties have privileged rights for the Estlink capacity in both directions, there are still numerous opportunities for third parties to acquire transfer capacity. Initially, the project parties (at the beginning only project parties are capacity owners) and later on all capacity owners have the possibility to sell transfer capacity in both directions on year, month or day auctions, which are regularly organised according to the Auction Regulations.

In addition, third parties have the possibility to buy transfer capacity for the next day from so-called free capacity auction. Free capacity means the residual capacity for the next day, which remains unused after submission of usage notifications by the project parties (after the announcement of spot-market results of Nord Pool Spot). Based on the balance of these binding usage notifications and on the total physical capacity available on a daily basis, the capacity for the free capacity auction is calculated. In the calculation of the available free capacity, the NEL takes into consideration electricity transfer also in the opposite direction, i.e. follows the so called netting principle.

## 2.3 Renewable Support Mechanisms

### 2.3.1 Differences from country to country

In order to promote the use of renewable energy sources, different types of support mechanisms are used in the Nordic countries. Examples of support mechanisms used are feed in tariffs, green certificates, investment support and operation support. The Nordic countries all use at least one of these mechanisms.

The support level of course affects the investment climate for new renewable power in different countries, but it should be noted that there are several other factors that are important when taking investment decisions, e.g. local physical conditions for renewables, production taxes or environmentally related taxes such as carbon, or fossil fuel taxes. (In Norway in principle all electricity production is based on renewable energy sources, in spite of the fact that support levels are low).

Issues regarding support mechanisms for renewable electricity are important because they fundamentally influence the liberalised Nordic electricity market, and because both the support schemes and their consequences are complex.

For a description of the support mechanisms in each of the Nordic countries, please see the Nordic market overview report (outcome of task 1).

### 2.3.2 Restrictions or complications associated with getting full value for RES output

As differences in support level affect the amount and type of RES in each country, it may also affect the transmission patterns across the countries. For instance, the support of wind power in Denmark has most probably resulted in some more volatile import/export patterns between Denmark and Norway/Sweden.

However, there seems not to be any restrictions or complications associated with getting full value for RES output no matter where the generated electricity output ends (is consumed). In Denmark, for instance, the subsidy to electricity generated at wind turbines and biomass CHP plants is given for the amount of electricity delivered to the grid irrespective of the actual import/export situation and thereby whether the generated amount of electricity is used in Denmark or in other countries. In Sweden where there is an electricity certificate system, producers of renewable electricity also receive certificates no matter where their generated amount of electricity is actually consumed.

## 2.4 Utilisation for Variable Generation

In the Nordic power system, electricity exchange between countries takes place via Nord Pool and transfer capacities are allocated concurrently with electricity being traded by use of the concept implicit auction. It is not so that the electricity that actually flows through the lines are "ear-marked" and can be assigned to e.g. wind power or thermal generation. Therefore, it is also difficult to quantify how much trade that is caused by RE sources or how much each RE source uses the interconnectors.

However, the exchange of electricity in the Nordic system is heavily influenced by the availability of hydro power. In dry years, the power flows north, while the opposite is the case in wet years. In the same way, wind power is motivating power exchange - but much short cycles of hours and days instead of month and years. The large daily variation in prices in the German thermally dominated system also motivates power exchange.

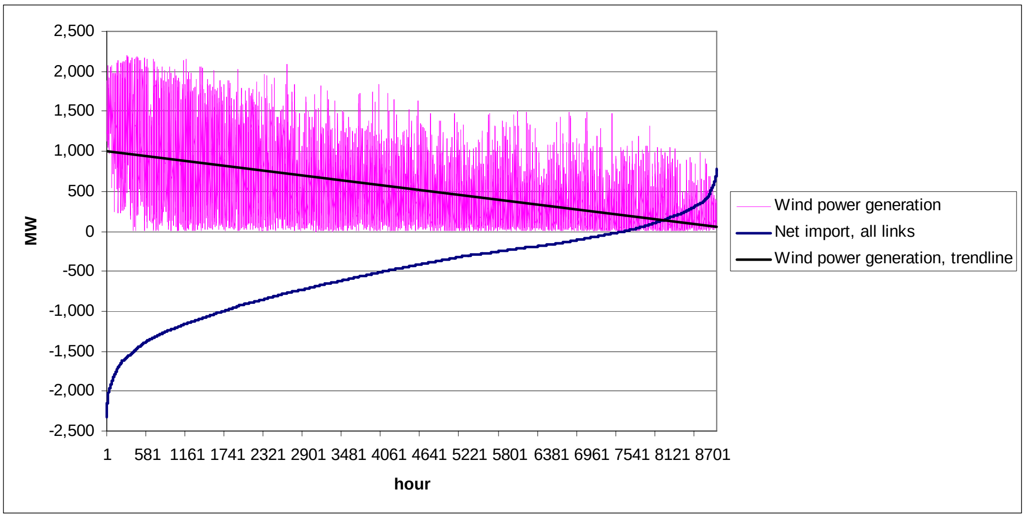
The two figures below show how the power exchange helps to compensate for fluctuations in wind power generation in Western Denmark. Also, it illustrates how the exchange of electricity within the Nordic system flows north in a dry year.

In

Figure 16, the hourly wind power generation and the hourly net import are sorted after increasing net import. It appears that in 2006 the export from Western Denmark was much higher than the import. The number of hours with net export (negative net import) was 7,435 whereas the number of hours with net import was only 1,325. The total net export from Western Denmark was 4.5 TWh (of which 2.4 TWh was to Norway and Sweden and 2.1 TWh was to Germany). The main reason for the electricity flow from Westen Denmark to Norway and Sweden was that 2006 was a relatively dry year with respect to precipitation. In wet years with much hydro power generation, the flow goes opposite.

Figure 16 also shows how the net import to Westen Denmark is in general higher when the wind power generation is low - or opposite how the net export increases for increased wind power generation.

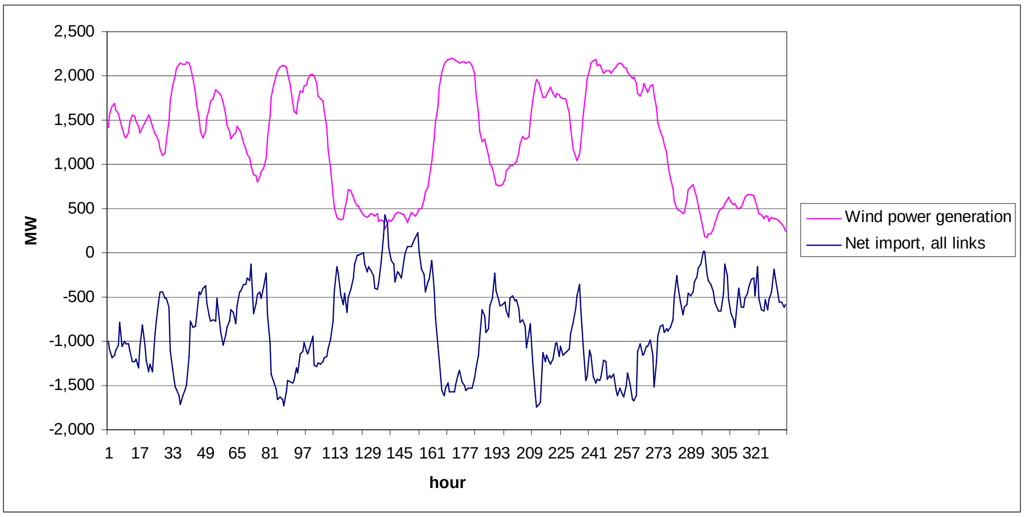
**Figure 16: Wind power generation and net import in Western Denmark in 2006 sorted after increasing net import**




Source: Energinet.dk [18]

In Figure 17 this is illustrated more clearly. The figure shows the wind power generation and the net import in Western Denmark in week 49-50 in 2006. It appears that the net import in these two weeks is almost fluctuating in opposition to the wind power generation and thereby compensates for the fluctuations in wind power. For instance, around hour no. 160 the wind power generation increases from 500 MW to more than 2,000 MW during a relatively short period which is counterbalanced by a decrease in the net import (i.e. increased export).

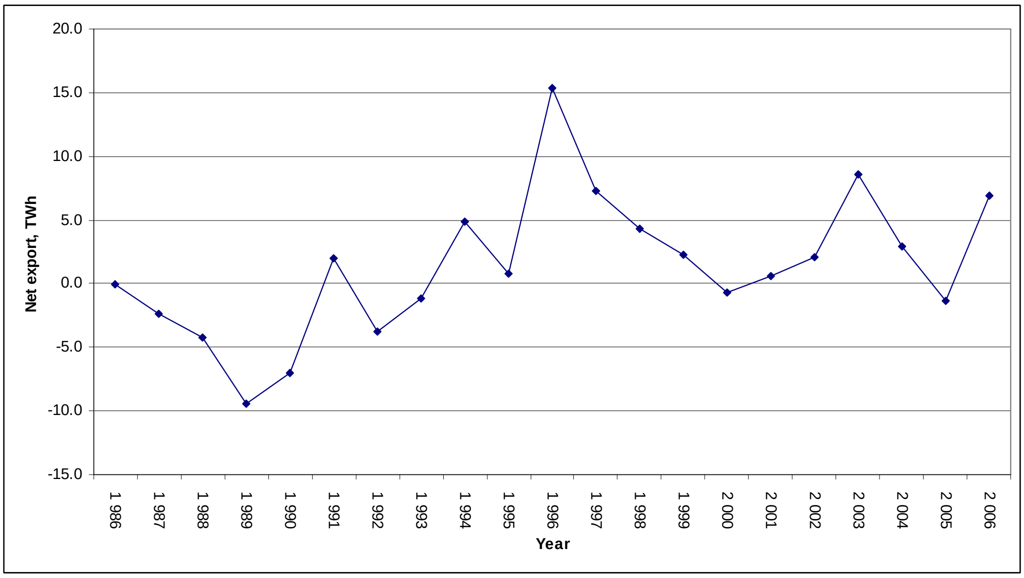
**Figure 17: Wind power generation and net import in Western Denmark in week 49-50 in 2006**




Source: Energinet.dk [18]

Apart from the figures above, the large influence on cross-border electricity trade from RES can also be seen from the large variations in the import/export patterns from one year to another depending on the precipitation. Figure 18 below shows the variation in net export from Denmark (wind/thermal system). The net export from Denmark is high in dry years with low amounts of hydro power (in Norway and Sweden) and opposite in wet years. In 1996 which was a very dry year, the net export from Denmark amounted to 15.4 TWh, whereas in 1989 there was a net import to Denmark of 9.5 TWh.

**Figure 18: Annual net export from Denmark (wind/thermal system), 1986-2006**




Source: Danish Energy Authority (2007) [13]

The larges variation in net export, i.e., from -9.5 TWh to 15.4 TWh = 24.9 TWh corresponds to more than 70% of the Danish electricity consumption in 2006 of 34.1 TWh.

## 2.5 Summary

### 2.5.1 Current Cross Border Flows

Within the Nordic power market there are strong electricity interconnections and trade between the countries is encouraged by the variation in generation technologies. In 2006, the amount of electricity trade between the Nordic countries was 8.4% of the electricity consumption. Historical trends indicate a continued increase in exchange of electricity. More efficient trade between regional markets as well as new transmission lines - like the Nordic five prioritised links - will increase the traded volume.

### 2.5.2 Cross Border Capacity Mechanisms and Trading

Nord Pool uses the concept **implicit auction** in form of **market splitting**, by which transfer capacity is allocated concurrently with electricity being traded.

The use of market splitting as the cross border and congestion management method in the Nordic system means that the market balance between supply and demand per bidding area is automatically determined by the combination of bids/offers in all bidding areas and utilisation of the available capacity between the various bidding areas.

Market splitting, however, is a simplified way to find dispatch based on bids. The method only includes limited information about the grid, i.e. the announced capacities between price areas. If the system was divided in more prices areas, more grid information could be taken into consideration, which most probably would lead to a more efficient allocation of resources. The most extreme version of dividing a market into price areas is "nodal pricing" (with a price for each node) which includes full information about the grid and gives the optimal dispatch. Using this system, the market players just have to indicate to which node (e.g. a transformer in the transmission grid) the bid is made. Several markets, e.g., PJM[8] in the USA and New Zealand have practised nodal pricing for years.

### 2.5.3 Renewable Support Mechanisms

There does not seems not to be any restrictions or complications associated with getting full value for RES output in the Nordic system no matter where the generated electricity output ends (is consumed). In Denmark, for instance, the subsidy to electricity generated at wind turbines and biomass CHP plants is given for the amount of electricity delivered to the grid irrespective of the actual import/export situation and thereby whether the generated amount of electricity is used in Denmark or in other countries. In Sweden where there is an electricity certificate system, producers of renewable electricity also receive certificates no matter where their generated amount of electricity is actually consumed.

### 2.5.4 Utilisation for Variable Generation

Electricity that actually flows trough the lines is not "ear-marked" and therefore cannot be assigned to e.g. wind power or thermal generation. Therefore, it is also difficult to quantify how much trade that is caused by RE sources or how much each RE source uses the interconnectors.

However, the exchange of electricity in the Nordic system is heavily influenced by the availability of hydro power. In dry years, the power flows north, while the opposite is the case in the wet years. In the same way, wind power is motivating power exchanges - but much shorter cycles of hours and days instead of month and years.

[8] PJM Interconnection is a regional transmission organisation (RTO) that coordinates the movement of wholesale electricity in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan; New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia - an area with a 51-million population.

# 3 GRID PLANNING

This section provides an overview of different planning approaches for integration of renewable generation within the Nordic countries comprising Denmark, Finland, Norway and Sweden. The work investigates proactive initiatives for investment planning that have been developed to meet the growing demand for variable generation connection in the Nordic countries, and to increase the efficiency of their incorporation in the grid system. The work focuses on large-scale integration of renewable sources with special emphasis on planning issues for wind power in the Nordic countries. The work will discuss on the extent that grid investment can be a barrier for renewable generation development.

## 3.1 Grid Investment

This section reviews different factors driving investments to incorporate renewable energy sources in the Nordic countries (Denmark, Norway, Sweden and Finland). The planning of grid investments in the Nordic countries is carried out by electrical utilities and Transmission System Operators (TSOs). The work will also examine issues in the development of transmission grids to connect offshore wind as well as new regulations regarding planning of new interconnecting links and offshore wind farms.

### 3.1.1 Costs for grid connection of distributed generation

In general costs for grid connection of renewable energy sources are split in costs for internal electrical installations and costs for connection of the generator to the electrical grid. The internal installation is typically the medium voltage grid that connects the generator unit(s) to the Point of Common Coupling (PCC). If the generator is large and the distance to the grid long there may be a need for a common step-up transformer for medium voltage in the generator grid to the local high voltage transmission level [5].

The cost for local electrical installations is in the range 3-10% of the total cost. This item is highly dependent on the generator size and hence the voltage level for connection to the existing grid as well as on the local equipment prices, local technical requirements, soil conditions, the distance between single generator units etc.

The grid connection costs for onshore and offshore wind farms are significantly influenced by the selected line solution. Conventional overhead lines are used as typical solution for grid connection of wind farms on land. The transmission grid connection for off-shore wind farms can be done by underground AC cables or **H**igh **V**oltage **D**irect **C**urrent lines either by traditional HVDC with tyristor-based converters or by HVDC with IGBT- based converters. The AC cable solution is the best and cheapest solution for offshore wind farms close to the shore. The HVDC line solution is recommended when the lines connecting the wind power plant to the transmission grid exceed 120 km [7]. The recent advances in HVDC technology using IGBT- based converters offers multi-terminal HVDC networks with technical advantages in power control capability and flexibility.

The different cost items for a typical 150 MW wind farm installed onshore and offshore are compared in Table 1. E.g. the cost for grid connection of a 150 MW offshore wind farm (offshore transformer station, internal electrical grid for the wind farm and transmission grid connection) is roughly estimated to 25% of the total cost for the wind farm. The cost for grid connection of the respective onshore wind farm is 15% of the total wind farm cost.

**Table 1: Comparison of costs for 150 MW wind farm**

| | Offshore wind farm % | Onshore wind farm % |
|---|---|---|
| Foundations | 16 | 5,5 |
| Wind turbines | 51 | 71,0 |
| Internal electrical grid | 5 | 7,5 |
| Offshore transformer station | 2 | - |
| Grid connection | 18 | 7,5 |
| Operation & maintenance facilities | 2 | |
| Engineering, project administration | 4 | 2,5 |
| Miscellaneous | 2 | 7,0 |
| Total | 100 | 100 |

### 3.1.2 Grid reinforcements for large-scale integration of renewables

The Nordel cooperation acknowledges that technical requirements and costs for grid connection of renewable generation depend to a large extend on the penetration levels and the nature and robustness of the existing electrical infrastructure such as the overall composition of generation sources and regional interconnections. In some Nordic countries unnecessary grid investments without technical appropriate justification should be avoided in grids with moderate penetration level of renewable generation.

The costs for additional network and connection of renewable generation are typically covered by local/ regional customers via additional grid tariff. In the future these costs could be socialised within a "grid infrastructure" component on Nordic or international level [7]. Such initiative requires establishment of corresponding accounting rules for the grid operators.

The majority of wind power plants are installed in peripheral regions with bellow average power demand, and limited transmission capacity of the regional network. During the periods of strong wind the total wind power output can not be consumed locally and flow to load centres over long distances in the transmission grid. Furthermore the grid infrastructure needs upgrading and modification in order to accommodate efficiently increasing amounts of renewable generation. The process of grid upgrading requires short-term measures (optimisation of existing infrastructure, adapted procedures for energy management etc.) as well as long-term grid investments to enable integration of renewable energy sources in relation to:

- Reinforcement and extension of existing transmission and distribution lines and substations,
- Establishment of new transmission and distribution lines substations,
- Establishment of new voltage control devices (such as capacitor banks or advanced SVC / FACTS devices) .
- Establishment of back up capacity
- Establishment / increased utilization of interconnection lines in the Nordic power system.

According to reference [7] a number of national studies indicate that the grid extension costs caused by additional wind generation are in the range 0,1-4,7 Euro/ MWh wind energy. The higher value corresponds to a 30% wind penetration, which approaches the trend in the Nordic countries. The system integration costs determined the under conservative assumptions (low gas price, low to zero benefit from $CO_2$ quotes) form a fraction of the actual consumer price for electricity.

The need for infrastructure investment due to grid connection of renewable generation is not arising exclusively from increased amount of renewable sources- The grid investments would benefit the entire power system and all system users and thus it can not be always considered to be a barrier for renewable generation development in the Nordic countries. The cost of grid extension could be to some extent socialised between different Nordic and European actors involved in implementation of renewable generation units.

### 3.1.3 Examples of grid investments in Denmark

Commissioning of the 200 MW windfarm Horns Rev 2 in 2009 requires only minor reinforcements of the 150 kV grid. Construction of other large scale wind farms are foreseen in the Danish part of the North Sea. Connection of additional windfarms will probably require substantial upgrading of the 400 kV North-South link in Jutland.

Furthermore the planned interconnection between Western and Eastern Denmark (Great Belt) and a number of reinforced interconnections to Germany, Norway and Sweden would improve the power transfer in the system [1], [4].

In Eastern Denmark the connection of a new 200 MW offshore wind farm at Rødsand requires some reinforcements (at inlet crossings) of the southern part of the 132 kV grid.

Finally an upgrade of the Great Belt interconnection between Western and Eastern Denmark and a reinforcement of the Øresund link to Sweden would improve the wind power transfer in the Eastern Danish system.

## 3.2 Planning & Security Standards

The future development of power systems with a large amount of renewable sources calls for innovative planning and redesigning of electricity networks that encourages flexible principles. E.g. flexible consumption and generation pattern, generation storage, virtual power plants based on clusters of distributed sources (as well as in combination with conventional power plants), utilization of interconnections need to be incorporated in the overall power system planning.

Reference [6] proposes technical and economical incentives for an "active network", where the distribution and transmission networks are designed and operated in a closely integrated platform. This approach facilitates intelligent distributed control and active management of distributed generation in a deregulated electricity market with large scale renewable generation. E.g. offering equal conditions for central and local electricity production units will bring all power plants to contribute with ancillary services to system stability and flexibility [6].

### 3.2.1 Planning

- ***Denmark***

  Energinet.dk plans and expands or reinforces the transmission grids when necessary. The planning must support the objectives laid down in Danish and European energy policies, including the Danish government’s Energy Strategy 2025. Furthermore, the development of the electricity and gas systems must strike a balance and take account of the wish for a high level of security of supply, emergency preparedness, market mechanisms, environmental concerns and socio-economic factors.

  An annual transmission report describes the alterations and expansion requirements in relation to the electricity transmission grid. The report also gives a more general description of potential future construction projects. The strategic and technical considerations behind the large construction projects are described in the annual System Plan.

  The counties in Denmark were abolished with the Local Government Reform, which came into force on 1 January 2007. With that step, responsibility for providing the necessary planning basis in conjunction with the establishment of large-scale electricity and gas infrastructure projects has basically been transferred from the counties to seven national environmental centres. The environmental centres have in this manner become significant cooperation partners for Energinet.dk. This is particularly true of the environmental centres in Roskilde, Odense and Aarhus, which are responsible for the planning basis for large-scale infrastructure installations, including the preparation of environmental impact assessments.

The members of the Electricity Infrastructure Committee are the Danish Ministry of Transport and Energy, the Ministry of Finance, the Ministry of the Environment, the National Association of Local Authorities in Denmark, the Danish Energy Authority and Energinet.dk. The committee's report must be presented to the Minister for Transport and Energy by 1 March 2008. According to its mandate, the committee is to prepare a technical report describing and quantifying the total need for expansion and the tasks to be solved by the electricity infrastructure when it comes to integrating renewable energy and local electricity generation, maintaining the security of supply and facilitating the electricity market at transmission level.

- ***Sweden***

  Svenska Kraftnät runs and plans the national electrical grid. The duties of the system operator include the responsibility for the electricity system being in a short-term state of balance and its installations working together in an operationally reliable way.

  A special permission (a concession) granted by the Swedish Energy Agency is required in order to construct or operate high-voltage electricity lines. The obligations of the holder of a concession concern only network operations. Network concessions are granted by the Government or by the Network Authority.

  The Swedish Energy Agency monitors network fees and other conditions relating to the transmission of electricity. Network operations are governed by the Electricity Act. The Act states that holders of network concessions should be obliged to connect the lines and plants of others to their own network on reasonable terms and to transmit electricity on reasonable terms regardless of who the owner of the power is. Exemptions from the obligation to connect others may be granted by the Network Authority if there are special reasons.

- ***Finland***

  Fingrid maintains, operates and develops the main grid and connections to other grids in accordance with customer needs and by following principles agreed upon between the Nordic transmission system operators, and national engineering practices. Fingrid's grid has been constructed as a ring network so that a failure in any individual line does not interrupt electricity transmission. The volumes of electricity transmitted on the lines are monitored constantly, and transmissions are restricted to a level where potential faults do not lead to the overloading of the remaining parts of the grid.

The planning of the tariff and grid is carried out by Fingrid in four-year main grid contract periods. The current period runs from 2008-2011. Reactive power agreements and reactive power reserve agreements are also contracted for four year periods. The formation of these plans involves consultation with the grid customers.

The terms which govern connection to the main grid and the technical system requirements imposed on power plants were specified and updated in 2006. The connection terms are supplemented by separate instructions (grid codes), which support the detailed engineering of the connection and specify the requirements concerning the connection of wind power units and direct current connections to the grid.

The grid service is agreed upon through a main grid contract which is signed between a customer connected to the Finnish grid and Fingrid. After signing the main grid contract, the customer obtains a right to transmit electricity to and from the Finnish main grid through his connection point. Fingrid removes transmission congestions in the grid through counter trading or reinforcement.

- ***Norway***

Statnett SF is the TSO and is responsible for the Central Grid (Transmission) tariffs and the system responsible entity according to the regulations. Statnett also owns about 80 per cent of the main grid infrastructure. The Main Grid Commercial Arrangement is a nationwide system for transmitting electricity between different regions and parts of the country. The charging system for the Main Grid Commercial Arrangement is based on leasing charges for power lines, transformers and switching facilities. The main grid infrastructure is leased from 40 different owners. Most of Statnett's facilities are leased to the Main Grid Commercial Arrangement. This arrangement allows a common pricing system for transmission services and provides all players with grid access on equal terms. The costs for leasing infrastructure have to be calculated in accordance with guidelines set by the regulatory authorities. In principle, costs and income should balance.

The responsibilities of the TSO are not limited to the central grid alone, but can be extended to regional transmission and even distribution when deemed necessary.

Tariffs (based on income cap set by the Regulator for each network company) are paid at all physical exchanges between network levels.

The TSO Statnett plans the development of the grid. Traditionally, grid planning was based on the “N-1 criterion”, which means that a system must be able to tolerate the breakdown of one component without causing an outage in the electricity supply. The N-1 criterion is now used more as an aid in planning. Nordel’s dimensioning rules provide a modified N-1 criterion and specified acceptable consequences of various combinations of operational conditions and fault incidents.

Statnett sets limits on what outages are acceptable. The main principles apply in operations and are a fundamental prerequisite for maintenance and grid planning. The grid must be strengthened if it is economically rational to do so, or if it has to be done to satisfy the limits. This is determined on the basis of the following factors [29] that grid components shall be loaded within fixed capacity limits, including the possibility for short-term overload and that the following consequences shall not be unacceptable:

- A grid disturbance shall not result in more than 1 GWh non-supplied energy
- Points of delivery shall have voltage and adequate capacity within 2 hours (point of delivery with one-sided supply shall have voltage and adequate capacity within 4 hours)
- A grid disturbance shall not result in an outage of more than 1400 MW consumption
- A connection point in the main grid shall have maximum 2 outages per year

After an outage, the grid shall be operated so that there is little risk of a new outage in the same point until the cause of the fault has been clarified and necessary corrective action has been taken.

### 3.2.2 Grid Code Requirements

The interconnection of renewable production in the Nordic countries is controlled by the Nordic grid code [2] as well as mandatory national grid codes and grids access requirements. The Nordic Grid Code concerns the TSOs operation and planning of the electric power system and the market actors' access to the grid. The Code lays down fundamental common requirements and procedures that govern the operation and development of the electrical power system.

The Nordic grid codes include specific codes for wind power plants. The wind turbine manufacturers have responded to these requirements by particular measures in the field of wind turbine control and electrical system design.

The Nordic Grid Code is made up of the following elements:

- General provisions for cooperation
- Planning Code
- Operational Code (System Operation Agreement)
- Connection Code
- Data Exchange Code (Data Exchange Agreement between the Nordic transmission system operators (TSOs).

The Operational Code and the Data Exchange Code are binding agreements with specific dispute solutions. The Planning Code and the Connection Code are rules that should be observed. They correspond to Nordel's recommendations in these areas.

The grid code includes some general requirements as well as some specific requirements depending on the type and size of technology. In each country, however, there can be some national requirements that are stricter than the requirements stated in the common grid code.

Grid connection code requirements for wind power in the Nordic countries in particular are included in the Nordic Grid Code 2007 in form of minimum technical requirements that new wind turbine systems have to fulfil at the connection point to the transmission network in order to provide for adequate safe operation and reliability of the interconnected Nordic power system. The most essential grid code requirements in the Nordic countries are summarized below.

- ***Active power control***

  It must be possible to control the active power production from the wind plant. The following control functions must be available:

  An adjustable upper limit to the active power production from the wind plant shall be available whenever the wind plant is in operation. The upper limit shall control that the active power production, measures as a 10 minute average value, does not exceed a specified level and the limit shall be adjustable by remote signals. It must be possible to set the limit to any value with an accuracy of ±5%, in the range from 20% to 100% of the wind plant rated power.

  Ramping control of active power production must be possible. It must be possible to limit the ramping speed of active power production from the wind turbine in upwards direction (increased production due to increased wind speed or due to changed maximum power output limit) to 10% of rated power per minute. There is no requirement to down ramping due to fast wind speed decays, but it must be possible to limit the down ramping speed to 10% of rated power per minute, when the maximum power output limit is reduced by a control action.

Fast down regulation. It must be possible to regulate the active power from the wind turbine down from 100% to 20% of rated power in less than 5 seconds. This functionality is required for system protection schemes. Some system protection schemes implemented for stability purposes require the active power to be restored within short time after down regulation. For that reason disconnection of a number of wind turbines within a wind plant cannot be used to fulfil this requirement.

Frequency control. Automatic control of the wind turbine's active production as a function of the system frequency must be possible. The control function must be proportional to frequency deviations and must be provided with a dead-band. The detailed settings are provided by the TSO's.

- ***Reactive power capacity***

  The wind plant must have adequate reactive capacity to be able to be operated with zero reactive exchange with the network measured at the connection point, when the voltage and the frequency are within normal operation limits.

- ***Reactive power control***

  The reactive output of the wind plant must be controllable according to TSO specifications.

- ***Dimensioning voltage and frequency***

  The wind plant must be able to meet performance requirements in relation to voltage and frequency as outlined in the connection code.

- ***Operational characteristics during grid disturbances***

  The wind plant must be able to continue operation during and after disturbances in the transmission network.

- ***Start and stop***

  The grid code recommends that the wind plant is designed so that the wind turbines within the wind plant do not stop simultaneously due to high wind speeds.

- ***Remote control and measurements***

  Wind plants must be controllable from remote locations by telecommunication. Control functions and operational measurements must be made available to the TSO on request. The TSO in each area specifies the required measurements and other necessary information to be transmitted from the wind plant.

- ***Test requirements***

  Prior to the installation of a wind turbine or a wind plant, a specific test programme must be agreed with the TSO in the area. The test programme shall be the documentation of the capability of the wind turbine or the wind plant to meet the requirements in the connection code.

Details upon national grid code rules can be found in reference [9], [10] for Denmark, [11], [12] for Norway and [13], [14] for Sweden. National rules apply for instance to hydropower plants that are covered by the connection code. In Norway there are national requirements for hydro power plants. In Finland, general requirements to be met by thermal power and hydropower are used. No particular grid code requirements for wind power are established in Finland. The increasing contribution of wind energy in the Nordic countries requires advanced solutions and enhanced characteristics of wind generation units corresponding to the requirements of traditional power plants to keep the high level of power quality and security of supply.

The conventional planning (and control) methods related to variable production and variable demand [7] are adequate for dealing with penetration levels of wind power up to approx. 20% of gross demand. Power systems with larger wind power penetration are to accommodate proactive procedures and planning tools as well as excessive requirements with regards to ancillary services9 (fault ride-through capability, frequency and voltage control etc.).

The Transmission System Operator in Denmark (Energinet.dk) has adopted advanced set of planning and operating procedures to secure the power system security and reliability with respect to increasing amount of renewable generation. The large penetration level of wind power10 in Denmark justifies for strict planning standards / grid codes related to renewable generation connected to distribution and transmission grids. The Danish grid codes related to offshore and onshore wind power include restrictive requirements for power quality and grid support from wind turbines. The restrictive planning requirements and improved technical performance of wind turbines are necessary to reduce transmission grid constraints and unintentional wind power rejection as well as to control exceeding surplus of wind energy in the system.

Restrictive and costly grid requirements for wind power at low penetration levels should be included only if they are technically required for reliable and stable power system operation. For example it is more economic to provide primary and secondary control/regulation from conventional power plants and wind farm operators should be demanded to provide such services only when limitations in existing reserves are foreseen due to critical contingencies.

[9] Grid supporting services
[10] The installed wind capacity in Denmark for year 2005/ 2006 is 42% of the peak system load.

### 3.2.3 Offshore

- ***Norway***

  Norway has excellent wind resources, both at land and at sea. As of today, no offshore wind parks have been developed, but several are at the drawing board. The company Havgul has applied for a permit to develop three wind parks off Ålesund, on the Norwegian west coast. The turbines will be of capacity between 3.5 and 8 MW, and will be installed at shallow water between 5 and 15 m sea depth. In total, the three parks will have an installed effect of 1500 MW, and a production of over 4 TWh.

## 3.3 Transmission Access & Charging in the Nordic countries

### 3.3.1 Connection Charging

Smaller RE power sources may be subject to some connecting charging to the local distribution company in the area where they are connected. Connection costs related to the connection of larger RE plants that are connected directly to the transmission system, e.g. a new large wind park, are in general covered by the transmission system operator.

In Denmark, offshore and land based wind turbines in special areas designated for wind development receive connection up to the boundary of the wind farm paid for by the transmission or distribution company. Other offshore wind generators receive connection to the closest land point and have to pay the offshore portion [30]. Other RES generators only have to pay the costs of connection to the lower voltage network, even if the network operator from objective criteria chooses another connection. However, if the generator for some reason wants to be connected at a higher voltage level than the network operator chooses, the generator has to pay the cost difference[11].

In Sweden and Norway there is a similar connection cost scheme, where project developers pay the costs if the upgrade refers to a radial line; while costs are shared between the owner of the production plant and the transmission system operator when the upgrade is done in the meshed grid. Therefore, upgrades that benefit only the owner of the generator are paid by the generator, whereas when upgrades benefit others (mainly in 400 kV) then the transmission system operator pays a part or all costs.

### 3.3.2 Transmission Access

Renewable energy sources have high priority in the power system. However, due to system security and system stability, there can be an upper limit on e.g. how much wind power there can be in the system at a given

[11] Section 67 of the Electricity Supply Act

time. Therefore, in some situations, it can be necessary to (partly) reject contributions from wind power.

Generators have firm access. However, due to system security and stability, there can be an upper limit on how much wind power there can be in the system at a given time. Therefore the system operators have the option to reduce some generators' generation in such "critical situations" and compensate the generators for the missing income.

As an example, in situations with surplus of wind power in Denmark and without possibilities for exporting to other Nordic countries (or Germany), the Danish transmission system operator will ask owners of large off-shore wind farms to reduce their power generation, and the TSO will compensate the owners of the wind farms for missing income.

- ***Denmark***

  It is a national requirement to produce more renewable energy. The infrastructure needed to do this is paid for by the consumer through the PSO tariff or the TUoS and DUoS charges.

  An imaginary box is placed around the windfarm, typically 50 meters or one rotor diameter from the outer turbines. The developer is responsible for construction of and pays for everything inside the box. The utility company is responsible for construction of and pays for everything outside the box. Metering takes place in principle at the box limit. The metering voltage is 10kV. The utility company has an obligation to connect the windfarm without undue delay. In practice the utility often offers to construct the substation on the site and meter at a convenient voltage level and location. The cost of the difference in construction costs and the compensation to the metering as actually used is calculated and negotiated between the parties to the benefit of both.

  The utility has a refusal option. If the utility company can prove that the cost of the grid connection is not economically sound for the society they can appeal to the Electricity Commission and if they give consent refuse to pay for the connection.

  Reinforcements are identified and work commenced at the point RE projects apply for development permits. The TSO usually commences front end work (design and consenting) ahead of the RE project receiving consents but does not commence construction until the RE project is consented. This system is not regulated through laws or Codes, so allows the TSO to decide the timing of delivery. Contracts contain clauses enabling the TSO to cancel the works at any time if the RE project is not going ahead.

  The need for the reinforcement still needs to be proven however. The TSO must demonstrate that there is sufficient need (above 100kV only) and approval must be sought either from the Ministry for Transport and Energy (projects greater than DKK100 million), or the

Danish Energy Agency (projects less than DKK100 million). At present Denmark does not plan reinforcements in any “in anticipation of need” strategic way. However, work on a national development plan for grid development is starting soon and this is likely to take a more strategic viewpoint potentially upgrading grid in anticipation of future needs.

Planning issues for both grid and RE projects have been eased by the identification of strategic RE development areas and a high level of community involvement via ownership schemes of RE projects. Fast tracking of RE project consenting occurs in target regions and this helps ease consenting of grid reinforcements.

Priority dispatch is given to RE (and CHP) over fossil fuel generation when grid capacity is insufficient and the grid is not in danger. In the latter (emergency) cases some constraint can be exercised over RE if absolutely necessary. This has largely been achieved through retro-fit works as much capacity is connected at distribution level with little or no control. When constraint is necessary it is non-RE generation that is constrained first.

### 3.3.3 Transmission Charging

Smaller RE power sources may be subject to some connecting charging to the local distribution company in the area where they are connected. Connection costs related to the connection of larger RE plants that are connected directly to the transmission system, e.g., a new large wind park, are in general covered by the transmission system operator.

In general producers pay a grid tariff for using the transmission network. However, in Denmark for instance, wind turbines and local CHP units that remain subject to purchase obligation are exempt from the grid tariff. The tariffs are settled with the party that holds balance responsibility for the relevant production.

Point-of-connection tariffs apply throughout today’s unified Nordic power system. Different rates apply to feeding power into the grid (delivery) and drawing power from the grid (power take-off). These charges also depend on geographic location within the transmission grid.

- ***Denmark***

  In Denmark, most generators have to pay a grid tariff (per produced kWh). Some 98% of system costs are recovered from demand customers leaving only 2% recovered from generators. UoS charges are however time dependant reflecting system capabilities. The day is divided into three periods: Peak, High load and Low load. The hours of the day that correspond to each period are differentiated between the October-February and the March-September periods.

However, wind turbines and local CHP units (RES or not) that are subject to purchase obligation (from the TSO) are exempt from the grid tariff. The reason for this is that the TSO is obliged to purchase electricity from these generators to a fixed price set by the law. The TSO could choose also to collect the grid tariff from these generators, but then it would have to pay the generators a higher price for their generation, so that the generators still receive the price as set by the law (which is a price that they are guaranteed for their delivery to the grid). For all other generators (RES or not) the grid tariff is collected and it does not differ from one type of generator to another.

- ***Finland***

  Fingrid charges a consumption fee, use of grid fee and connection point fee for the grid service. A market border fee is charged on the basis of the volume of electric energy imported into Finland through cross-border connections excluding electricity imports from a reciprocal common electricity market area.

  The energy-based fees are based on physical measurement data and they are independent of electricity trade between the market parties.

  **Consumption fee:** the consumption of electric energy beyond the connection point between the customer and Fingrid. The consumption fee is specified separately for winter periods (1 November to 31 March) and for other times.

  **Use of grid fee:** the volume of electric energy transmitted through the customer’s connection point, specified separately for output from the grid and for input into the grid.

  **Connection point fee:** each physical connection.

### 3.3.4 Congestion

In addition to the income from grid tariffs, a very important income to the TSO's arise from congestion rents which in case of a bottleneck in the transmission system corresponds to the price difference between the two areas on each side of the bottleneck multiplied by the transmitted amount of electricity. For instance, if there is a bottleneck between Eastern Denmark and Southern Sweden, and the price in Eastern Denmark is 30 EUR/MWh and the price in Southern Sweden is 40 EUR/MWh, and the transmitted amount of electricity (from Denmark to Sweden) is 1,700 MW, the congestion rents (to be shared by the Danish and Swedish transmission system operator) are 17,000 EUR per hour. This amount of money arises because the Danish producers receive the area price in Eastern Denmark which is 30 EUR/MWh and the Swedish consumers pay the area price in Southern Sweden which is 40 EUR/MWh.

There is no direct link between the congestion rents and investments in new transmission lines in the Nordic countries. From a theoretical economic point of view, however, it can be argued that the congestion rents must correspond exactly to the costs of establishing and operating the transmission network (over time). If congestion rents are higher, the transmission system should be reinforced, and opposite, if congestion rents are smaller, there has been over-invested on the transmission side. This, however, is based on an assumption that full competition exists, and that price differences between areas are not influenced by market power or other forms of market failure.

### 3.3.5 Losses

In Finland and Denmark the network operators apply postage stamp pricing for transmission losses (no locational element). In Denmark, these charges only apply to consumers, not generators. Both countries differentiate the charges regarding the period of the transmission of electricity, with the most expensive period in winter weekday daytime.

- Denmark: differentiated postage stamp applied only to consumers
- Finland: differentiated postage stamp applied to customers, uniform postage stamp applied to producers

In Sweden and Norway the management of the losses is different. Both have adopted a system where the losses are charged to every network user according to the time period of the transmission and the marginal loss coefficients. These coefficients are set for injection and withdrawal of electricity at each node and are positive or negative according to the location of the node. In a node where a supplementary injection increases the losses, the marginal loss coefficient is positive for the generator. At the same time, the consumer located at this node will be charged a negative marginal loss coefficient, as his supplementary consumption will reduce the amount of losses.

- Norway: differentiated tariff applied to consumers and producers, based on marginal loss rates at each connection point
- Sweden: differentiated tariff applied to consumers and producers based on marginal loss rates at each connection point

## 3.4 Summary

The note investigates different planning approaches for large-scale integration of renewable energy sources in the Nordic countries. The investigation focuses on factors that influence grid investments due to increasing amount of wind power in Denmark, Sweden and Norway.

The large penetration level of wind power and renewable generation requires an integrated approach for planning and security requirements in distribution and transmission grids. E.g. due to the high level penetration of renewable generation in Denmark the TSO has been adopted strict planning standards / grid codes, proactive procedures and planning tools as well as excessive requirements with regards to ancillary services for wind farms and other distributed energy sources.

The Nordic TSO cooperation points out that that the technical requirements and costs for grid connection depend to a large extend on the penetration levels and the nature and robustness of the existing electrical infrastructure such as the overall composition of generation sources and regional interconnections in the Nordic power system. The Nordic initiatives show an excellent example to overcome barriers in central planning of grid investments and promote enhanced utilization of the Nordic grid and cooperation of different actors in the energy sector.

# ANNEX A – ABBREVIATIONS

| Acronym | Definition |
|---|---|
| ATC | Available Transfer Capacity |
| BC | Baltic Cable |
| BRP | Balance Responsible Parties |
| CEE | Central Eastern Europe |
| CfD | Contract for Difference |
| CHP | Combined Heat and Power |
| $CO_2$ | Carbon Dioxide |
| CWE | Central Western Europe |
| DUoS | Distribution Use of System |
| EC | European Commission |
| Elbas | Electricity market for delivery intra-day |
| Elspot | Electricity market for delivery the next day |
| ETSO | European Transmission System Operators: ETSO is an International Association of TSOs. |
| EU | European Union |
| EWIS | European Wind Integration Study, initiated by the European Transmission System Operators |
| GW | Gigawatt = 1,000,000 kW (unit of power/ capacity) |
| GWh | Gigawatt hour = 1,000,000 kWh (unit of energy) |
| HVDC | High Voltage Direct Current |
| IEA | International Energy Agency |
| IGBT | Insulated-Gate Bipolar Transistor |
| kW | Kilowatt = 1,000 Watts (unit of power/ capacity) |
| kWh | Kilowatt hour = 1,000 Watt hours (unit of energy) |
| MW | Megawatt = 1,000 kW (unit of power/ capacity) |
| MWh | Megawatt hour = 1,000 kWh (unit of energy) |
| NEL | Nordic Energy Link |
| NI | Northern Ireland |
| NTC | Net Transfer Capacity |
| OTC | Over The Counter |
| PCC | Point of Common Coupling |
| PTR | Physical Transmission Rights |

| Acronym | Definition |
|---|---|
| RE | Renewable Energy |
| RES | Renewable Energy Sources |
| RETD | Renewable Energy Technology Deployment |
| SO | System Operator |
| TUoS | Transmission Use of System |
| TSO | Transmission System Operator |
| TWh | Terrawatt Hour = 1,000 MWh (unit of energy) |
| UCTE | Union for the Co-ordination of Transmission of Electricity. The association of transmission system operators in continental Europe. |

# ANNEX B – GLOSSARY

| Term | Definition |
|---|---|
| Bilateral | Trades or other contracts between two participants, for example a generator and supplier. |
| Capacity | Cf. Energy, Power. The maximum ability of a generating station to generate an amount of electricity in a given time. Measured in units of power (kW). The actual energy generated is dependant on the load factor. |
| Clip Size | The minimum size of interconnection capacity contracts. |
| Credit Cover | The cash or other financial security that must be provided. |
| Day Ahead | The day prior to the day that is being traded for or balanced. |
| Deep Connection Costs | Cf. Shallow Connection Costs. The costs of reinforcing and upgrading the wider network to enable additional generation or demand to be connected. |
| Energy | Cf. Power, Capacity. Formally defined as the ability for a system to do work. In the case of an electrical energy this is measured in kWh. Energy cannot be stored in the transmission network, so at any given time the total energy generated must equal the total energy demand and total losses (due to heating of wires etc.) This is known as balancing the system. |
| Gate Closure | The last time at which energy can be traded before the markets are closed. Balancing trades may take place closer to real time on a separate balancing market. |
| Great Britain | England, Scotland and Wales (excludes Northern Ireland) |
| Group Processing | This means that the grid operator puts applicants into a queue and groups them into areas or zones. Reinforcement is then carried out on selected zones to accommodate the applicants in that zone. There is no guaranteed timescale for connection. |
| Intraday | Within the day that is being traded for or balanced. |
| Ireland | The term Ireland refers to the state of Ireland (Eire), which excludes Northern Ireland. Within this document we have usually referred to “the island of Ireland” or “all-island” to include both Eire and Northern Ireland. For clarity, the state of Ireland is referred to as Eire throughout. |
| Load Factor | Also may be known as a capacity factor. The ratio of the actual energy output of a power plant over a period of time and its energy output if it had operated a full capacity of that time period. For example, an onshore wind farm might have a load factor of 30-40%. This means that on average it generates at 35% of its capacity, although at any given time it may be generating anywhere between 0% and 100% of its total capacity. |
| Locational | Cf. Postage Stamp. Differentiated by geographical location. For example, in the case of transmission charging, this typically will mean higher charges further from demand centres. |

| Term | Definition |
|---|---|
| Long | Cf. Short. Where a participant has more generation than is required to balance their demand (including losses where applicable) |
| Main Price | Cf. Reverse Price. The balancing price where a participant is out of balance in the same direction as the market, for example a participant that is "short" when the market is "short". |
| Merit Order | The order that a system operator will place generators in based on the costs to deliver a certain quantity of generation. Those generators that will allow the forecast demand to be met at the lowest costs (subject to system constraints) are described as being in the merit order and are despatched. |
| Postage Stamp | Cf. Locational. Uniform, equal throughout the network. |
| Power | Cf. Energy, Capacity. Power is the ability to create energy in a given time, and can be expressed in the following equation: $Power(kW) = \frac{Energy(kWh)}{Time(h)}$ |
| Price Maker | Cf. Price Taker. In the context of an electricity pool, a price making generator will submit a number of bids/offers indicating how much electricity they would be prepared to despatch at a given price. The system operator will place the generators in order of cost to determine which plants will be despatched. |
| Price Taker | Cf. Price Maker. In the context of an electricity pool, a price taking generator will not submit a bid or will submit a bid at zero. This means it will always be despatched (subject to system constraints) and will receive the pool price. Price taking generators include variable generators with low marginal costs, such as wind. |
| Real Time | The actual time period that energy is being traded for or balanced. |
| Reverse Price | Cf. Main Price. The balancing price where a participant is out of balance in the opposite direction to the market, for example a participant that is "short" when the market is "long". |
| Shallow Connection Costs | Cf. Deep Connection Costs. The costs of physically connecting a generator to the nearest appropriate point in the transmission network, this may typically be the closest substation. This does not include costs associated with any required reinforcements to the wider transmission network. |
| Short | Cf. Long. Where a participant has less generation than is required to balance their demand (including losses where applicable) |
| Supplier | Normally used to describe a retail electricity supplier that sells electricity to final consumers, this can include domestic, commercial and industrial consumers |
| United Kingdom | Includes England, Scotland, Wales and Northern Ireland |
| Vertical Integration | Vertical integration is the degree to which a firm owns its upstream suppliers and its downstream buyers. For example, within the electricity industry this can be used to describe the situation where a parent company owns both an electricity retail supplier and generator. |

# ANNEX C – REFERENCES


| Number | Reference |
|---|---|
| 1 | Nordic Market Report, Nord Pool 2004 |
| 2 | Vattenfall electricity market report 2006 |
| 3 | WILMAR, Description of Power Markets |
| 4 | Energinet.dk (2006): System Plan 2006. Energinet.dk, June 2006 |
| 5 | Energinet.dk (2007a): Handling of notifications and schedules in the Danish electricity market. |
| 6 | Energinet.dk (2007b): Regulation A: Principles for the electricity market. Energinet.dk, January 2007. |
| 7 | Nordel (2006a): Annual statistics 2006. Nordel, 2006 |
| 8 | Nordel (2006b): Status on Nordel's work on Enhancing Efficient Functioning of the Nordic Electricity Market. Nordel, April 2006 |
| 9 | Nordel (2007a): Nordic Grid Code 2007 (Nordic collection of rules. Nordel, 15 January 2007. |
| 10 | Nordel (2007b): Wind power in Nordel - system impact for the year 2008. Nordel, 16 January 2007. |
| 11 | Nord Pool (2006): Trade at Nord Pool's Financial Market. Nord Pool, 30 March 2006. |
| 12 | Swedish Energy Agency (2007): The electricity certificate system, 2007 |
| 13 | Danish Energy Authority (2007): Energistatistik 2006 (Energy Statistics 2006). September 2007. |
| 14 | Rydén Bo et al. (2006): Ten Perspectives on Nordic Energy. Final report for the first phase of the Nordic Energy Perspectives project. Elforsk, September 2006. |
| 15 | Energinet.dk (2007): Anlægsplan 2007. Energinet.dk, 2007 |
| 16 | Deutsches Windenergie-Institute GmbH, Germany, Tech-wise A/S Denmark, DM Energy, United Kingdom: "Wind turbine grid connection and interaction", EC publication ENERGIE, year 2001 |
| 17 | Large scale integration of wind energy in the European power supply, analysis, issues and recommendations, The European Wind Energy Association (EWEA) report, year 2007 |
| 18 | Info from Nordic Transmission System Operators<br>www.energinet.dk,<br>www.fingrid.fi,<br>www.statnett.no<br>www.svenskakraftnät.se. |

| | |
|---|---|
| 19 | Decentralized generation connected to transmission level in Sweden: Affärsværket Svenska Kraftnäts föreskrifter om driftssäkkerhetsteknisk udformning av produktionsanläggninger, Svenska Kraftnät 2002 |
| 20 | Grid code for wind connected to distribution level, Denmark: TF 3.2.6, Wind turbines connected to grids with voltage bellow 100 kV, Energinet.dk 2004 (ELTRA & Elkraft) |
| 21 | Grid code for wind connected to transmission level, Denmark: TF 3.2.5, Wind turbines connected to grids with voltage above 100 kV, Energinet.dk 2005 (ELTRA & Elkraft) |
| 22 | Grid code for connection to distribution level in Sweden: Anslutning av mindre produktionsanläggninger til elnättet, Svensk Energi 2001 |
| 23 | Connection of wind turbines in Norway: Guideline for wind farms >10 MW (Stattnet in cooperation with Sintef), year 2005 |
| 24 | Review of technical options and constraints for integration of distributed generation in the electricity networks, EU project SUSTELNET. |
| 25 | Connection of wind turbines in NorwayRetningslinjeer for nettilkobling af vindkraftverk, Sintef 2001 |
| 26 | http://www.eonnetz-eltra-auctions.org/ |
| 27 | http://www.balticcable.com |
| 28 | http://www.swepollink.se |
| 29 | Grid Development Plan 2005-2020, Statnett, June 2005 |
| 30 | Wind Turbines Order (No 1365 of 15/12/2004) |