System Plan 2007

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1. Introduction

Business orientation, development, respect and cooperation are core values for Energinet.dk. These values are reflected in all aspects of Energinet.dk's daily work and long-term planning.

The realisation of the ambitious objectives in the field of environment and energy calls for close cooperation and optimum interaction between the many innovative competencies in the sector.

Environment and energy considerations are high-priority areas, internationally as well as in Denmark. In System Plan 2007 we focus on the Danish government's ambitious objectives in the environment and energy field. We analyse, assess and draw up an initial proposal for the means and instruments required to ensure the practical operation of the future energy system when the long-term objectives for environmental improvements, renewable energy integration and a continued high level of security of supply are going to be implemented in a responsible manner from a socio-economic point of view.

This is a huge task that will comprise the entire energy sector and not merely our own pipelines and cables. It is necessary to establish a closer coupling with both the heat and transport sectors. Authorities, researchers, industry and other business partners in the energy chain – from production to consumption – have to be involved to make it possible for Denmark to realise the vision of an energy system based on renewable energy. With System Plan 2007, we endeavour to take yet another of many steps in that direction.

Energinet.dk is facing several large-scale construction projects in both the electricity and gas areas. New offshore wind projects and other environmentally-friendly types of energy necessitate the reinforcement and expansion of the electricity system. Security of supply and market development are strengthened by higher-capacity international connections and alternative gas supply routes to Denmark. Energinet.dk is responsible for securing Denmark the required electricity and gas infrastructure in the short and long term.

We are confident that the best and most sustainable solutions are found through open and broad dialogue – which implies, in our view, that all technical, environmental and economic aspects are presented for debate. System Plan 2007 points out that the achievement of optimum and sustainable energy solutions calls for the cooperation and involvement of other players and sectors in the planning process. We look forward to accomplishing the task.

President and CEO

2. Conclusions and focus areas

Seen in the light of the international climate debate and the Danish government's objective of continued integration of large volumes of renewable energy and the development of well-functioning markets for electricity and gas up to 2025, the importance of long-term and coherent planning is evident. Energinet.dk is responsible for developing the infrastructure to make it sufficient, robust and flexible and, therefore, capable of meeting the energy and environment policy objectives – nationally as well as internationally.

Energinet.dk's system planning focuses on the balance between concerns for security of supply and emergency management planning, the environment and sustainability as well as market and economic efficiency. System Plan 2007 therefore also summarises Energinet.dk's activities in the areas of security of supply and emergency management planning, transmission, market, the environment and research and development.

In this year's plan, Energinet.dk has chosen to go into three themes in detail:

- Analyses of "A visionary Danish energy policy 2025"
- Power balances over the next decade
- Two gas infrastructure projects – Skanled and LNG

The System Plan paints a picture of the principal activities and focus areas to which Energinet.dk will direct attention during the next year or so. Some of the activities are assumed to be undertaken in interaction with other players and sectors and must be seen in an international context.

2.1 Electricity system

Analyses of the Danish government's long-term energy policy from January 2007 point to various challenges for the electricity system in regard to system balancing and the development of a robust electricity transmission grid.

In addition, the ongoing analysis of cables and overhead lines may appear to change the planning basis for the electricity transmission grid towards a higher degree of cabling and, in that way, change the cost structure of new installations significantly.

Energinet.dk's system and grid planning task is to identify solutions that enable the electricity system to handle the combined amount of challenges. The solution is a combination of means, and a part of the task is to determine the necessary and economically optimum combination of means.

Energinet.dk will explore:
- the individual means in greater detail and establish the steps necessary for using such means. This will be done through the integration of the electricity, gas, heat and transport sectors;
- possibilities of combining means, including steps to regulate wind turbine electricity generation, expand the transmission grid, use heat pumps, electric boilers, alternative connecting points and wind farm locations, demand response, electric cars, etc.

Energinet.dk is responsible for the security of electricity supply and in that connection focuses particular attention on the power balance over the next decade, seen in the light of the ageing portfolio of power stations and the growing volume of wind power.

Energinet.dk will:
- analyse potential power balance problems, secure favourable framework conditions for initiatives on the supply and demand sides and assess how foreign production capacity can be included in the power balance;
- contribute to the Danish Energy Authority's work to ensure access to suitable power station sites and investigate whether other factors prevent new players from investing in new power stations.

As part of Energinet.dk's responsibility for ensuring the security of supply in the long term, it is necessary to set a quantified target for the security of supply so that it can be maintained on the basis of socio-economic optimisation of the level of security of supply and of the means available.

Energinet.dk will:
- renew its focus on efforts to quantify the security of supply.

Until March 2008, an Electricity Infrastructure Committee set up by the Danish Minister for Transport and Energy in the summer of 2007 will be drawing up a technical report on the future expansion and cabling of the Danish electricity system. The report will provide the basis for subsequent political negotiations and decisions on the expansion of the electricity system.

Energinet.dk chairs the committee and serves as its secretariat, contributing analyses of:

- the need for expanding the electricity system;
- alternative expansion strategies and
- the consequences of a range of alternative expansion models in regard to the environment and landscape, security of supply, the proper functioning of the electricity market and economics.

Effective competition in the electricity market – nationally as well as internationally – is still a key priority for Energinet.dk. Since the market liberalisation, considerable movements have been observed in the end-user market, particularly among the large customers. Today, we also see a growing trend for household customers to exercise the option of choosing a new electricity supplier. The ambition of the Nordic energy authorities is to lay down the framework for a common Nordic end-user market.

Energinet.dk will continue to:
- contribute to the Danish Energy Authority's work to examine the perspectives of creating a data hub to serve as a link to retail market data.

The European Commission's sector inquiry of January 2007 into competition in the electricity and gas sectors confirms the need to take a number of new steps with a view to creating well-functioning energy markets across Europe.

Energinet.dk strives to:
- create a closer link between the Nordic and the German markets by setting up market coupling between the Nord Pool Spot and EEX power exchanges. Initially, market coupling will comprise the daily capacity on the Danish-German border and the Kontek Link;
- establish Intraday trading between Jutland and Germany.

A daily market for buying ancillary services has been introduced. Experience shows that resources not previously available to the system have been activated and that the price relates to the price obtainable in the spot market.

Energinet.dk will:
- investigate the possibilities for cross-border trading with ancillary services in order to meet some of the demand for ancillary services from foreign suppliers and to offer Danish suppliers new market potential.

2.2 Gas system

Within a foreseeable future, Danish natural gas production is expected to be unable to meet the demand for natural gas in Denmark. Gas production in the Danish gas fields in the North Sea will not continue at the present level of about 9 billion m^3 per year for more than five to ten years. New natural gas supply routes to Denmark are therefore needed. At the same time, attention is focused on efforts to further develop the gas market, for instance by ensuring access for more players.

Energinet.dk analyses various possibilities of a new gas infrastructure that supports the objectives of security of supply and a well-functioning gas market. The Skanled project (a gas pipeline connecting Norway, Sweden and Denmark), the Baltic Pipe project between Poland and Denmark and the possibility of increasing capacity on the Danish-German border (at Ellund) are examples of projects included in the analyses.

Energinet.dk will continue to:
- analyse a number of specific, alternative gas supply routes with a view to choosing the connection(s) that is/are most suitable for Denmark;
- prepare for the possible realisation of Skanled, including submitting proposals for possible routings in Denmark. This is done in cooperation with the environmental authorities and the affected local authorities.

Effective competition in the gas market is a primary focal point for Energinet.dk. The work involved in establishing a Danish gas exchange will be another key priority for Energinet.dk in the years to come. Energinet.dk wants to be at the forefront of this area, which is expected to be of vital importance to future gas trading and which offers unique opportunities for creating greater transparency.

Energinet.dk will:
- contribute to the continued development of market mechanisms, including the continued harmonisation of rules and procedures, bilaterally as well as internationally;
- establish a gas exchange together with Nord Pool Spot in March 2008, initially covering the Danish market.

2.3 National and international energy markets

The EU is expected to make a steadily growing impact on the development of the rules, regulations and terms of the European market – not least in view of the European Commission's third liberalisation package, which prepares the ground for more formalised and binding cooperation between the European TSOs for electricity and gas, respectively. Energinet.dk will be well prepared to meet these challenges, which also open up opportunities for turning the development in a market-friendly direction.

Energinet.dk will:
- contribute actively to developing the European electricity and gas market through the new European cooperation forums and the European Network for TSOs for electricity and gas, respectively.

2.4 Research and development

By conducting own research and development activities and administering R&D programmes, Energinet.dk contributes to ensuring a robust and environmentally friendly electricity and gas system in the short and long term.

Energinet.dk has launched a range of initiatives, including:
- the EcoGrid project aimed at developing new, long-term technologies and market solutions for the electricity system of the future;
- surveys into the interaction between alternating current cables and other grid components, including the technical possibilities for increasing the use of 400 kV cables over long stretches of land. For instance, two PhD projects have been initiated.

3. National and international framework

The framework conditions within which Energinet.dk operates change continuously, both nationally and internationally. At the national level, the Danish government published its proposal for a long-term energy policy entitled "A visionary Danish energy policy 2025" in January 2007. On 1 January 2007, the Local Government Reform took effect, involving the establishment of seven regional environmental centres, which will in future consider approvals for infrastructure projects under the Danish Planning Act.

At the international level, the European Commission presented its vision for an energy strategy in January 2007, which was followed by a proposal for the third liberalisation package in September 2007.

3.1 National framework

3.1.1 The government's long-term energy policy, 2025

With "A visionary Danish energy policy 2025", the Danish government's vision is that Denmark should in the long term end its reliance on fossil fuels and instead use renewable energy. The government's objective is, up to 2025, to reduce the use of fossil fuels by at least 15% from the current level and effectively counteract increases in total energy consumption. Section 4 takes a closer look at the consequences for the electricity system.

The government's proposal for a long-term energy policy is being discussed with the political parties represented in the Danish Parliament to conclude a broadly based political agreement.

3.1.2 Local Government Reform 2007 and new environmental centres

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.

In connection with new cable installations, however, it is generally the individual local authority that is responsible for providing the necessary decision basis – unless the cable installations involve more than two local authority areas. The same applies to gas infrastructure projects affecting more than two local authorities.

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.

3.1.3 Gas storage facility

On 1 May 2007, Energinet.dk took over the gas storage facility in Lille Torup from DONG Energy. The European Commission made its approval of the merger between DONG and Elsam conditional on the disposal of the storage facility. As a result of a Danish political request to maintain public ownership of the gas storage facilities, Energinet.dk acquired the Lille Torup gas storage facility for DKK 2 billion and set up an independent company, Energinet.dk Gas Storage.

3.2 International framework

3.2.1 European Commission's energy strategy proposal

The European Commission's energy strategy proposal is the first result of the decision made in 2005 by the European Heads of State and Government to ensure a higher degree of coordination between the EU member states' national energy policies. The proposal contains three priority areas:

1. The EU should cut its greenhouse gas emissions to 20% below 1990 levels by 2020 (30% if a global climate agreement is concluded) by:
   - raising the share of renewable energy to 20% by 2020;
   - reducing total energy consumption by 20% by 2020;
   - increasing the level of biofuels in the transport sector to 10% by 2020;
   - working to capture and store carbon dioxide from coal-fired power stations.

2. Competition in the EU's internal energy market should be improved by strengthening:
   - the unbundling of production and distribution activities from transmission grid operation in the energy sector;
   - the national competition authorities and, if needed, establishing a joint Council of European Energy Regulators;
   - cooperation between the EU member states' transmission system operators (TSOs) for electricity and gas, respectively,

3. European security of supply should be strengthened by:
   - developing a solidarity mechanism to ensure the security of supply, including strategic gas storage facilities;
   - interconnecting all European member states in a joint European electricity and gas grid and diversifying EU energy supply sources through the prioritisation of strategic electricity and gas infrastructure projects;
   - monitoring the EU's energy security situation through a European energy monitoring centre;
   - setting up a joint European energy foreign policy in relation to important supplier countries and other major importers of energy;
   - increasing research efforts within new energy technologies.

3.2.2 European Commission's third liberalisation package

In September 2007, the European Commission presented its third liberalisation package, ie the third package of amendments to directives and legislative proposals aimed at providing the framework for the internal electricity and gas markets in the EU.

The proposals mainly build on the findings of the European Commission's Energy Sector Inquiry, which analysed the competition in the European electricity and gas market. The final results of the inquiry were submitted in January 2007. It was critical of the current situation in the European electricity and gas market and concluded that a range of barriers to free and fair competition still exist.

The European Commission proposes a directive for electricity and gas, respectively, with a view to achieving increased and more effective separation ("unbundling") of production and trading activities from the infrastructure. The directives present two models, ie ownership unbundling, which is the preferred option, and an alternative option known as the ISO (Independent System Operator) model, which would be an exception to the directive. With the ISO model, the integrated company retains ownership of the transmission grid. On the other hand, the actual TSO tasks must be transferred to an independent system operator (ISO) where the vertically integrated company is not allowed any ownership interest. Decisions to invest in a new transmission grid must be made by the ISO.

Three regulations set the stage for increased and more committing cooperation at the European level for electricity and gas TSOs as well as for regulators. It recommends that the TSOs assume a statutory role in relation to the development of common rules and standards that can be made legally binding on the parties. They should also be responsible for drawing up investment plans for the European infrastructure. The new cooperation forums will probably be based on existing cooperation structures, but have been designated ENTSO (European Network for Transmission System Operators) by the European Commission – for electricity and gas, respectively. The work undertaken by TSOs is subject to approval by the European regulators and the European Commission, which are also entitled to present legislative proposals if work progresses too slowly or the proposals from ENTSO seem inadequate.

The European regulators' co-operation must be improved through the establishment of the new organisation ACER (Agency for the Cooperation of Energy Regulators), which will be based partly on the existing cooperation of the present organisation, ERGEG. The cooperation aims at improving the regulators' possibility of making joint and uniform decisions on transnational issues, particularly in relation to investment decisions. Moreover, they will to a certain extent be responsible for monitoring that the national regulators' work benefits the development of the internal market and does not serve national interests. Finally, the regulators must approve proposals for rules and investment plans from ENTSO.

The package of directives also advocates greater independence and the delegation of more powers to the national regulators. They must attain a higher degree of independence from commercial and political interests and take steps to ensure compliance with EU legislation.

The new legislative package will mean that the work at European level in relation to the development of rules, regulations and terms will be very important to Energinet.dk in the future – especially in view of the possibility that ENTSO's decisions may be made binding on the TSOs.

4. Analyses of "A visionary Danish energy policy 2025"

Energinet.dk is responsible for developing the electricity and gas systems to ensure that they always meet the energy and environment policy objectives. In January 2007, the Danish government presented its long-term energy policy: "A visionary Danish energy policy 2025". The proposed package sets various targets and objectives, which should be seen as the first step towards realising the government's long-term vision of making Denmark independent of fossil fuels.

The targets and objectives for 2025 include
- reducing the use of fossil fuels by at least 15% from the current level;
- implementing efforts to rein in total energy consumption;
- implementing annual energy savings of 1.25% against a scenario without energy savings initiatives;
- increasing the share of renewable energy to at least 30% of energy consumption;
- strengthening action in research, development and demonstration of new energy technologies, and
- increasing the use of biofuels in the transport sector to 10%.

This theme analyses the challenges which the electricity system will be facing as a result of the realisation of the targets and objectives. More specifically, it analyses how a realisation of the government's policy package will affect the energy and power balance, the electricity transmission grid, fuel consumption and the environment. The analyses are mainly rooted in the challenges posed by the government's proposal to the electricity system when large volumes of wind power (up to 50% of electricity consumption) must be integrated. The present electricity system is not designed to handle wind power volumes of this magnitude.

The theme presents at an overall level the findings of the analyses for 2025. More detailed analytical findings and assumptions can be seen in Appendix 1.

4.1 Analysis assumptions

The analyses have been drawn up on the basis of the Danish Energy Authority's assumptions from January 2007 entitled "Base projection to the CO_2 allocation plan for 2008-2012 and the government's energy strategy: A visionary Danish energy policy 2025". These have, to the extent necessary, been supplemented with assumptions and preconditions as specified by Energinet.dk. They are outlined below.

The government's objective for the period up to 2025 is to achieve annual energy savings in end consumption of 1.25% against a scenario without energy savings initiatives. Even with strengthened electricity savings initiatives, the consequences of these assumptions will be an increase in electricity consumption from 35 TWh in 2005 to 38 TWh in 2025.

In 2025, electricity generation capacity will be distributed as follows: about 4,100 MW from central power stations, 2,300 MW from local CHP plants and 6,500 MW from wind power stations. During this period, onshore wind power capacity will increase by 1,000 MW to a total of 4,000 MW in 2025. The new land-based wind turbines will be distributed across Denmark in the same way as the existing ones. Similarly, the construction of new offshore wind turbines will boost offshore capacity to a total of 2,500 MW. The expansion has been prioritised as described in "Future offshore wind turbine locations – 2025" of April 2007.

Table 4.1: Assumptions concerning new interconnections according to alternatives 0 and 1, respectively.

		Alternative 0	Alternative 1
Great Belt		600 MW	1,200 MW
Germany-Western Denmark	Imports:	950 MW	2,500 MW
	Exports:	1,500 MW	2,500 MW
Norway -Western Denmark		1,000 MW	1,600 MW

4.1.1 Interconnections

Two alternatives are being investigated:

Alternative 0 comprises the existing electricity transmission grid, including the present interconnections with neighbouring areas and the already decided Great Belt Power Link 1. The purpose of including this alternative in the analyses is to investigate and document how the existing electricity transmission grid would be affected by the demands which the realisation of "A visionary Danish energy policy 2025" will place on the grid.

Alternative 1 comprises not only existing and decided interconnections, but also the establishment of Great Belt Power Link 2 (600 MW assumed in operation by 2018) and Skagerak 4 between Jutland and Norway (600 MW assumed in operation from 2013). In addition, the interconnection between Germany and Jutland will be upgraded to 2,000 MW by 2015 and to a total of 2,500 MW in both directions by 2025.

Alternative 1 is one of several opportunities for interconnection expansion. Skagerrak 4 is one of Nordel's priority cross-sections, and the expansion of the interconnection between Jutland and Germany is among the EU's priority TEN projects (Trans-European Network). An additional expansion of the Great Belt Power Link is at this point deemed to be realistic before 2025 as it will support the domestic use of renewable energy and the security of supply within the Danish borders.

Critical electricity surplus
Critical electricity surplus means the surplus electricity generation which cannot be sold in a particular area and which cannot be exported from the area.

Critical electricity surplus is a calculation concept that will never be used in practice as electricity generation must at all times equal electricity consumption, including any net exports. In case of a critical electricity surplus, generation therefore has to be reduced.

4.2 Challenges for the electricity system

4.2.1 Energy balance

The balance of the electricity system between production, consumption and exchanges with other countries must be maintained under all operating conditions, and the resulting energy balance is therefore assessed for the two alternatives. In alternative 0 wind turbine expansion thus results in a significant critical electricity surplus and, consequently, system imbalance, which must be compensated for using other means. On the other hand, alternative 1 – with the stronger interconnections – makes it possible to maintain system balance to a much higher degree. A more detailed description is found in Appendix 1.

4.2.2 Fuel consumption and emissions

For both alternatives, the consumption of fossil fuels in the electricity and CHP sector is practically at the same level as in 2005. In view of the present assumptions, the electricity and CHP sector will therefore not contribute noticeably to meeting the government's target of reducing Denmark's fossil fuel consumption by 15% by 2025.

As the fuel mix will not change significantly from 2005 to 2025, emissions will not change decisively either.

The reason why national emissions and fossil fuel consumption do not fall in spite of the massive wind power expansion is partly an increase in electricity consumption and partly growing exports. Assuming a CO_2 allowance price of DKK 150 per tonne in 2025, renovated Danish coal-fired power stations with high efficiency ratios will be competitive in the international electricity market.

Denmark is an integral part of the European electricity market, and the environmental impact of the Danish renewable energy expansion therefore cannot be measured for Denmark alone. A measurement must necessarily also include the reduced emissions from displaced production in the importing country. All other things being equal, growth in Danish renewable energy generation will primarily displace electricity generation based on fossil fuels in the integrated market area.

It should be noted that CO_2 emissions per unit produced in Denmark will decline

Reserves
Risk of outages of production units and interconnections and uncertainty of consumption and wind power forecasts involve a need for upward and downward regulation reserves, which can at all times be activated by TSOs to balance the system.

Regulating power
Regulating power is the actual upward and downward regulation service activated by the order of TSOs.

from 500 g/kWh in 2005 to 420 g/kWh in 2025, which can primarily be ascribed to the increase in wind power production from 6.7 TWh in 2005 to 20.2 TWh in 2025.

4.2.3 Balancing the electricity system

The electricity system requires a constant accurate balance between production and consumption. It is therefore necessary to always have reserve capacity available that can provide the required regulating power at short notice. The growing share of wind power increases the need for reserve capacity, which is necessary to ensure that it is always possible to balance the entire system.

Today, regulating power is supplied from central and local production plants in Denmark and from abroad. In 2025, wind power electricity generation will exceed domestic demand for many hours. The function of the thermal generation facilities will change from basic and medium load production to peak load production and to regulating power and exports. The future need for new thermal plants will therefore comprise quickly regulating units with relatively few operating hours a year.

4.2.4 Consequences for the power balance

The assumption of about 6,500 MW of wind power in 2025 implies that a significant part of the present business basis for central and local CHP plants is taken over by wind turbines. This may mean that some of these generating facilities will no longer be profitable in their present form and, in consequence, will be scrapped.

In 2025, under the given assumptions, there will be a conventional production capacity (coal, gas, biomass) of about 6,400 MW and a maximum consumption of about 7,200 MW, corresponding to a 10-year winter. Maximum consumption can therefore no longer be covered by conventional domestic facilities, and some of the capacity will have to come from wind turbines or other countries.

4.2.5 Electricity transmission grid in year 2025

In the period up to 2025, two factors will have a massive impact on the development of the electricity transmission grid; grid connection of offshore wind farms and exchanges with neighbouring areas.

Without grid reinforcement measures, capacity transports will result in overloads of the 150 kV grid in Western Jutland and the 400 kV grid in Central and Eastern Jutland. The 400 kV grid in Central Jutland in particular will be severely affected. The same applies to the 132 kV grid and the 400 kV grid in Southern and Northern Zealand, respectively.

The general picture is that wind power is the primary cause of overloads in the east-westbound direction. In the north-southbound direction it is, besides wind power, also the capacity exchanges through the interconnections to the neighbouring countries that cause grid overloads.

Analyses of alternatives 0 and 1 emphasise the need for new infrastructure. Where and to what extent an expansion of the domestic transmission grid will be needed depends on the alternative chosen. Alternative 1 will, with the increased capacity on the interconnections, create a greater need for reinforcement than alternative 0. Even today, the possibilities of exchanging energy with neighbouring countries are at the core of reliable operations and a well-functioning market. This trend will grow with a larger share of wind power.

A more detailed description of the challenges is found in Appendix 1.

4.3 Means to meet the challenges

As can be seen from the previous section, a realisation of "A visionary Danish energy policy 2025", combined with an expansion of the interconnections, will present the system with a number of challenges in regard to the energy and power balance, grid overloads and an increased need for ancillary services.

Below follows a presentation of the means that should be taken into account in planning decisions in order to find potential solutions to the challenges at hand.

It has been important for Energinet.dk to look at a broad spectrum of means. In other words: means that can contribute individually to addressing the challenges, whether or not they also involve other sectors and areas than those for which the TSOs are directly responsible.

The means are described with the primary focus being on their technical possibilities of contributing to achieving balance in the electricity system. In connection with System Plan 2007, no socioeconomic or financial analyses of the profitability of the means for the players have been undertaken. Moreover, the stability of the electricity grid remains to be analysed. Further steps to look into these aspects will be taken in the system and grid planning stage.

Basically, the potential means can be classified into the categories of production, transmission and consumption, and it is beyond doubt that the optimum combination includes means from all three categories. The electricity market rules are of decisive importance to the utilisation of the electricity system, and a market-related means, such as the establishment of more price areas, may be considered if necessary.

Electricity generation side
- Regulation of wind turbine generation
- Geographical spread of offshore wind farms
- Mobilisation of reserves, regulating resources and new types of facilities.

Ancillary services
'Ancillary services' is the joint name for various services to which TSOs require access in the operating phase in order to maintain the safe and stable operation of the electricity system.

Electricity transmission side
- Relocation of the grid connection point for offshore wind farms
- Increased grid transmission capacity, eg by using high-temperature conductors
- Reinforcement and expansion of the domestic grid.

Electricity consumption side
- Connection to the heating system – electric boilers and heat pumps
- Electric cars and hybrid cars as demand response
- Additional demand response
- Electricity storage: Hydrogen, Compressed Air Energy Storage, battery.

4.4 Description of individual means

4.4.1 Electricity generation side

Regulation of wind power production
A simple means of balancing the system and reducing the grid load can be provided by the downward regulation of wind power production in periods of substantial wind power production.

During normal operating conditions, the potential wind power production naturally has to be fully utilised, but during short periods of extreme wind power production, high grid load and very low prices, a reduction in wind power production can be the economically most attractive means of achieving system balance or reducing the grid load. A reduction in wind power production also makes it possible to use the wind turbines for providing both upward and downward regulation.

Naturally, the downward regulation of wind power is only allowed when other means of achieving system balance or reducing the grid load involve costs that exceed the value of the lost electricity generation from the wind turbines.

Geographical spread of offshore wind farms
The analyses are based on the offshore wind farms being located as described in the report "Future offshore wind turbine locations – 2025" prepared by the Danish Energy Authority's committee for future offshore wind turbine locations 2007. However, the locations described showed a modest financial difference, and there was some uncertainty as to the correlation between water depth and costs of foundations.

Locations in the North Sea are optimum in terms of wind, but a high concentration of offshore wind farms here would create grid overloads. Geographically more diverse locations in the North Sea and/or the Baltic Sea would result in the fronts hitting the wind turbines at different times, thus reducing the need for regulation.

For instance, Kriegers Flak in the Baltic Sea may be a possible alternative location which also allows for the upgrading of interconnections between Nordel and the continent for the benefit of both the international electricity market and the security of supply on Zealand and in Southern Sweden.

Locating offshore wind turbines at Kriegers Flak will obviously reduce the load on the Jutland transmission grid but will create a need for reinforcement of the Zealand transmission grid.

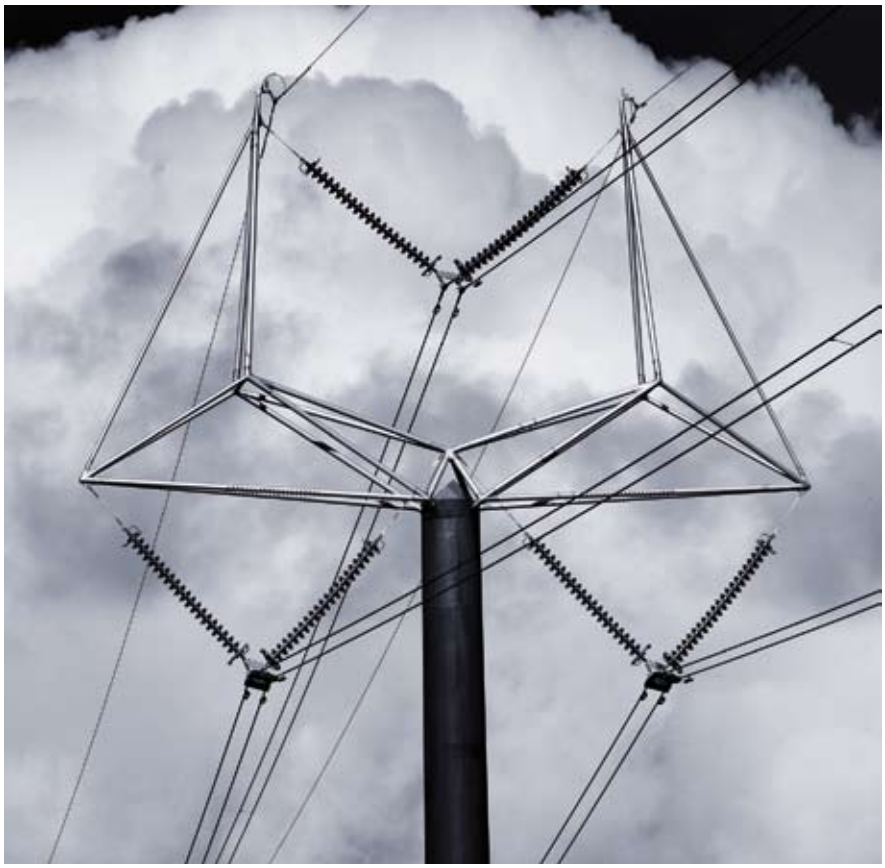
Mobilisation of reserves, regulating resources and new types of facilities
The large share of wind power calls for production facilities with good power regulating capabilities. This includes facilities that, for instance, are characterised by low standby and start-up costs, short starting times, high upward and

downward regulation gradient and low minimum production.

Energinet.dk is working to create good framework conditions for establishing new facilities with these properties on market terms.

The possibility of furnishing reactive reserves independently of the central production facilities in the future will also be explored. In this connection, the different value of the ancillary services is assessed at transmission level and lower voltage levels. How this should be reflected in future schemes is also assessed.

If central power station units will not always be on standby in the future, it must be possible to make a black start of the system without these units. The development of the concept to apply distributed production from black start is a central theme in Energinet.dk's current Cell Project (described in detail in section 13 on research and development).



4.4.2 Electricity transmission side

Relocating the grid connection point for offshore wind farms

The analyses presuppose five new 200 MW offshore wind farms at Horns Rev, engendering a very concentrated power infeed in the Endrup grid connection point at Esbjerg. The impact of the offshore wind farms on grid overloads can be limited by, for instance, allocating this power so that not all five offshore wind farms are connected at Endrup.

The effect of allocating power infeed from the offshore wind farms has been investigated. Two 200 MW offshore wind farms are assumed to be connected in Endrup, while three 200 MW offshore wind farms are assumed to be connected in Landerupgård at Kolding. The studies show that a more diversified power infeed from the offshore wind turbines at Horns Rev under alternative 0 has a load-reducing effect on the electricity transmission grid. Indeed, this enables the offshore wind turbine power to be led direct to the 400 kV grid in Eastern Jutland and on to Zealand via the Great Belt Power Link. This reduces the frequency as well as the degree of overload of the 400 kV grid in Central Jutland and to some extent the 150 kV grid in Western Jutland. Alternative 1 still entails a risk of considerable grid overload which, under the given assumptions, will require an expansion of the electricity transmission grid.

Connection of up to 1,200 MW wind power at the Endrup 400 kV substation will create a need for connecting the substation to a 400 kV ring structure. If this ring structure is not established, outage of the Endrup substation's present 400 kV radial structure will mean that the current amount of momentary reserves increases. In case of an outage involving a total production of 1,200 MW, it would be necessary to momentarily import this volume via the interconnections between Germany and Jutland. Such a considerable power reserve - approximately twice as large as today – is considered both technically and economically unacceptable. Relocating the grid connection point for three of the offshore wind farms would solve this problem.

One possibility of connecting some of the offshore wind farms is to use the direct current technology HVDC VSC (Voltage Source Converters) by laying a cable all the way from the offshore wind farms across Jutland to Landerupgaard. The only thing that remains is to assess whether this is technically and economically expedient. As regards the offshore section in particular, there is only limited experience with the HVDC VSC direct current technology.

High-temperature conductors

Upgrading existing overhead lines by adding high-temperature conductors makes it possible to transmit large volumes of power. High-temperature conductors are thus one way of eliminating moderate overloads on overhead lines. Improved power transmission through the upgrading of existing overhead lines

as an alternative to grid expansions entails a major transmission loss, which has both economical and environmental consequences. Together with the regional transmission company N1 A/S, Energinet.dk has upgraded the 150 kV connection between Tange and Trige to gain experience in using high-temperature conductors, which are only used to a limited extent internationally.

Reinforcement and expansion of the domestic grid
Electricity grid overloads can of course be countered by expanding the electricity transmission grid.

One way of eliminating overloads in the north-southbound direction under alternative 1 (see Table 4.1) involves expanding the system with a third 400 kV connection in Jutland. There will also be a need for reinforcement of the east-westbound direction. Southern Zealand will require reinforcement of the 132 kV grid, and SEAS-NVE and Energinet.dk have started the preparations.

The structure and principles for establishing the future electricity transmission system is currently the subject of debate. There is a political desire to study the technical possibilities of increasing the use of underground cables rather than using traditional overhead lines and towers. This is described in detail in section 6 on electricity transmission.

4.4.3 Electricity consumption side

Electricity can be converted into heat using electric boilers and heat pumps. At times when bound electricity generation exceeds demand because of excess wind power, it may be attractive to convert electricity into heat. In this situation, the price of electricity is traditionally low, and households as well as district heating companies may benefit from heat pumps or electric boilers. Environmental gains might be achieved if the consumption of, for example, oil or natural gas is simultaneously reduced.

Plug-in hybrid cars
Plug-in hybrid cars are cars that run on electricity as well as petrol/diesel, and which can be recharged from the grid. Electricity is used for the larger part of daily travel requirements. Today, longer distances are usually travelled using the combustion engine.

Household heat pumps: "A visionary Danish energy policy 2025" assumes that 100,000 heat pumps will be installed in Danish households; primarily households in areas with no district heating or natural gas supply. The heat pumps can contribute to balancing the electricity system in times when the wind power share is high and to reducing grid load if they are installed in areas of surplus electricity.

In Western and Southern Jutland in particular there is an estimated potential for household heat pumps of close to 500 MW in installed capacity. The proliferation of heat pumps is linked to the regular price of electricity as periods of very low prices are not sufficient to increase their popularity.

Heat pumps and electric boilers in areas with district heating: In December 2005, the Danish Parliament adjusted the electricity tax allowing CHP plants to apply electric boilers or heat pumps for district heat production.

By way of an example, calculations have been made for heat pumps in CHP plants in South-West Jutland, ie in Esbjerg, Holstebro and a number of local CHP areas. A conservative estimate indicates that the maximum electricity demand will be 125 MW, whereby the critical electricity surplus is reduced by approx. 60 GWh. A similar example involving electric boilers in the same area shows that the maximum demand would be 380 MW, while the critical electricity surplus would be reduced by approx. 170 GWh. In this example, thermal production is increased by 185 GWh.

Electric boilers and heat pumps can also be used for ancillary services and as reserves in the electricity market. Still, this requires communication between Energinet.dk and electricity customers through a balance responsible party for production. Energinet.dk has launched several development projects to identify the technical possibilities and economic potential.

Electric cars and hybrid cars as demand response
Increased use of electric and hybrid cars offers the opportunity of utilising the battery capacity of the cars. By controlling the charging of hybrid cars, significant flexibility can be mobilised which is valuable to the operation of the electricity system and its ability to integrate fluctuating electricity generation. Hybrid cars are available already, whereas long-range electric cars are still a fairly expensive technology.

A conservative estimate indicates a total potential charge effect to the tune of 2,500 MW nationwide. This estimate is based on the assumption that in 2025 one third of the cars weighing less than two tons are electric cars and that the charging process takes place during the three hours (typically at night) when prices are lowest. Electric and hybrid cars will only have a positive impact on grid overload in the local areas where they are being charged.

As for the impact on ancillary services, there is a difference between electric and hybrid cars. Electric cars will cause an increase in the consumption of electricity, which must also be covered in calm weather. Hybrid cars have a built-in reserve in the form of a combustion engine.

The combination of large-scale wind power expansion in Denmark and the increased use of electric cars hold a significant potential for social synergy. On the one hand, balancing and reserve benefits are achieved in the electric system, and on the other hand it will be possible to solve some of the serious environmental problems of the transport sector (reduction of CO_2 emission, particles, air

pollution, etc.). To this must be added the option of further railway electrification.

Additional demand response
Today, the consumption of large and small-scale electricity customers is very inflexible. Given the increase in the volume of unplanned wind power and the demand for balanced electricity generation and consumption, demand response is the perfect opportunity. If electricity consumption can be moved from hours with heavy loads and high prices to hours with light loads and low prices, customers as well as the TSO will benefit. Appliances for cooling, heating, ventilation, washing and drying are examples of consumption which may be moved without any loss of comfort.

Response demand requires the installation of new electricity meters offering digital communication and hourly consumption registration. Several grid companies are currently replacing electricity meters. At year-end 2008, SYD ENERGI Net A/S will have replaced all electricity meters in Southern Jutland with new meters thus opening up for using demand response in the region. Energinet.dk supports a development project where daily energy forecasts for Southern Jutland will make it possible for customers to move electricity consumption to hours when prices are low.

Nordel has estimated that the Danish potential for demand response is approx. 8% of the total electricity system peak load. At the time of writing, less than 1% of Danish electricity consumption falls under the category of demand response and it includes only selected corporate customers. Large-scale demand response requires an analysis of the electricity system and preferably that electricity is consumed close to, for example, the location where variable wind power is produced.

In 2007, Energinet.dk is involved in nine research and development projects aimed at implementing demand response. In Norway, Sweden and Finland the issue is being targeted as well; in the US, Italy and other countries, demand response is used with the aim of preventing a breakdown of the electricity system.

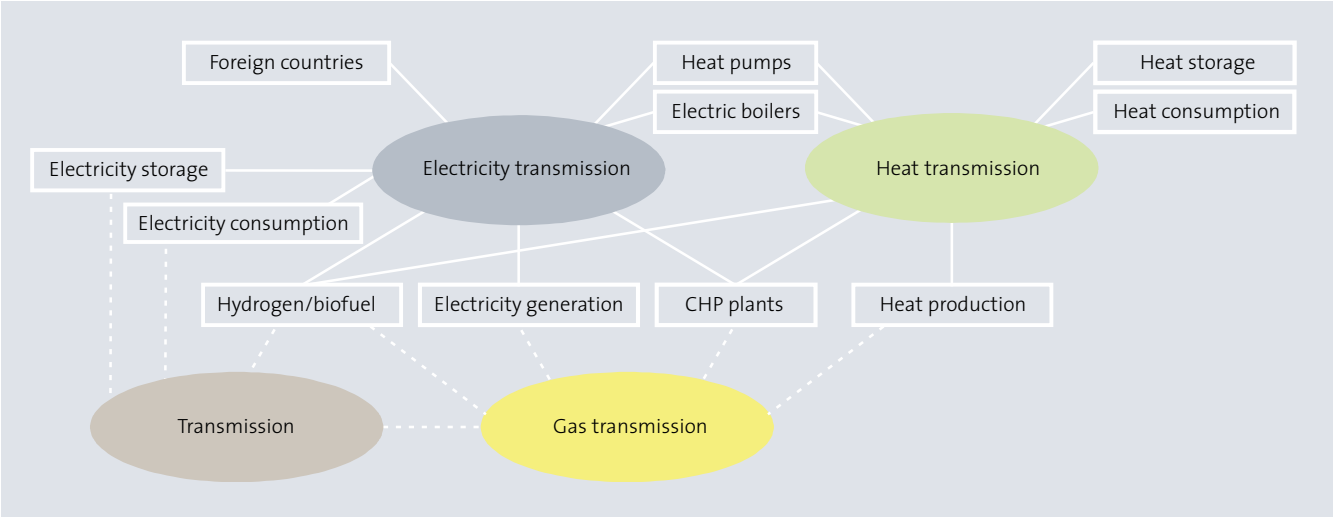
Hydrogen
In the long run, hydrogen may play a role in, for example, the transport sector's energy supply. Hydrogen production may take place by means of electrolysis at times when the price of electricity is relatively low.

Players may establish electrolysis units either locally at the site of hydrogen consumption or by way of central production. Local production will make significant demands on grid distribution capacity. In the case of centralised hydrogen production, production may take place at one of the hubs of the electricity transmission grid – such as the site where the electricity generation of an offshore wind farm comes ashore.

An electrolysis unit would be an asset to Energinet.dk in the balancing of the electricity system as the unit can be upgraded and downgraded fairly quickly.

Compressed Air Energy Storage
With a CAES unit (Compressed Air Energy Storage) it is possible to "store" electricity in the gaseous state under pressure

Figure 4.1: It is essential to combine means to meet the full scale of challenges.



below ground, in, for example, a salt dome. Under the ForskEL programme in 2005, Energinet.dk supported a project to investigate whether the CAES technology presents an economic and energy-efficient alternative to other types of electricity storage and regulation. The project is described in detail in section 13 on research and development.

Batteries

If electricity generation exceeds demand, excess capacity can be stored in batteries. In high-voltage systems, batteries are suitable for storing electricity for short periods of time ranging from less than one second to one hour. At present, storage for longer periods of time is uneconomic because of the loss of energy and the need for high-capacity batteries. Therefore, current technology does not make it worth while storing electricity from wind power for calm periods. On the other hand, batteries may serve a purpose in the electricity system in that they ensure the quality of electricity when, for example, wind power generates electric "noise". In other situations as well there may be a need for storing electricity for short periods of time, such as in the event of black start, etc.

Energinet.dk supports research and development projects aimed at testing the newest and most promising battery types in the electricity system.

4.4.4 Dividing Western Denmark into two price areas

In principle, the internal overload problems in the West Danish electricity transmission grid can be solved by introducing new bidding and price areas in Western Denmark. This will ensure that the exchange between the areas does not exceed the physical limitations of the system, as the trading capacity between the areas is defined on the basis of the potential for physical exchange.

Dividing Western Denmark into two price areas does by no means signify that these areas will have different prices during all hours. During a number of hours the two price areas will have the same price as each other and/or some of the other neighbouring areas.

Unless the other means, as described above, are activated to such an extent that grid overload problems are eliminated, dividing Western Denmark into two price areas must be regarded as the only legitimate and realistic method for handling internal capacity restrictions.

4.5 Possible combinations of means

The integration of 50% wind energy into the electricity system places strong demands on flexibility elsewhere in the system. This applies to production, grid and consumption. The preceding section describes a range of means that may contribute to providing this flexibility. The list of means is hardly complete, and more options must be expected to become available.

It is beyond doubt that a combination of means will be necessary to meet the full scale of challenges relating to grid loads, ancillary services and the energy balance. A broad spectrum of means is required, and the integration of the electricity, gas, heat and transport sectors is essential to reach the objective (see Figure 4.1).

In the continued planning, the characteristic features of the individual means as well as the technical and economic possibilities will be mapped out, and an optimum combination of grid reinforcement measures and other means will be identified against the background of detailed system and grid analyses. The optimum combination must be tested for its ability to withstand various future scenarios up to 2030. This will be achieved by testing them against Energinet.dk's scenarios – as outlined in "Scenario Report, phase 1".

5. Electricity market

One of Energinet.dk's tasks is to lay down the framework for a well-functioning market.

5.1 Trends in end-user electricity market

Since 2003, it has been possible for Danish electricity consumers to change electricity suppliers. On average, 50,000 customers have made use of this possibility every year. These customers are primarily large electricity consumers having made use of the market, but the number of households changing suppliers is on the increase. According to the Danish Energy Association, around 75,000 customers changed electricity suppliers during the first six months of 2007. The majority of these customers have hourly-read meters. Figure 5.1 shows the number of customers who have changed suppliers between 2003 and 2007.

To ensure easy and equal access for the market players to all the data used, for instance, for changing suppliers, Energinet.dk is participating in an analysis regarding a so-called data hub – a large central database.

The Nordic energy authorities believe the time is ripe for laying down the framework for a common Nordic end-user market. Energinet.dk backs this point of view. Developing a shared model for balance settlement constitutes an important element in these plans. Energinet.dk cooperates with the other TSOs in the Nordic region on implementing a shared model for balance settlement. The model is set to be implemented in 2009.

5.2 Assessing market efficiency

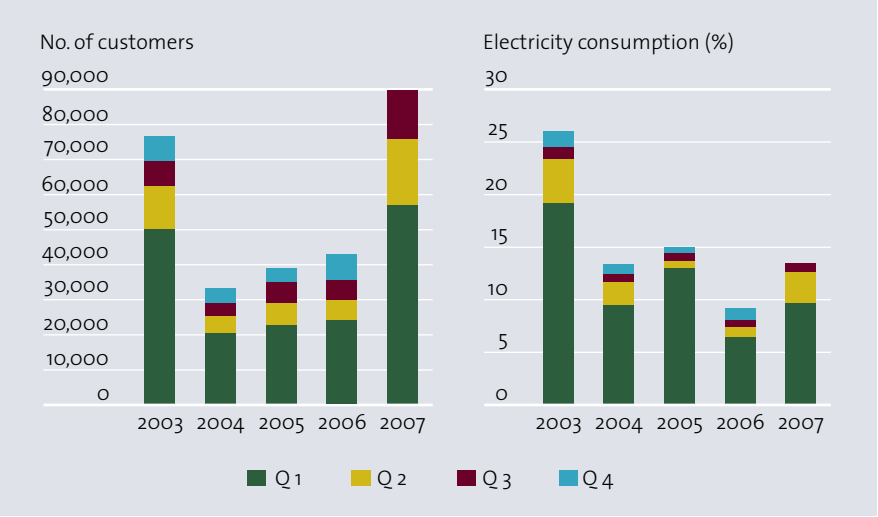
5.2.1 Market coupling

Energinet.dk cooperates with E.ON Netz, Vattenfall Europe Transmission, Vattenfall AB, EEX and Nord Pool Spot to couple the Nordic power exchange Nord Pool Spot and the German power exchange EEX. This should pave the way for optimum utilisation of the interconnections seen from a socio-economic point of view so that electricity always flows towards the high-price area.

At first, market coupling will comprise the day-to-day capacity on the Jutland-German border and the Kontek Link. In the long term, the Baltic Cable is also likely to be involved. The market coupling is set to be implemented in spring 2008. A joint company – the European Market Coupling Company – will be established for this purpose, with an office in Hamburg. Energinet.dk will own 20% of the company. At the same time, work is being undertaken to couple the German market and the markets in France and the Benelux countries from 2009. This will prepare the ground for a truly coupled market from the South of France to the North Cape.

At the Jutland-German border, the annual and monthly capacity will so far still be sold at explicit auctions. On the Kontek Link, all capacity will be allocated to the market coupling from the outset.

Figure 5.1: Customers who have changed electricity suppliers between 2003 and 2007, and their electricity consumption.



5.2.2 Congestion management

Svenska Kraftnät continues to restrict the possibility of exporting electricity to Eastern Denmark when the internal transmission grid in Sweden is experiencing congestion. Copenhagen Economics has made a calculation showing that consumers in Eastern Denmark paid an overprice of some DKK 750 million between 2001 and June 2006.

Energinet.dk finds that this runs counter to the EU guidelines on handling trans-

mission grid limitations. The practice adhered to by Svenska Kraftnät adversely affects electricity consumers in Eastern Denmark. The Danish Energy Association has filed a complaint with the European Commission's Directorate-General for Competition.

5.3 Market for ancillary services

The market for ancillary services has developed favourably in several areas since its start in 2004; the main explanation being that local CHP plants now have to operate on market terms. Moreover, Energinet.dk has come up with new ways for players to participate in the market; the latest being the daily market for buying reserves.

5.3.1 Daily market for buying reserves

Energinet.dk has introduced a daily market for buying reserves. The market aims at ensuring that resources, such as electricity generation units and electricity consumption that can only be available for individual hours or days, can participate in the market for ancillary services. The daily market also paves the way for ongoing adjustment of reserve purchases to current needs.

The market has led to the activation of resources that were not previously available on the market for ancillary services. The potential for attracting new players has not yet been fully exploited, and Energinet.dk will continue to provide the foundation for greater participation in the market for ancillary services.

5.3.2 Possibilities of buying ancillary services abroad

Given the considerable technology and market integration between the European electricity systems, the potential for developing cross-border markets for ancillary services is vast.

To ensure operational reliability, part of the required ancillary services will necessarily have to be provided locally or regionally.

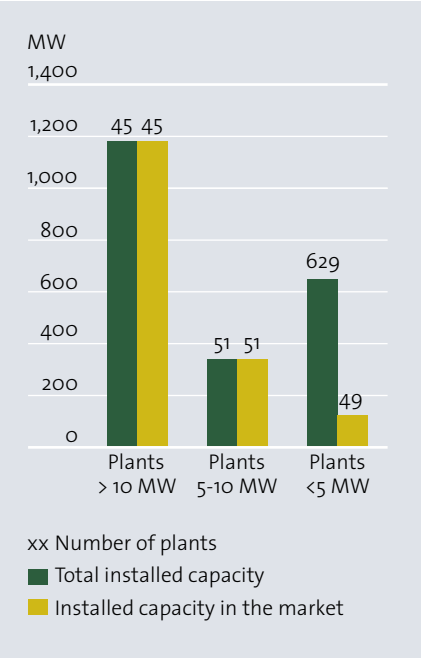
Energinet.dk works on enhancing the possibilities of cross-border trading in ancillary services to cover part of the demand for ancillary services from foreign suppliers and to offer Danish suppliers new market potential.

5.4 Local CHP plants on market terms

As part of the energy-political agreement of March 2004, it was decided that all local CHP plants in excess of 10 MW should join the spot market from 1 January 2005 and that all units in excess of 5 MW should be on the spot market from 1 January 2007. Furthermore, plants below 5 MW are free to participate. Figure 5.2 shows the number of plants participating in the spot market.

In addition to participating in the spot market, local CHP plants can also take part in the reserve and regulating power market.

Figure 5.2: Number of plants participating in the spot market.



5.5 Demand response

The objective of demand response is to move consumption from periods of peak demand and high electricity prices to periods of low demand and low electricity prices.

In 2007, Energinet.dk held the chairmanship of a working group on electricity meters and communication. The members of the working group were representatives of grid companies, electricity traders, the Confederation of Danish Industries and the Danish Energy Association. The background was a wish to assess the need for communicating the authorities' requirements for electricity meters that would allow remote reading – also in the homes of private consumers. The purpose of such requirements was to improve the possibilities of realising demand response and to ensure well-functioning competition in the retail market.

The report from the working group points out that the primary development in the communication and control options is not expected to involve the meters. Another conclusion is that basic requirements ought to be made for the meters and the related communication, for example that the consumption is registered per hour and remote-read once a day. Moreover, the electricity supplier ought to provide the customer with the decision basis in the form of price signals based on the price per hour.

About 200,000 meters are assessed to have been replaced already, and a decision has been reached to replace about 300,000 additional meters.

5.6 Trading virtual power

After the merger between Elsam and Nesa in 2003, Elsam (now DONG Energy) was ordered to offer virtual power through auctions in Western Denmark. The auctions take place four times a year, and the contract offered has a duration of

either 3, 12 or 36 months. At each auction, each buyer is not allowed to acquire more than half of the volume offered.

The sale of virtual power consists of an option payment determined at the auction and an energy payment determined by the Danish Competition Authority based on DONG Energy's production costs at the most fuel-efficient CHP plant in Western Denmark. The virtual power auction gives the buyer the right to make use of a virtual power station and the right to nominate to the market in the same way as generators who own their production facilities.

250 MW was offered in 2006 and 500 MW in 2007. In 2008, 600 MW will be offered for sale.

Energinet.dk believes, as do the competition authorities, that the introduction of virtual power has only had a limited effect on competition in this market.

5.7 Intraday trading in the Nordic countries and North Germany

In the Nordic countries, trading can be conducted through the Elbas market up to one hour before the day of operation (Intraday trade).

The Elbas market was established in 1999, and only Finland and Sweden have been part of the market from the start – Eastern Denmark joined in 2004.

Elbas
The Elbas market is a real-time market that does not close until one hour before the delivery hour. Ordinary spot trading takes place before the actual day of operation. The total volume traded in the Elbas market in 2006 was 1.1 Twh.

In 2006, Elbas was introduced in the Germany KONTEK price area and later in the whole of Germany. In April 2007, Elbas was extended to include Western Denmark as well, and Norway is expected to join in the first half of 2008.

It is still only possible to do Intraday trading via the Kontek link. Energinet.dk is cooperating with E.ON Netz to enable Intraday trading across the Jutland/German border at the beginning of 2008 as the European Commission's guidelines on congestion management stipulate that cross-border Intraday trading must be possible from 1 January 2008.

6. Electricity transmission

According to current principles for the establishment and renovation of high-voltage installations, new 400 kV units will normally be established as overhead lines across open land. However, this has proved difficult to carry out in practice, and there is a political wish to increase cabling at the highest voltage levels. This is the reason why a committee has been established for the purpose of preparing a technical report on the future development of the electricity transmission grid. This is also the reason why this year's system plan does not include any decision basis regarding the construction projects that are described in more detail in the annual transmission report.

6.1 Expansion and cabling

6.1.1 New situation regarding the choice between cables and overhead lines

The choice between cables and overhead lines is often a major issue in connection with specific projects for high-voltage grid expansion. New overhead lines may be seen as an intervention in the landscape, and experiences from the authorities' consideration of the most recent projects for expansion of the high-voltage grid – for example the connection of the offshore wind farm "Horns Rev 2" – have demonstrated the need for reassessing the former administrative basis for the planning and realisation of new construction projects.

So far, Energinet.dk has carried out its planning in accordance with the Danish Ministry of the Environment and Energy's principles for the establishment and renovation of high-voltage installations from 1995 with subsequent updates – latest the Danish government's energy strategy 2025 from June 2005. According to these principles, new 400 kV units will normally be established as overhead lines running across open land when this is not in conflict with specific national nature interests and urban areas.

However, this has proved more than difficult in practice. Wishes have been expressed in both local and national politics for increased cabling at the highest voltage levels due to the visual nuisances presented by overhead lines.

Therefore, it needs to be clarified how the electricity transmission grid is to be expanded in future, and the Danish Minister for Transport and Energy has therefore asked Energinet.dk to head an electricity infrastructure committee that is to prepare a technical report on the future expansion of the electricity transmission grid.

In this connection the expected need for expansion has to be quantified and specified. At the same time, a basis should be established to allow systematic discussion of the issues that should be taken into account when planning the expansion of the electricity transmission grid, for example considerations regarding security of supply, market development, visual environment and landscape, other environmental issues and socioeconomic issues.

6.1.2 The Electricity Infrastructure Committee

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.

The technical report is to comprise an analysis of the potential future grid structures based on various long-term grid expansion strategies. Furthermore, it is also to include an analysis of increased cabling of the Danish 400 kV grid.

Based on these analyses, the technical report should propose a number of specific models for the future expansion of the electricity infrastructure based on various technological possibilities.

The technical report is to identify environmental/landscape, technical, financial and socio-economic consequences of the individual expansion models. It should also include an evaluation of the impact on electricity prices.

The aim is for the alternatives to fulfil comparable requirements as to the security of supply, market expansion and incorporation of large volumes of renewable energy in accordance with the objectives laid down in "A visionary Danish energy policy 2025". The alternatives should also be assessed in view of the possibilities for interaction with foreign countries.

6.1.3 New projects put on hold

In connection with the Minister for Transport and Energy's approval of Energinet.dk's investment and financing plan for 2007, the Danish Ministry of Finance announced that any renovations of the 400 kV grid that are not made for safety reasons ought to await the completion of the analytic review of the future electricity infrastructure.

Similarly, the expansion of the Kassø-Revsing line awaits the completion of the analytic review of the future electricity infrastructure.

6.2 Analysis of grid expansion and cabling

Prior to and parallel with the work performed by the Electricity Infrastructure Committee, Energinet.dk is carrying out an in-house project setting out and analysing in detail the consequences of various expansion models for the electricity transmission grid. The work supports and contributes to the work of the Electricity Infrastructure Committee.

The project comprises grid and system analyses, environmental analyses, technology, market conditions and economy.

The grid analyses describe and quantify the requirements for the future electricity infrastructure with regard to:

- incorporation of renewable energy as well as local electricity generation,
- maintaining the security of supply,
- contingency measures and operational considerations
- well-functioning competitive markets.

Based on these assessments a set of grid expansion alternatives will be prepared. These are analysed and assessed in terms of economy, the environment, market functionality and security of supply.

The environmental impact of the specific expansion alternatives is assessed, for example with respect to interference with nature, visual aspects, noise, leaching of chemical substances and emissions.

By means of Energinet.dk's analysis tools a market valuation is made of the various grid expansion alternatives and feasibility studies are made regarding the use of relevant market mechanisms for handling transmission system congestion in the various grid expansion alternatives.

The technical aspects of the various electricity transmission technologies are described, including overhead lines, AC cables and different types of DC cables, for example with respect to magnetic fields, operational advantages and disadvantages, sensitivity, etc.

So far, 400 kV AC cables have only found limited use over long distances, and the operational experience with regard to the technology is therefore limited. Energinet.dk has initiated studies of the interaction between DC cables and the other grid components, including the technical feasibility of increased use of 400 kV cables. Among others, two research projects (PhD projects) have been initiated. In addition, a case study is carried out regarding a 400 kV cable installation on the 106 km section between Endrup and Idomlund in Western Jutland.

6.3 Common grid dimensioning criteria

The purpose of the grid dimensioning criteria is to identify any problems in relation to adequacy (weaknesses, congestion) and security (stability) in the grid and to compare the quality of possible solutions to such problems. Accordingly, the grid dimensioning criteria form the basis for decisions on grid reinforcement and expansion.

Energinet.dk has harmonised the grid dimensioning criteria used by the former transmission system operators east and west of the Great Belt so that standardised grid dimensioning criteria will be used for the whole of Denmark. The harmonised grid dimensioning criteria are prepared in order to ensure compliance with commitments towards Nordel as well as the UCTE. This is necessitated by the fact that Eastern Denmark is part of the synchronous Nordel cooperation and Western Denmark is part of the synchronous UCTE cooperation.

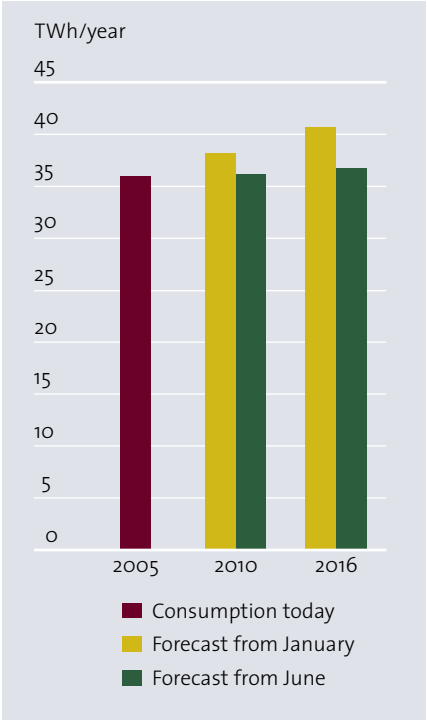
As part of the grid dimensioning criteria, planning of reactive power is made in cooperation with the transmission and grid companies.

Quality assurance activities are carried out in cooperation with the transmission companies and the grid companies. After the completion of these activities, the other market players and relevant authorities will be consulted before the findings are published.

Reactive power
Reactive power takes up capacity in the power grid. At the same time, it is a precondition for maintaining voltage and restoring the voltage after serious system disturbances such as blackouts.

7. Power balances for the next ten years

Figure 7.1: Projections of the electricity consumption in 2010 and 2016 based on 2005. The forecast from January 2007 comprises a limited amount of savings, whereas the forecast from June 2007 assumes efforts to achieve savings.



Adequacy, defined as the electricity system's ability to satisfy the consumers' demand for electricity at any given time, is an essential element in the assessment of the security of supply. Adequacy comprises primary fuel, production capacity and grid. Adequacy is, among other things, assessed by preparing power balances showing the overall expected production capacity available in proportion to the expected maximum consumption in an area.

In this section, the power balances are prepared as planning balances, which means that the entire expected production capacity available is included. The daily operational planning also takes into consideration any broken-down plants, units in reserve and plants being maintained or rebuilt.

Energinet.dk has prepared the power balance for the coming three winters, 2007/2008, 2008/2009 and 2009/2010, for both Eastern and Western Denmark. The Great Belt Power Link is expected to be commissioned in spring 2010 and after that balances will be made for Denmark as a whole. A power balance has also been prepared for 2016 as the Danish executive order on the limitation of emissions of certain pollutants into the air from large combustion plants will introduce stricter requirements in 2016, which may have an impact on part of the production facilities (see section 12 on environment and climate).

7.1 Power balances for the coming three winters

The power balances for the coming three winters are based on documentation prepared in connection with Nordel's power balances. Assumptions regarding power station capacity and electricity consumption are described in more detail in the memorandum "Analyseforudsætninger 2007-2016" (Analysis Assumptions 2007-2016).

7.1.1 Electricity consumption

Energinet.dk examines the power balance for two different electricity consumption forecasts that are both prepared by Risø National Laboratory on behalf of Energinet.dk (see Figure 7.1). Both forecasts assume economic growth corresponding to the projections of the Danish Ministry of Finance from December 2005 and August 2006.

One of the electricity consumption forecasts was prepared in January 2007 and assumes that the number of new initiatives aimed at energy savings will be limited. According to this forecast, the increase in the total annual electricity consumption in Denmark will be about 1.2% per year up to 2010 and then 1.1% per year up to 2025.

The second forecast was prepared in June 2007 and assumes higher implementation of energy saving measures in accordance with the political agreement from 10 June 2005 and "A visionary Danish energy policy 2025" from January 2007. According to this forecast, the increase in the total annual electricity consumption in Denmark will be 0.14% per year up to 2010 and then 0.3% per year up to 2025.

How quickly energy savings will be realised and how they will impact the energy consumption profile for the day and the maximum power consumption has not been clarified. This is the reason for calculating the power balance based on both forecasts.

Security
Security is the system's ability to handle sudden disturbances such as electrical short circuits or the unexpected outage of system elements. The concept covers dynamic events.

Adequacy
Adequacy is the system's ability to meet consumers' total power demand and to satisfy their requirements as regards energy at all times, taking account of planned and reasonably expectable trips of system elements. The concept covers stationary conditions.

7.1.2 Production units

The evaluation of the potential production changes over the period up to 2016 is based on a number of calculation assumptions regarding new production units or units that are to be scrapped. The evaluations are, among other things, based on information from the production companies, Vattenfall and DONG Energy.

The Biomass Action Plan will be fulfilled from January 2009 when the new straw-fired unit 8 at Fynsværket will be commissioned. In January 2009, the renovated Unit 1 at Amagerværket will be commissioned with about 70 MW.

The production capacity included in the power balance takes the delivery of CHP into account by reducing the nominal capacity of the plants. The calculation does not include contributions from wind power to cover maximum consumption. One of the reasons is that winter days with heavy frost often coincide with light or no wind, which means that hardly any electricity is generated by the wind turbines.

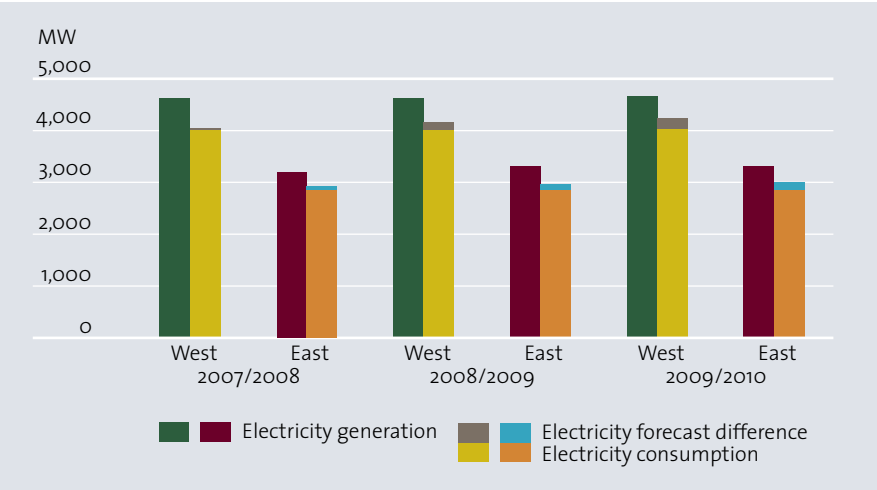
The power balances for the coming three winters are illustrated in Figure 7.2.

For the coming winter (2007/2008), the figure shows a positive power balance for Eastern Denmark of 300 MW and 500 MW for Western Denmark based on the high electricity consumption forecast. The corresponding figures based on the low electricity consumption forecast are 350 MW and 600 MW, respectively.

It should be noted that this is the planning balance. In the operating balance for the coming winter, it is important to note that Unit 4 of 270 MW at Asnæsværket is held in reserve (can start at one week's notice) and Unit 22 of 260 MW at Kyndbyværket is closed down for renovation from 1 January 2008. Unless new measures are taken, the operating balance for the coming winter will therefore be negative for Eastern Denmark.

It is doubtful whether it will be possible to get access to power from Sweden. In August 2007, Svenska Kraftnät published the report 'Den svenska effektbalansen vintrarna 2006/2007 och 2007/2008' (The Swedish power balance for winters 2006/2007 and 2007/2008). For the winter 2007/2008, a positive balance of approximately 5,000 MW is expected in a normal winter, whereas the balance is around zero in a cold winter. Moreover, internal transmission grid congestion means that potential Swedish surplus power (in Northern Sweden) cannot be transferred to Eastern Denmark.

Figure 7.2: Maximum electricity generation and electricity consumption for the coming three winters based on the two electricity consumption forecasts broken down into Eastern and Western Denmark.



7.1.3 Impact of electricity savings

For the winter 2009/2010, the electricity consumption forecast featuring the stronger savings efforts shows a power requirement that is 400 MW below that of the energy consumption forecast from January 2007, which only includes a limited number of new saving initiatives. It should be noted that it is a precondition that the 24-hour profiles of the two forecasts are identical. A 400 MW reduction corresponds to the total power produced by, for example, Units 2 and 4 at Asnæsværket.

Whether the savings will be realised during the relatively short number of years up to the winter of 2009/2010 is subject to some uncertainty. Furthermore, it is uncertain how the savings will be spread over a 24-hour period. If they are to have any impact on the power balance, they also need to be realised during peak power load, eg through demand response.

7.2 Power balance in 2016

7.2.1 Production facilities

The decision to scrap plants depends on factors such as age of plant, operating hours and operating patterns.

The age distribution of central and local power stations is shown in Figure 7.3. As can be seen from the figure, a total of 3,400 MW at central power stations are today more than 25 years old. As for the local CHP plants, the majority of these are faced with having to decide whether to renovate or replace production facilities within a short number of years.

Several of the old power stations will not be able to comply with the stricter environmental requirements in 2016. At the moment, around 1,000 MW will not be able to comply with the stricter requirements in 2016. Assuming that these power stations are scrapped and new ones are not established, the power balance for 2016 indicates a shortage of around 1,500

MW. If the forecast involving the stronger savings efforts is used as basis, the shortage will be reduced to about half.

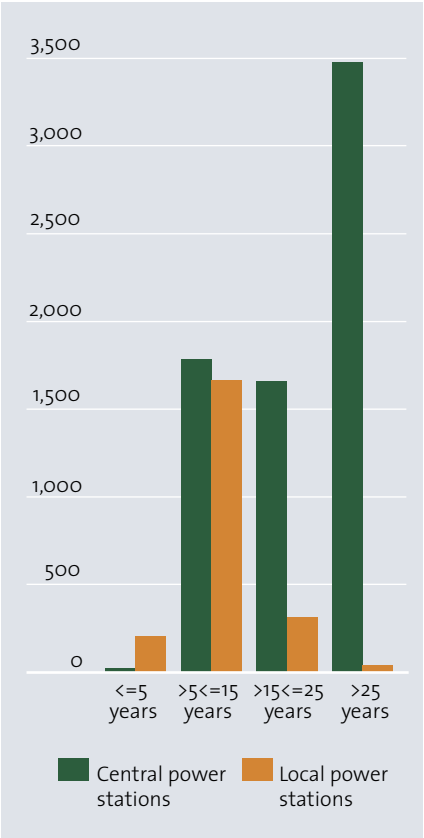
Energinet.dk is aware of several potential CHP projects, and it must therefore be assumed that the development in the power balance, combined with the increasing need for regulating services, will provide adequate incentives for investment in new electricity generation facilities with the properties required in an electricity system with a high share of wind power.

Energinet.dk will continue its work to ensure favourable framework conditions for establishing new power station capacity and for developing demand response.

7.3 Power station sites

The competition in the electricity market depends on new players gaining access to the market. Studies (eg investment and pricing in a liberalised electricity market, Risø) have shown that existing generators will often lose so much of their earnings on their existing power stations that they are unwilling to make new investments, unless they fear that a competitor will do it instead. In this connection, access to power station sites is an absolute necessity to be able to invest in new electricity generation capacity.

Figure 7.3: Age composition of central and local power stations.



From a socioeconomic perspective, it is not desirable to allow existing producers to let power station sites remain unused. If a site is entirely or partly unused, it is important to make it possible for competing investors to use the site for power station capacity. Similarly, it is important to survey and develop new power stations sites, should the need arise.

Energinet.dk will contribute to the work of the Danish Energy Authority to ensure access to suitable power station sites and examine whether other conditions are preventing players not having a Nordic power station portfolio from gaining access to the market and investing in new power stations.

7.4 Power from neighbouring areas

The purpose of establishing a single European market for electricity is to achieve higher financial efficiency through competition. To achieve this objective it is essential that day-to-day operations and decisions on the long-term investments are based on equal market conditions in the integrated market area.

To fully benefit from the borderless market the individual countries need to leave decisions about investments in generation and consumption capacity to the market players to whom national borders are less important. This will result in a mutual dependency when it comes to balancing consumption and production between the countries. In such a system, it will not be a relevant objective to strive at having a positive power balance at any given time between domestic consumption and production. However, this does not change the fact that the transmission system operator needs to ensure that balance can be achieved at any given time between demand and supply within the area. But it is irrelevant whether the resources to ensure this originate from domestic or foreign suppliers. In view of this mutual interdependency, the following sections will assess the trends in power balances in the UCTE area (Union for the Co-ordination of Transmission of Electricity) and the Nordel area, respectively.

10-year winter
The power balances apply the power requirement of a winter that statistically occurs every ten years. This corresponds to the procedure used in Nordel.

7.4.1 The UCTE area

In January 2007, the UCTE published the report "System Adequacy Forecast 2007-2020". The report assesses two ways of expanding the generation capacity: One possibility that only includes projects already agreed upon and another possibility that assesses the likely expansion.

In the UCTE's opinion, excess generation capacity will be reduced during the period, but the generation capacity will be adequate up to 2010, also if only projects agreed upon are included. However, to maintain the security of supply after 2013, a decision about new power stations will have to be reached. This can be postponed until 2015 if the peak demand on the consumption side is reduced.

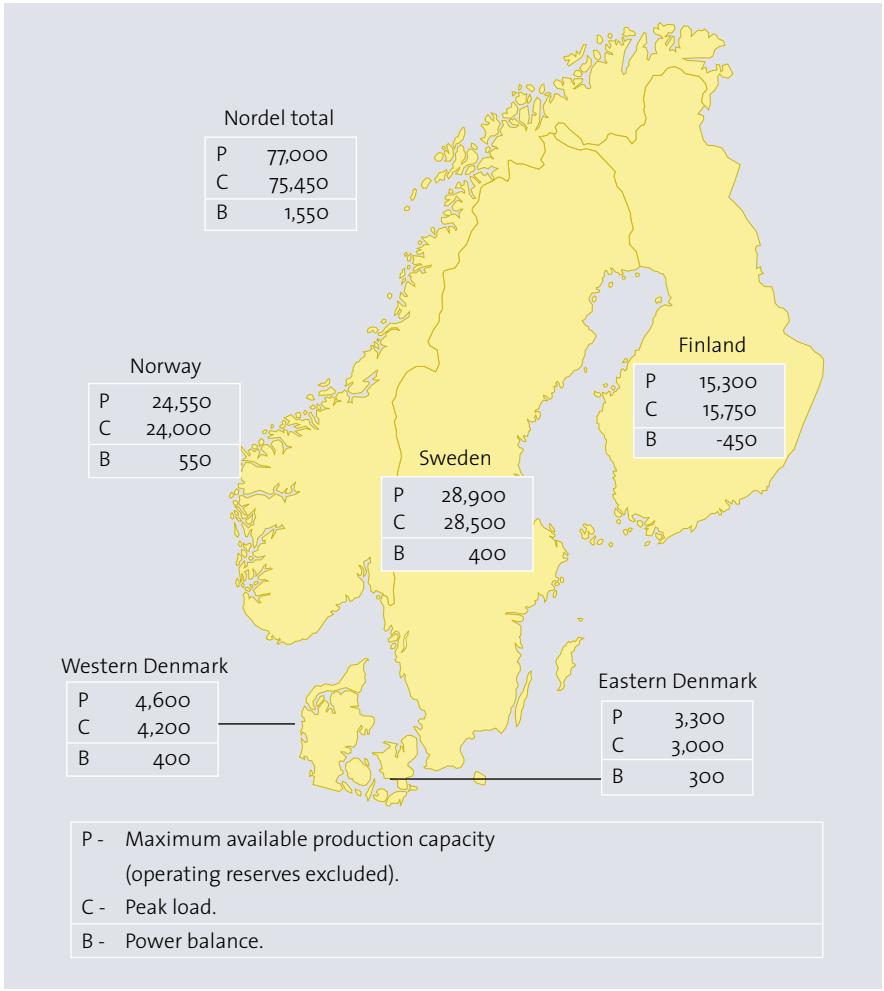
South of Denmark, there seem to be no surplus power at the moment which could be used as basis for the power balance.

7.4.2 Nordel's power balance

Figure 7.4 shows the power balance for the Nordic countries for the winter 2009/2010; that is before the Great Belt Power Link is commissioned. The power balance is prepared based on Nordel's power balance for the same year based on a 10-year winter.

The total power requirement of the Nordic countries is reduced by 2% in order to take into account that peak demands do not occur at the same time in the four countries. For 90% of the time in the Nordic countries, total wind power production corresponds to at least 6% of the total wind power installed. Therefore, in the Nordel power balance, the wind power is assigned a power capacity value of 6%.

Figure 7.4: Electricity capacity and maximum consumption in Nordel 2009/10 (MWh/h) based on a 10-year winter. No exchange between areas.



The power balance is calculated for the countries as a whole, and in some cases there will be internal congestion in the transmission grids that may reduce the possibilities of power transmission.

Nordel has decided to supplement the power balances with quantitative analyses of the risk of power shortage. The analyses are made by means of the MAPS model, which can handle risk of failures in production and transmission units. On the demand side, the model takes into account the probability of cold and mild winters and the resulting higher and lower electricity consumption.

The analyses comprise calculations for the integrated Nordic system and estimate the probability of system faults and market errors. System faults are defined as errors resulting in power delivery failures in one or more locations in the Nordic electricity system. Market errors are errors having the effect that no supply/demand equilibrium can be established in the spot market.

Based on an overall socioeconomic evaluation, it was decided to use a 1‰ criterion for system faults as well as for market errors. Accordingly, the criteria are complied with if the probability of market errors and system faults, respectively, for the total Nordic system is less than 1‰.

8. Long-term security of electricity supply

Energinet.dk is responsible for the short and the long-term security of electricity supply. This comprises adequacy, which is the system's ability to fulfil the customers' need for power and energy at any given time, and security, which is the system's ability to handle sudden disturbances. Energinet.dk is furthermore responsible for ensuring that contingency measures form part of the planning.

8.1 Quantifying security of supply

Being able to maintain the security of supply requires increased understanding of the interaction between circumstances that have a positive or negative impact on the security of supply.

It also requires that a quantified objective be laid down for the security of supply to ensure that the security of supply can be maintained based on a socio-economic optimisation of the level of security of supply and the available means.

As basis for our quantification of the security of supply, Energinet.dk has chosen to use the planning tool ASSESS. The tool was developed by the French transmission system operator and is based on the production and transmission system as well as the electricity consumption. It is also used by system operators in Belgium, England, Scotland and Ireland. ASSESS describes the system adequacy expressed as the probability of electricity not being delivered to the consumer and the probability of supply failure due to system inadequacy.

After the introduction of local power stations in the market, the dynamics and incentive structure of the system have changed and this may result in changed conditions regarding the stations' maintenance, operations strategy, availability, etc. As part of the ASSESS analysis, it is therefore necessary to update Energinet.dk's documentation, such as data regarding the availability of central and local production facilities.

The ASSESS work will be in focus once again in 2008 as part of the continuation of Energinet.dk's project on the quantification of the security of supply.

In addition to system adequacy, the work regarding security of supply will also focus on system reliability, meaning the system's dynamic conditions during and immediately after a potential contingency scenario. System reliability

analyses will comprise dynamic simulations performed by means of the power system analysis tool PowerFactory.

The security of supply work will also identify the effect of increased cabling on the availability of the electricity transmission system (see section 8.2). Cables have other properties than overhead lines and an electricity transmission system dominated to a larger extent by cables at 132/150 kV levels will pose challenges in terms of system reliability. If cabling is further increased at the 400 kV level, these challenges will become even more pronounced as the cabling will not be the same stabilising factor in the system as the existing overhead grid lines. In particular, the potentially extended use of the DC technology HVDC VSC will present some control and regulation challenges that also ought to be examined.

8.2 Availability statistics

Planned unavailability of the transmission system where components are being maintained or subject to other planned work has represented 2.0-2.5 % in recent years – corresponding to 175-220 hours a year. Planned unavailability is assessed to be on the rise due to the increased grid maintenance requirements.

Forced unavailability of the overhead lines, for example due to lightning, galloping lines, ice, insulator breaches, flashover due to salt or flashover to trees, has remained relatively stable in recent years around 0.3 % corresponding to 26 hours a year. Cable damage is primarily caused by digging. The statistical documentation for cable failures is still insufficient.

n-1 principle
The so-called n-1 principle means that electricity system operation must be maintainable in case of outage of any grid component (line, transformer or generator). In practice, this means that outage of a single grid component must not lead to persistent overload of the remaining grid components or give rise to instability in the electricity system.

In the past ten years, end users have on average been without electricity for 18.4 minutes a year.

Generally, the overall unavailability of the transmission grid has only a limited impact on the security of supply in the underlying grids and with the end users.

The reason why the unavailability of the transmission grid is so insignificant to the security of supply is that the transmission grid is operated as a meshed grid – meaning that every grid node has at least two independent supply lines.

8.3 Contingency preparedness

Contingency preparedness is taken into account at various stages in transmission planning and in connection with the construction of the transmission systems.

When designing and dimensioning the grid structure, the vulnerability of the transmission grid is examined in accordance with the grid dimensioning criteria (see section 6 on electricity transmission). Contingency preparedness is part of the grid dimensioning criteria.

The vulnerability analysis performed in June 2006 for the electricity system showed that the transmission system is vulnerable at weak points and to many coinciding errors. In general, n-1 assessments assume that all systems are redundant, even if two systems are physically close, eg hanging on the same row of pylons.

As to production capacity, Energinet.dk is continuously monitoring the fuel situation. To reduce the significance of a specific type of fuel, several of the central power stations are capable of using several types of fuel. It is assessed that critical dependency on a single type of fuel does not exist.

The distribution systems are vulnerable to weather conditions, such as storms or hurricanes, particularly at low voltage levels. This vulnerability is diminishing due to the continued cabling at low voltage levels.

Increased cabling of the electricity transmission grid presents new challenges in relation to contingency preparedness and security of supply. Generally, the overall availability of cables is assumed to be better than that of overhead lines. However, the problem regarding the long-term cable outage in the event of cable breakdowns (internal faults, damage caused by digging, etc.) constitutes a significant challenge when planning the future electricity transmission grid.

9. Gas market

Energinet.dk is tasked with ensuring a smooth and flexible gas market, including developing the products and facilities to be used by the commercial players.

9.1 General trends in the natural gas market

The Danish gas market is divided into a wholesale market and a retail market. In the wholesale market, shippers reserve capacity with Energinet.dk for gas transmission through Energinet.dk's gas transmission grid to the Danish market for storage in Stenlille and Lille Torup and to Sweden and Germany as transit. In the retail market, the gas suppliers supply gas to end users via the distribution grids.

The number of players in the Danish market has increased, including the number of international players. The reasons for this include the internationally attractive Danish storage prices, which in connection with the warm German winter have proved interesting for a number of foreign players. Furthermore, DONG Energy's annual Gas Release releases a certain amount of the company's gas in the Danish market.

Today, gas is traded in more flexible ways. The best example is gas trading on Energinet.dk's Gas Transfer Facility (GTF), which increased significantly at the beginning of the year because a number of large gas suppliers opted to have their purchases delivered to the GTF instead of supplying them direct to addresses in the distribution grid.

It also seems that the gas market players are increasingly sensitive to market signals. Again, the low Danish storage prices and the low German gas prices (due to the warm winter in Germany) perfectly illustrate a market trend where gas to an increasing extent follows the price in a large regional area and thus more than ever follows a more regional supply and demand pattern. Capacity products with a short time frame (eg daily, weekly, monthly) are also more widely used, eg in case of high electricity prices on Nord Pool Spot. DONG Energy is no longer the only company that imports gas into Denmark via Nybro, other players have bought access via DONG Energy's pipelines from the North Sea.

Moreover, 2007 is characterised by significant periodic gas flow changes at the Danish-German border (Ellund), meaning that the physical gas flow to Germany has been very limited (over the summer, there were days with zero gas flow). Gas flow has otherwise been at a stable high for the past ten years. However, there are still commercial exports to Germany

Gas release
Requirement placed on DONG Energy by the European Commission in 2006 as a condition for approving the merger between DONG and Elsam. The requirement entails that DONG Energy must release an average 400 million m^3 for sale to other players in the Danish market over a six-year period.

due to existing contracts. The significant increase in commercial imports from Germany is probably due to the warm winter in Europe which has resulted in markedly lower gas prices in Germany in particular. The natural gas has thus moved towards areas with higher prices or gas storage facilities in other markets. This has created congestion at Ellund and meant that the sale of interruptible capacity at Ellund has risen considerably. A range of changes and initiatives have therefore been launched to make both sides of the border work better together marketwise.

9.2 Storage market

On 1 May 2007, Energynet.dk took over the Lille Torup gas storage facility, which has a working volume of approx. 440 million m^3. The gas storage facility in Stenlille on Zealand has a working volume of approx. 520 million m^3 and is still owned by DONG Energy.

Interruptible capacity
Capacity agreement where customers have access to capacity to the extent that customers who have ordered uninterruptible capacity do not use their full order or if flow conditions are favourable. Interruptible capacity is only sold in case of contractual bottlenecks.

The commercial part of Energinet.dk's storage business is principally different from the tasks Energinet.dk oversees as transmission system operator for electricity and gas. This is why the storage business is organised in the separate company, ie Energinet.dk Gas Storage. The storage business is subject to other regulation than the other self-sustaining activities, and the storage business is allowed to generate a certain profit with a view to necessary consolidation and hedging.

The acquisition of the gas storage facility in Lille Torup aims at supporting competition on storage services and flexibility. The demand for Energinet.dk Gas Storage services has been high for the winter 2007/2008. Demand comes from both national and foreign players. The latter reflects the emergence of an increasingly integrated North European gas market.

It seems as if the market will demand still more storage capacity. The reason for this is primarily general market trends and the fact that shippers increasingly request flexible energy supplies.

Before the end of 2007, a cross-ministerial analysis project is expected to clarify whether the storage market in Denmark must be deregulated from the current cost-oriented regulation towards more market-based regulation.

9.3 New market concept for emergency supply

On 1 October 2007, Energinet.dk introduced a new emergency supply concept. The objective is to enable Energinet.dk to use the large gas consumers' interruptibility in emergency situations.

The new concept ensures transparency as it creates a direct link between the consumers who are to be supplied with gas in an emergency situation and the quantity to be supplied in proportion to the specific amount that Energinet.dk must pay for this service.

9.4 Harmonisation of rules and procedures

Energinet.dk is working to harmonise rules and procedures across borders in the European natural gas market. Energinet.dk is actively involved in the European regulators' regional initiatives in the gas market, Gas Regional Initiative (GRI), which is to remove the barriers to regional trading and, in the long run, ensure better conditions for developing regional trading sites, regional gas exchanges, etc.

Energinet.dk is an active player in the north-west European region (England, Benelux, Germany, France, Sweden and Denmark), which is also the most liberalised region.

Energinet.dk is involved in the "day ahead capacity auctions" project where the border point towards Germany

(Ellund) constitutes one of the focal points together with Bunde-Oude on the German-Dutch border. The project was launched at the request of EFET – European Federation of Energy Traders. The objective of the project is to make cross-border trading easier. The day ahead project provides an important example of the work to make both sides of the border points work better together and ensure simple and flowing transmission across the borders.

Energinet.dk is working bilaterally to harmonise rules and products in relation to particularly Svenska Kraftnät and BEB, the transmission system operators in Sweden and Germany, respectively. Especially the increased demand for capacity at the Danish-German border (Ellund) has engendered increased need for harmonising and further developing products and rules.

9.5 Establishment of a gas exchange

As part of the efforts to develop the natural gas market, Energinet.dk and Nord Pool Spot have decided to establish a gas exchange which is to cover the Danish gas market. The gas exchange will issue a publicly known gas price on a daily basis, something which does not exist today. The exchange will open in March 2008.

Energinet.dk and Nord Pool Spot are currently presenting the model for the players and defining their expectations and ideas for products, deadlines, etc.

The development of a Danish gas exchange should be seen as a natural development step in a larger European context. A Danish gas price will thus reflect the price levels and trends of existing gas exchanges. The increased price transparency caused by the establishment of the Danish gas exchange is expected to benefit Danish consumers.

The German power exchange, EEX, started a German gas exchange in 2007. In this connection, two geographically and partially overlapping price areas were established in Germany, both including the cross-border point towards Denmark (Ellund). As real price areas are established in especially Northern Germany, it is important that a Danish gas exchange has been established and that experience has been gained. This will enable Energinet.dk and Nord Pool Spot to lay the foundation for Denmark joining a common North-West European market area.

At the same time, increased trading at Ellund is assumed to imply that the area becomes an important trading point. This development is expected to continue concurrently with the development of gas exchanges on both sides of the border.

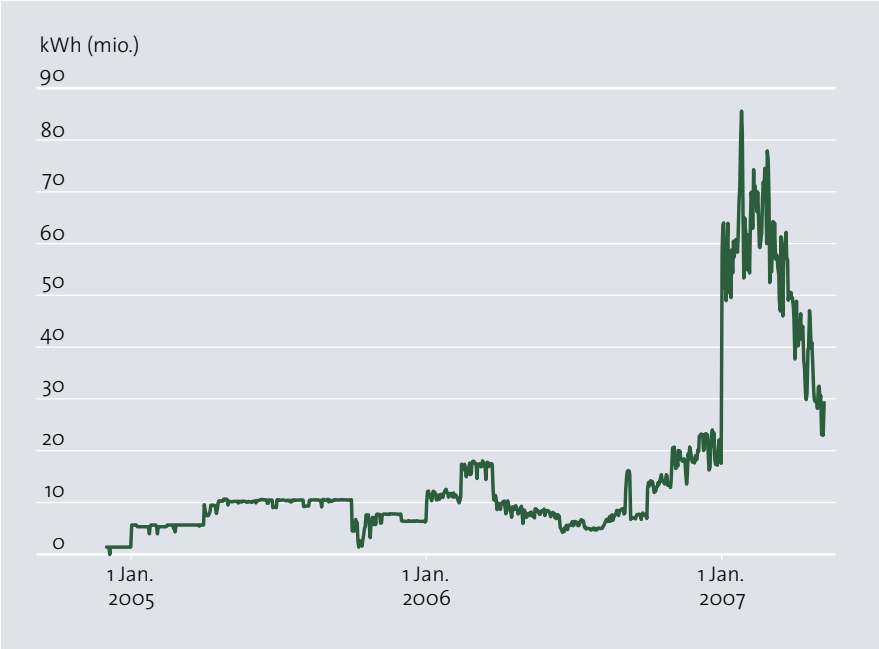
9.6 Trading on the GTF – Gas Transfer Facility

More and more bilateral trades are made on the existing Danish trading site for gas (the Gas Transfer Facility, GTF), and the trades are conducted with an increasing number of commercial players. Generally, development is progressing positively.

In 2005, trading was mainly based on fixed monthly contracts where gas ownership switched between few players. In 2006, trading became visibly more flexible from day to day, and gas ownership switched more often between an increasing number of players.

In 2007, GTF trading volume increased further. DONG Energy's Gas Release ensures extra daily trading of approx. 15 million kWh. Furthermore, gas trading on the GTF increased significantly from 1 January 2007 when a number of Danish gas suppliers started supplying their purchases in the wholesale market to the GTF instead of the distribution grid. In 2007, daily gas volumes traded aggregated 20-80 million kWh, corresponding to 15-50% of total Danish gas consumption (see Figure 9.1).

Figure 9.1: Daily trades on the Gas Transfer Facility.



10. Long-term gas supply

Energinet.dk is in charge of securing the gas supply and has launched an analysis to identify possible natural gas supply routes when the Danish gas production in the North Sea abates.

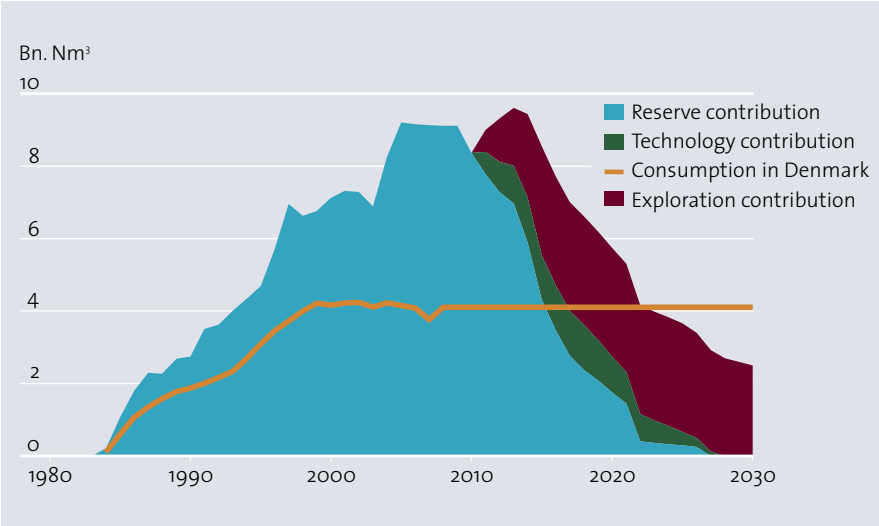
10.1 Danish natural gas resources

Within a foreseeable future, Danish natural gas production is expected to be unable to meet the demand for natural gas in Denmark. Gas production in the Danish gas fields in the North Sea is not expected to continue at the present level of about 9 billion m^3 per year for more than 5-10 years. "A visionary Danish energy policy 2025" predicts that Denmark may need to start importing natural gas from around 2015. There is uncertainty as to how much of Danish-produced natural gas will be exported directly to the Netherlands without going trough Denmark, a fact that may expedite the point in time when we are no longer self-sufficient. Conversely, exploration and technology contributions may postpone the point in time when we are no longer self-sufficient. However, none of these factors will change the fact that new natural gas supply routes to Denmark are needed within the next 5-10 years.

10.2 Gas infrastructure analysis

Energinet.dk has launched a comprehensive gas infrastructure analysis to identify other gas supply routes. The analysis work considers a number of alternative natural gas supply routes to Denmark. The first step has been to identify projects that may have a positive impact on the security of supply and competition in Denmark. The work analyses and compares these projects to be able to recommend the socioeconomically best and most realisable new natural gas supply route(s) to Denmark while taking environmental aspects into consideration.

Figure 10.1: Gas production from the Danish gas fields in the North Sea. Data on reserve contribution, technology contribution and exploration contribution have been obtained from the Danish Energy Authority.



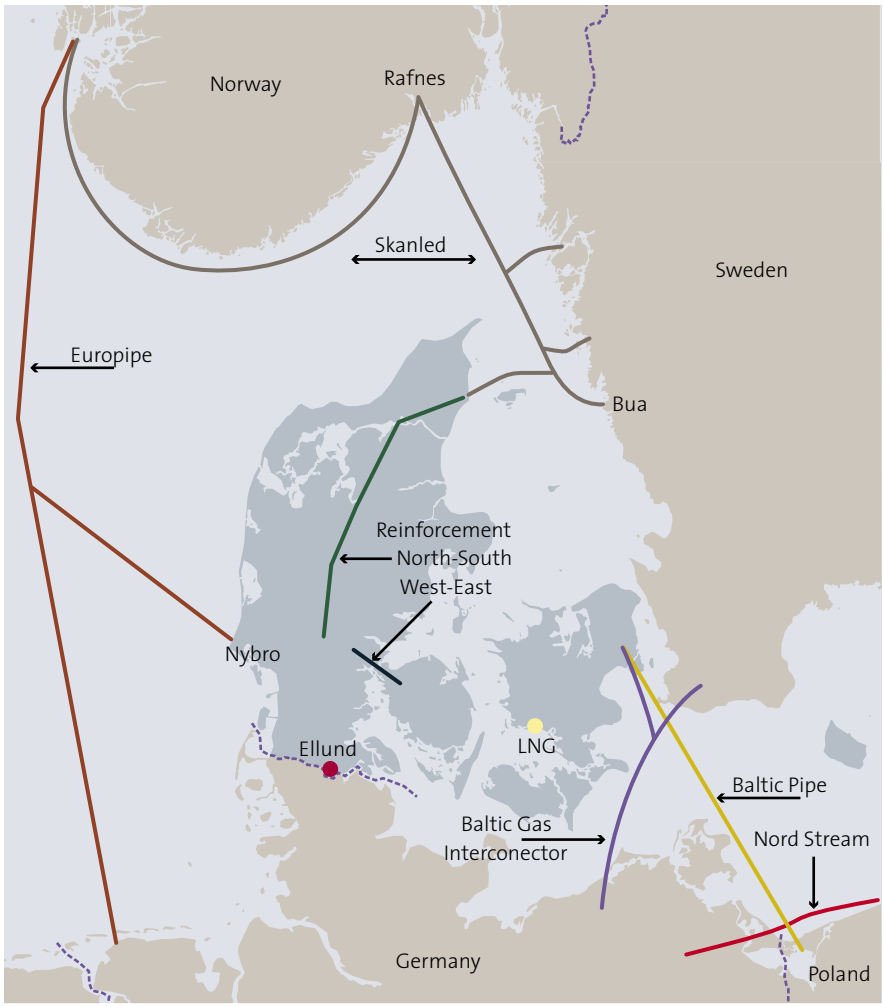
The analysis work also includes a number of specific projects which one or more players are developing or considering. This comprises Skanled, Baltic Pipe, analyses of an extension of the capacity at the Danish-German border (Ellund), Baltic Gas Interconnector, Nord Stream and other physical options that may potentially become projects such as, for example, Europipe-Nybro and LNG. The projects are described in brief below.

Energinet.dk will also analyse a situation where Denmark does not have access to new gas resources. In this case, focus must be directed at, for example, savings and fuel transition as a consequence of a possible free choice of fuel, and these initiatives will be compared with the infrastructure expansion projects. For example, existing Danish biogas resources and sale of biogas via the natural gas grid will be analysed as a possible contribution to future gas supplies. The preliminary results of Energinet.dk's analyses indicate that these initiatives will not be able to solve the gas supply problems in the long run but may serve as an important supplement to the pipeline project(s) that must ensure new gas supply routes to Denmark.

The many different solutions in play impact each other greatly. Project profitability is interdependent and the likelihood of realising the individual projects will change as some of them are implemented. With the exception of Nybro-Europipe II, it will be necessary to reinforce the domestic gas transmission grid regardless of the projects realised.

The intention of the gas infrastructure analysis is thus to ensure the optimum

Figure 10.2: Projects included in the gas infrastructure analysis.



basis for making investment decisions, including domestic investments needed to obtain the full value of the international projects.

10.2.1 Individual projects in the gas infrastructure analysis

The *Skanled* project facilitates transmission of Norwegian gas to Denmark and Sweden. *LNG* has been analysed with a view to assessing the possibilities of using liquefied gas as an alternative to the supply of natural gas via pipelines.

The Skanled and LNG projects are described in more detail in section 11.

Polish gas company PGNiG is developing the *Baltic Pipe*, which is a pipeline between Denmark and Poland. In 2007, PGNiG bought a share in the Norwegian gas field Skarv for the purpose of transmitting gas from the Norwegian continental shelf to Poland to diversify the Polish energy supply. PGNiG has also joined the Skanled consortium to bring the gas to Poland via Denmark. The project allows Denmark to gain access, at a later stage, to the gas from the Polish portfolio, which today mainly comes from Russian and Polish production fields. PGNiG is far in its plans to establish a LNG receiving terminal on the Polish coast which, together with Baltic Pipe, will give the Danish gas market access to the LNG market.

The *Ellund project* concerns the possibilities of increasing the capacity at the Danish-German border in both northbound and southbound direction, including the possibility of expanding the transmission system in Southern Denmark or Northern Germany. These capacity expansions will allow the Danish natural gas market access to Norwegian gas via the Netherlands and/or Germany and to Russian gas via a number of Central and East European countries.

The idea behind *Baltic Gas Interconnector* (BGI) is to connect the markets in Southern Scandinavia with the continental market via a pipeline from Rostock in Germany to Avedøre in Denmark and Trelleborg in Sweden. The project has obtained a number of permissions from the authorities, but has been temporarily put on hold by the owners because of insufficient supply of natural gas at Rostock. However, this may change if Nord Stream is realised.

Nord Stream – a consortium consisting of Gazprom, E.ON Ruhrgas and BASF – is planning two parallel pipelines, each with a capacity of 27.5 billion m^3/year from 2010 and 2012, respectively, via the Baltic Sea from the Russian city Vyborg at the Finnish border to Greifswald just east of Rostock. While the Baltic Gas Interconnector project has the planning permissions but no investment decision, the opposite is true of Nord Stream.

The considerations regarding *Europipe II-Nybro* deal with investigating the possibilities of transmitting Norwegian gas to Nybro via the existing connection between Norway and the continent. Energinet.dk has explored the possibilities, but the Norwegian system operator Gassco does not expect any capacity to be available on Europipe II within the next 10-15 years.

Thus, a number of possible gas supply routes exist. Previous work indicates that Skanled is one of the promising projects, while LNG in a large scale does not appear interesting for Energinet.dk at

present. No conclusions have been made on the analyses of the other initiatives and projects.

Energinet.dk will continue analysing a number of specific, alternative gas supply routes with a view to choosing the connection(s) most suitable for Denmark.

10.3 Storage capacity in Denmark

The potential access routes to Denmark may have different impacts on storage need in Denmark. The further away the gas comes from, the greater the need for a storage facility in immediate proximity to the consumers.

If a gas infrastructure expansion also ties Denmark to markets with a lack of gas storage facilities, international demand for Danish storage capacity will increase. Conversely, ties to an area with ample gas storage capacity will give Danish storage customers better opportunities of buying storage capacity. If realised, the Skanled project is expected to increase demand for storage capacity. This demand will most likely have to be met by Danish storage facilities, since the subsoil in Norway and Sweden makes establishing underground gas storage facilities difficult.

Energinet.dk's gas infrastructure analysis considers the possibilities of expanding storage capacity in Denmark and the ensuing socioeconomic profitability.

10.4 Emergency preparedness for gas

A vulnerability assessment of the natural gas system was conducted in July 2006 to identify and reduce the preparedness issues in the natural gas system. The assessment pointed out that the need for emergency supply and thus the vulnerability in the Danish natural gas system can be reduced by facilitating the supply of gas to the system via more entrance routes.

One of the pivotal evaluation parameters of the gas infrastructure analysis is the effect on the emergency supply need, including whether the gas will enter the natural gas system at a location that will ensure greater system robustness in future.

11. Skanled and LNG

As mentioned in section 10 on long-term gas supply, Energinet.dk has launched a gas infrastructure analysis which is to provide the framework for future investments in ensuring supply routes to the Danish natural gas market.

The analysis encompasses a number of possible supply routes and will determine what is best in terms of socioeconomy, security of supply and market. Skanled and LNG are the two projects where the initial analyses have come the farthest. The initial analyses find Skanled promising, while LNG has been found irrelevant in the short run. The reasons for this are outlined below.

11.1 Skanled

The Skanled project will facilitate transmission of Norwegian gas from Kårstø in Western Norway to Rafnes on the Norwegian east coast and on to the Swedish west coast and Northern Jutland in Denmark. See Figure 11.1.

11.1.1 Project background

The background for the project is a political desire in Norway to increase industrial use of natural gas in replacement of heavy fuel oil. Originally, the plans comprised the transmission of natural gas from Western Norway to the process industry in Eastern Norway. Subsequently, the plans have been extended to include

LNG
LNG (Liquefied Natural Gas) is natural gas stored at very low temperatures and atmospheric pressure. LNG only takes 1/600 of the space of natural gas and is thus easier to transmit over long distances.

Figure 11.1: The Skanled project

both Sweden and Denmark. In Sweden, the main reason for the interest in the project is – as in Norway – to become able to offer large industries natural gas as an alternative to heavy fuel oil and thus ensure stable, long-term and competitive energy and raw material supplies.

If Skanled is established, Denmark will gain access to gas resources that are expected to last for more than 30 years. Today, Norwegian gas needs to be transmitted via the Netherlands and/or Germany to reach Denmark. This involves considerable transmission costs, and insufficient capacity in the North-German system presents a considerable barrier. In addition to giving access to large volumes of natural gas, Skanled will improve the Danish security of supply by diversifying supplies. A transmission route from Norway to Denmark can be expected to engender more players in the Danish gas market for the benefit of competition. Finally, Skanled will allow transit of Norwegian gas via Denmark to the continent and will thus also contribute to improving conditions for a well-functioning international gas market.

Skanled will thus have a positive impact on both security of supply and gas market conditions in Denmark. Consequently, Energinet.dk decided to join the project. Besides Energinet.dk, a number of companies have signed a letter of intent to invest in the project – Skagerak Energi, Östfold Energi, Hafslund, Agder Energi, E.ON Ruhrgas, Göteborg Energi, Swedegas, Preem Petroleum and PGNiG.

According to the plan, the Norwegian government-owned Gassco will become operator with Energinet.dk and Swedish Swedegas as partners. So far, Energinet.dk has an ownership of 10%. Skanled's overall transmission capacity is expected to total 20-24 million m^3/day, of which a maximum of 14 million m^3/day will be transmitted to Denmark. An agreement has been made to the effect that Energinet.dk controls 5% of the pipeline capacity. The intention is that this capacity will be offered as short-term contracts.

11.1.2 Skanled in Denmark

The plan is that Norwegian natural gas must be landed some place between Frederikshavn and south of Sæby and then be transmitted to the natural gas storage facility in Lille Torup. At the same time, the transmission grid between Lille Torup and Egtved must be reinforced. The intention is to establish the new gas pipeline parallel to the existing pipeline for most of the way. Energinet.dk is currently investigating alternative landing options.

The gas pipeline will not be commissioned until the end of 2012 at the earliest, requiring a final investment decision in 2009. Until 2009, work related to, for example, public authority treatment in Norway, Sweden and Denmark will con-

Figure 11.2: Current and planned LNG receiving terminals and terminals under construction in Northern Europe.

tinue. In cooperation with the environmental authorities and the affected local authorities Energinet.dk will present proposals for possible routings. Energinet.dk has informed the following affected local authorities of the project: Frederikshavn, Brønderslev, Aalborg, Rebild, Vesthimmerland, Viborg, Ikast-Brande, Herning, Vejle and Vejen.

Once all permissions have been obtained from the authorities, Energinet.dk will have to consider whether it can recommend that the project is realised. If it can, the project will be submitted for approval by the Minister for Transport and Energy.

Energinet.dk and Swedegas has applied to the EU's TEN programme for financial support to Danish and Swedish activities in connection with the project. If the project is realised, Energinet.dk's total investment in both onshore facilities and offshore pipelines is estimated at DKK 3-4.5 billion.

A number of factors may impact on whether the project is realised, including the authorities' approval procedure in the countries affected.

Particularly, alternative gas infrastructure projects may affect Skanled. Although the Skanled project has now progressed so far that the authorities have started their approval procedure, there is still some way to go before a final investment decision becomes relevant.

11.2 LNG

11.2.1 Globally growing LNG market

The demand for natural gas has been on the rise in the past years. At the same time, we have seen a drop in production in the areas close to large gas-consuming countries; a drop which is expected to continue. This has entailed significant global growth of the LNG market.

Both natural gas exporting and importing countries have seen the advantages of using LNG to diversify supply. If one supplier experiences supply problems, alternative supplies can be bought relatively quickly in a growing world market. This is often not possible where pipeline supplies are concerned.

Global LNG production capacity has increased by more than 50% during the past five years; a growth that is expected to continue by 7-9% annually until 2015. This massive growth in the LNG market is expected to abate, and a more moderate trend is projected after 2020. This is primarily caused by uncertainty as to whether oil prices (and thus also gas prices) will continue to increase and as to whether the supply of ships, terminals, etc. can meet the demand.

In the long run, a well-functioning LNG market is expected to develop where spot prices will decide on what markets the LNG is sold. However, the current LNG market structure indicates that this is far from being the case at present. In many cases, the contractual setup related to LNG production, ships and import terminals means that there is no real competition on the supply and sale of gas.

11.2.2 LNG receiving terminals in Europe

There are currently 15 LNG receiving terminals in Europe with another 31 terminals being in the planning and estab-

lishment phase. Figure 11.2 shows current and planned LNG receiving terminals in Northern Europe.

There is a growing trend that some of the terminals are not established due to, for example, resistance in the local regions. Furthermore, some of the planned projects are in direct competition. Several of the potential projects involve LNG receiving terminals close to Denmark and may either direct or indirect impact the supply to the Danish natural gas market.

This is the case where the terminals in Wilhelmshaven (Germany) and Swinoujscie (Poland) are concerned, especially if they provide third-party access. In August 2007, the parties behind the terminal in Wilhelmshaven (E.ON Ruhrgas, Verbundnetzgas (VNG) and BEB Transport) started an open season to ensure third-party access. The terminal will have an annual capacity of 10 billion m^3, and the investment costs will aggregate around EUR 500 million. The background to the plans for a terminal in Swinoujscie is increasing Polish gas consumption and a wish for diversification. Annual capacity is expected to total 2.5-7.5 billion m^3. Both projects are in the planning stage, and investment decisions have yet to be made.

11.2.3 LNG terminal in Denmark

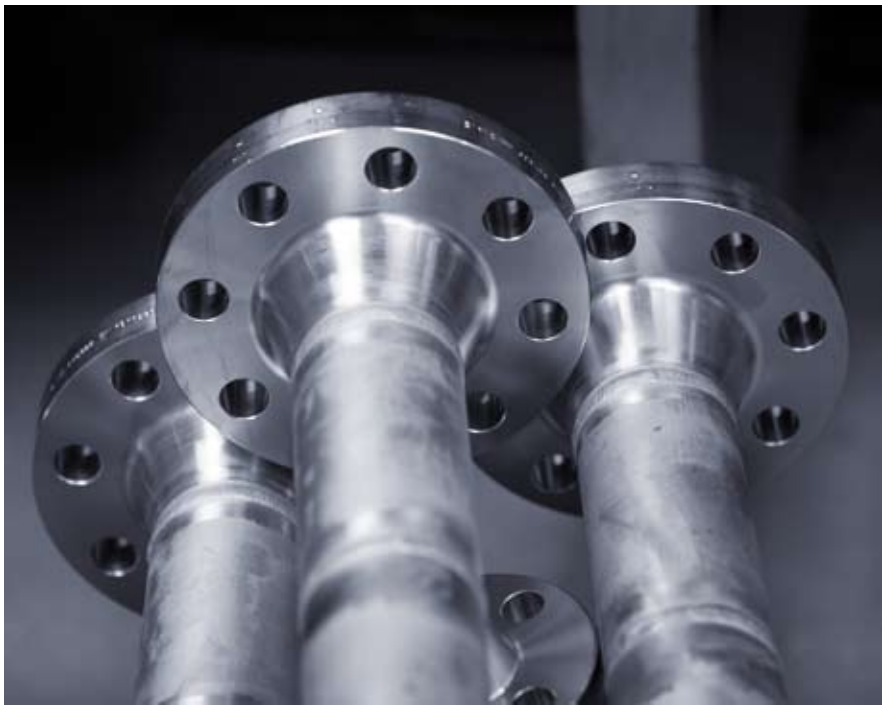
An LNG terminal in Denmark with an annual capacity of approx. 4 billion m^3 is expected to cost DKK 2-3 billion. Furthermore, a total establishment period of more than five years, including authority approval and environmental impact assessment, planning and design as well as commissioning, should be expected.

Obviously, the possibility of establishing an LNG import terminal in Denmark should be assessed regularly in conjunction with other possibilities to ensure gas transmission routes.

At present, Energinet.dk does not consider a Danish LNG import terminal as interesting seen from an economic and security of supply perspective, considering the financial risk profile. At the same time, Energinet.dk assesses that the positive effects of an LNG terminal on market development will most likely occur anyway if Denmark's neighbouring countries establish LNG terminals. The positive effects of diversifying natural gas supplies with a view to increasing the security of supply can thus be attained without establishing a LNG import terminal in Denmark. The development in the surrounding markets thus has a great impact on the value of a Danish LNG terminal.

Energinet.dk continuously monitors the development in technology for LNG terminals, the general price level of LNG investments and the global LNG market. The realisation potential of other gas infrastructure projects (see section 10) also plays a role in how attractive an LNG terminal will be. The benefits of a Danish LNG terminal change concurrently with the realisation/non-realisation of these projects.

However, it is possible that it would be financially interesting to establish an LNG import terminal in Denmark. Many of the existing LNG terminals in Europe and the terminals under construction have applied for an exemption from the third-party access requirement to secure their investments. In Energinet.dk's opinion, a Danish LNG import terminal should be open for third-party access.



12. Environment and climate

Environmental considerations are key when developing the Danish electricity and gas infrastructure. Consequently, environmental considerations are also an integral part of Energinet.dk's activities.

12.1 2009 UN Climate Change Conference

The 15th Conference of the Parties to the UN Convention on Climate Change (COP15) will take place in Copenhagen in November/December 2009. The backdrop is the Convention on Climate Change adopted in connection with the Rio Conference in 1992 setting voluntary targets for the rich countries to stabilise CO_2 emissions by 2000.

Subsequently, the parties have held 12 conferences to realise the objectives of the convention. Adopted at the third conference of the parties in December 1997, the Kyoto Protocol is a decisive instrument in this work covering the period 2008-2012. The objective of the Kyoto Protocol is that the industrialised countries must reduce their emissions of greenhouse gasses by at least 5% compared with 1990 levels calculated as an average during the commitment period 2008-2012.

The EU has undertaken to reduce emissions of greenhouse gases by 8%, and the EU member states have made a political agreement, the so-called burden-sharing agreement, stipulating how much the individual member states must contribute to the EU's total reduction of emissions. Under the burden-sharing agreement, Denmark has committed to reducing emissions by an average 21% during the period 2008-2012.

The choice of venue for the global conference in Copenhagen offers a unique chance of visualising the strengths of the Danish energy sector. In this respect, Energinet.dk can play an active role by contributing knowledge about the integration of large volumes of wind power, etc.

12.2 Environmental regulation

12.2.1 2005-2007 trial period of the CO_2 emission allowance directive

Since 1 January 2005, about 380 Danish production units have been comprised by the EU's emission allowance directive (CO_2), of which 255 belong in the electricity and heating sector. During the trial period of the emission allowance directive (2005-2007), electricity and district heating generators in Denmark have been granted total emission allowances of 21.7 million tonnes per year corresponding to approx. 75% of the expected CO_2 emissions during this period.

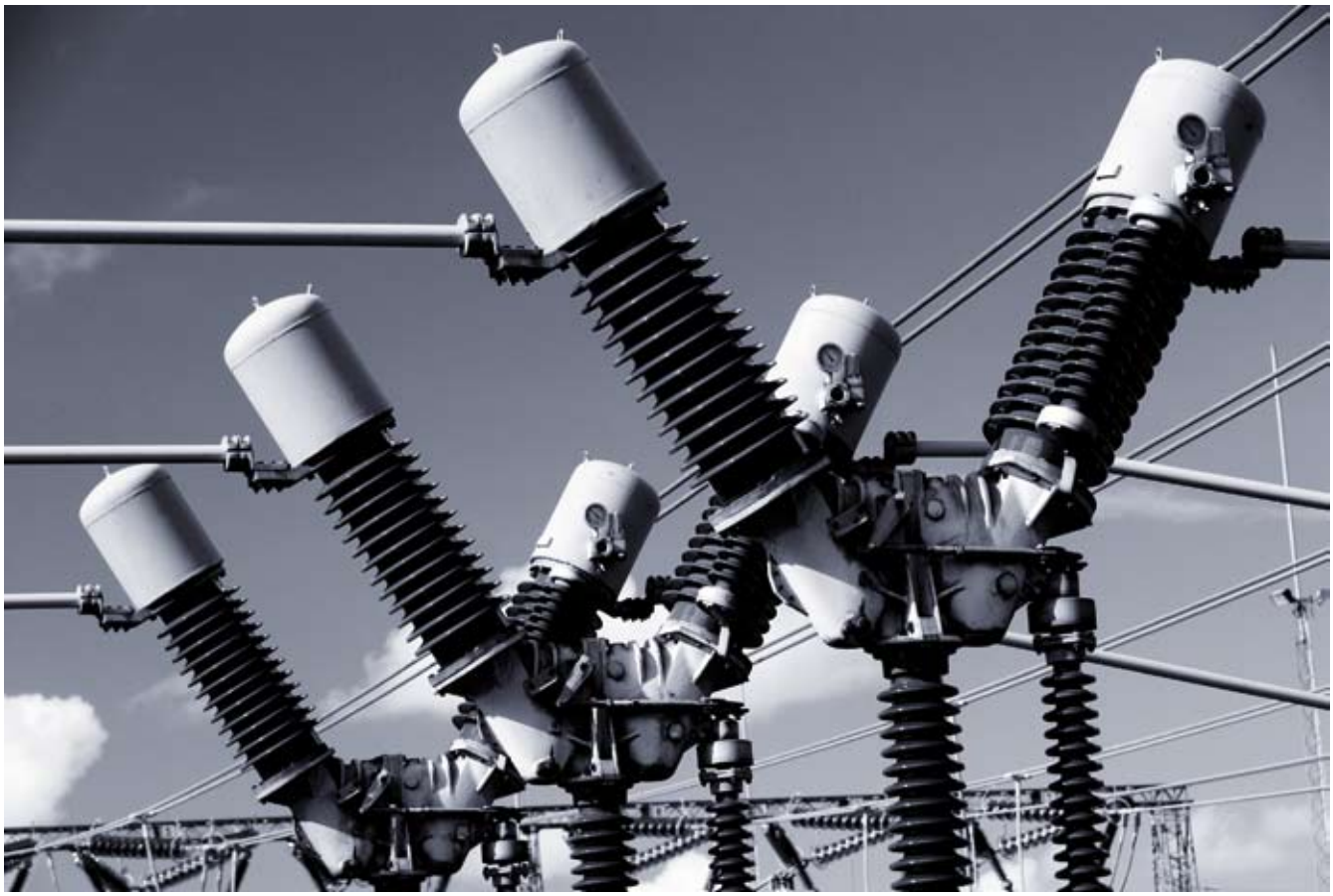
Reporting of CO_2 emissions from the Danish companies governed by the directive shows that in 2006, total CO_2 emissions from the electricity and CHP industry reached 34.2 million tonnes, while 2005 emissions reached 26.5 million tonnes. The reason for the relatively high CO_2 emissions in 2006 was high electricity exports. The increased CO_2 emissions have primarily taken place at the central power stations. In 2006, CO_2 emissions from the other industries were at the same level as in 2005. The 2005 and 2006 averages of CO_2 emissions basically correspond to the allowance.

12.2.2 Fulfilment of CO_2 commitments in 2008-2012

Denmark has committed to reducing total national greenhouse gas emissions by 21% from 2008 to 2012 compared with the 1990 level. This means an average reduction of emissions to 54.8 million tonnes of CO_2 per year from 2008 to 2012. Total expected CO_2 emissions during the same period amount to 67.6 million tonnes, leaving a shortage of 13 million tonnes of CO_2 equivalents.

On 31 August 2007, the European Commission approved the Danish allocation plan for the Kyoto period 2008-2012. The allocation plan documents how Denmark will meet its reduction commitment. Part of the shortage, 7.8 million tonnes, is handled by means of government initiatives, including the purchase of CO_2 credits and new climate initiatives in sectors not subject to allowances. The remaining shortage will be met by assigning 5.2 million tonnes fewer allowances per year to companies subject to emission allowances than their expected 2008-2012 emissions.

The Danish allocation plan for 2008-2012 entails a total allocation of free allowances for existing production units of 24.0 million allowances per year. The allocation plan's handling of the shortage focuses on the electricity sector, which must account for almost a third of the total reduction commitment. The electricity and heating sector is granted a total emission allowance of 15.8 million annually. The electricity sector is expected to cover 72% of the forecast need for allowances, depending on exports and imports from the Danish market.



12.2.3 New environmental regulation for SO_2 and NO_x

According to the EU NEC Directive, Denmark is under an obligation to reduce the emission of nitrogen oxides (NO_x) to 127,000 tonnes/year in 2010. Forecasts have previously indicated that the Danish NO_x emissions will exceed the emission limit by approx. 7,000 tonnes in 2010 unless additional means are applied.

As part of a major tax rationalisation scheme in the energy area, a proposal has been made to introduce a NO_x tax of DKK 5 per kg effective from 1 January 2010, the proceeds of which will be written back by reducing energy taxes. The tax is expected to reduce NO_x emissions by 6,000 tonnes and will thus contribute considerably to observing the emission limit. The introduction of the NO_x tax will also imply that the Danish executive order on SO_2-NO_x emission allowances which regulates NO_x emissions from the large power stations will be abrogated.

12.2.4 Executive order on large combustion plants

The Danish executive order on the limitation of emissions of certain pollutants into the air from large combustion plants (Executive order no. 808 of 25 September 2003) concerns limitation of SO_2, NO_x and dust emissions from plants with a thermal effect of 50 MW and above. The order implements the EU Directive on the Limitation of Emissions of Certain Pollutants into the Air from Large Combustion Plants (2001/80/EC) into Danish legislation. The regulation takes place in the form of emission limits that vary depending on plant age, size and fuel type. Plants established before 1 July 1987 must observe the limit values stipulated in the order by 2008.

The NO_x emission limits will be tightened from 2008 for existing units, ie plants with environmental authorisation from before 8 October 2003. In practice, plant owners can choose to either scrap the plants, declare limited operations until 2016 without reducing emissions, or renovate the plants and establish environmental installations. By 30 June 2004, generators had to inform the authorities which plants would reduce operations in the 2008-2015 period. Unit 3 at Fynsværket power station is the only unit which has declared limited operations.

The NO_x requirements will be tightened further from 1 January 2016 for plants using solid fuels and with a thermal effect of more than 500 MW. Plants in this category will thus have to observe the same strict requirements as those placed on new plants today – ie the plants cannot live up to the emission requirements after 1 January 2016 without establishing deNO_x units.

13. Research and development

Energinet.dk administers the three research and development programmes known as ForskEL, ForskIN and ForskNG. Collectively, the programmes aim to support a future energy system that is both environmentally-friendly and provides security of supply.

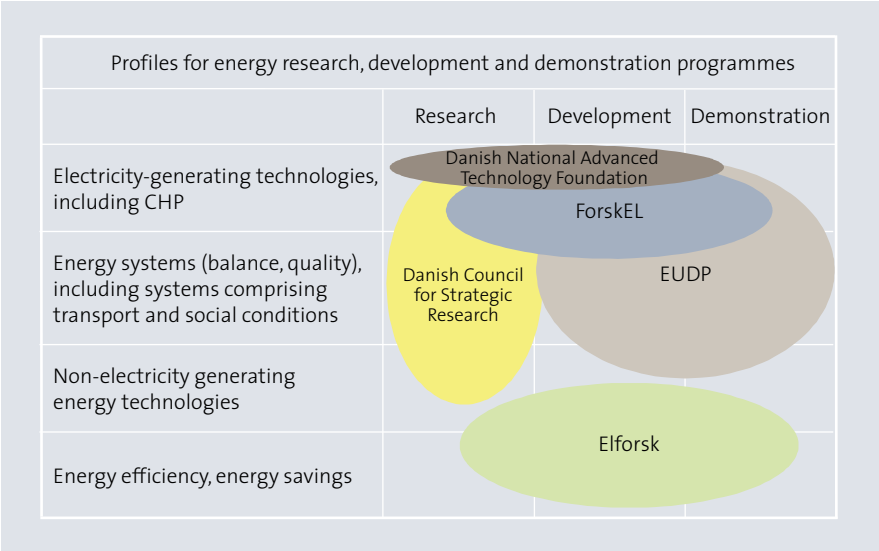
The object of the ForskEL programme is to support the development and use of environmentally-friendly electricity generation technologies, and for the period up to and including 2008 an annual amount of DKK 130 million is available for the programme.

ForskIN comprises research and development in the maintenance of supply security and development of the electricity system. At present, the programme has an annual budget of approx. DKK 10 million.

The object of the ForskNG programme is to ensure development of the natural gas system, eg to be able to transport biogas and hydrogen in the long term. At present, the programme has an annual budget of approx. DKK 5 million.

There are interfaces and potential overlaps between the three programmes rendering close coordination of the activities necessary. For instance, while ForskEL concerns the use of gas, ForskNG concerns the procurement and transmission of gas. The same applies to the interface between ForskEL and ForskIN. While ForskEL focuses on generation technologies, ForskIN concerns a targeted development of the electricity system itself and primarily aims at performing specific tasks in connection with the electricity transmission system.

Figure 13.1: Programme profiles.



13.1 Connection with other Danish R&D programmes

Besides the internal coordination of Energinet.dk's R&D programmes there is also a need for coordination with the other energy research programmes in Denmark. Each programme has its own profile (see Figure 13.1) justifying a place in Danish energy research, but close cooperation among them is necessary to create good synergies.

The Energy Technology Development and Demonstration Programme (EUDP) is a relatively new energy research programme replacing the Energy Research Programme (ERP). As a general rule, the EUDP will provide funding for the development and demonstration of energy technologies. However, the programme may also support actual research activities, for instance activities undertaken as part of the process optimisation from the laboratory to a full-scale plant. Distinguishing clearly between the ForskEL and EUDP programmes can be difficult as they may both include research and demonstration, but importance is attached to the fact that ForskEL only funds electricity generation and does not aim to implement Danish energy policy the way the EUDP does. The EUDP is administered by the Danish Energy Authority.

The Danish Council for Strategic Research's Programme Commission on Energy and Environment (PCEE) provides funding for strategic research in a wide range of energy technologies. The EUDP aims to support research results and to bring them to commercialisation through pilot projects and demonstration. The ForskEL programme also funds applied research, but only in electricity generation technologies while the PCEE may fund research in all energy technologies.

The object of the Danish National Advanced Technology Foundation is to promote research and innovation in technology areas where Denmark has

particular qualifications and potential. In its first allocations, the Foundation has provided substantial funding for energy projects.

Finally, the Elforsk programme deals with research and development in the area of efficiency energy use. The Association of Danish Energy Companies (Dansk Energi - Net) administers the programme with DKK 25 million a year.

The energy research programmes interact in a number of areas, and cooperation is therefore necessary to create good synergies in relation to Danish energy research in general. Cooperation takes place on a regular basis and includes the coordination of focus areas, energy strategies, joint calls, information meetings, conferences, application deadlines, publications, web portals and IT systems. Furthermore, the programmes cooperate closely on the daily administration of the programmes. In 2007, the ERP, Elforsk and ForskEL have issued their first joint annual publication, which also comprises projects under the Danish Council for Strategic Research, the Danish National Advanced Technology Foundation and Nordic Energy Research.

13.2 Research projects involving the electricity system

Energinet.dk provides PSO funding in the amount of DKK 130 million a year to the ForskEL programme. Since 1998, 231 projects have been completed under the programme. The projects have contributed to making electricity and CHP production in Denmark more environmentally-friendly. The international and Danish desire to increase the use of renewable energy in the energy systems calls for further research.

At the moment there are 131 projects in progress under the ForskEL programme. Below follows a description of two projects, the contents of which are closely related to the development of the electricity system of the future. Finally, there is a description of one of Energinet.dk's own development projects, which will contribute to adapting the electricity system to future requirements.

13.2.1 Compressed Air Energy Storage

An electricity system such as the Danish one with a steadily growing share of fluctuating electricity generation increases the demand for regulating capacity. With a CAES plant (Compressed Air Energy Storage) it is possible to "store" electricity in the gaseous state under pressure below ground, eg in a salt dome.

Under the ForskEL programme, Energinet.dk provided funding of approx. DKK 1.2 million in 2005 for a project aiming to investigate whether the CAES technology presents an appropriate economic and energy-efficient alternative to other types of electricity storage and regulation. The project was implemented in cooperation between the Technical University of Denmark (DTU), the University of Aalborg and DONG Energy. It was completed in the summer of 2007.

A CAES plant basically consists of three components: a compressor that converts electricity into compressed air, an underground cavern to store the compressed air, and a turbine which together with a generator reconverts the compressed air into electricity. Typically, the turbine is operated like a gas turbine with natural gas as extra fuel. CAES can achieve up to 70% efficiency.

CAES plants are used in, for example, Germany (60 MW input from the grid and 290 MW output to the grid) and the USA (50 MW input from the grid and 110 MW output to the grid). So far, the plants in both countries are used mainly for load equalisation between daytime and night time. In Denmark an obvious location for a CAES plant would be in one of the Danish natural gas storage facilities as these provide access to natural gas and a manned plant.

Project calculations have been made for a Danish plant with a maximum input from the grid of 215 MW, a storage capacity of almost 1,480 MW, and a maximum output capacity of 360 MW. The total construction price would be about DKK 1.3 billion.

A CAES plant can be operated in simple operation in the electricity spot market. It can purchase electricity for the compressor when it is cheap and sell electricity from the turbine when it is expensive. However, that is not sufficient to ensure a sound operating economy. One of the preconditions of the plant being financially interesting is that it optimises earnings in the reserve and regulating power market.

From a socioeconomic viewpoint a CAES plant can be considered neutral. In the slightly longer term, with its unique regulation capacity the plant may prove a valuable means of regulation for the TSO in an electricity system with large volumes of wind power.

13.2.2 EcoGrid

In connection with the calls of the energy research programme ForskEL in 2005, 2006 and 2007, Energinet.dk received a number of applications concerning the control and regulation of the electricity system. The project proposals addressed some of the issues facing the electricity system of the future. The issues were closely related to some of the challenges facing Energinet.dk with regard to integrating more renewable energy and distributed production while ensuring a robust energy system providing demand response and security of supply. Energinet.dk therefore decided to withdraw the applications from the ForskEl programme in order to launch EcoGrid, an entirely new activity where these projects are part of a larger context.

All in all, 16 Danish and foreign companies, universities and consultants joined Energinet.dk to establish EcoGrid.dk. The object of the project is to develop new, long-term technologies and market solutions for the electricity system of the future which will probably have to integrate

an even larger share of both distributed production and renewable energy. Furthermore, requirements are being made as to the flexibility and robustness of the system and the security of supply.

Three phases are planned for the project. The first phase started in May 2007 and is expected to be completed in mid-2008. It identifies and describes a number of solutions for the logical and physical electricity systems of the future, eg SmartGrid, Intelligrid, Microgrids, the Cell project, virtual power plants (VPPs) and agent-based distributed control. Furthermore, the project will examine the consequences of future market developments and identify new means. Together these "building stones" are to support the overall objectives and functions of the electricity system of tomorrow. The first phase will result in a number of recommendations concerning research and development activities.

The second phase will implement the research and development activities that were recommended. The activities will result in potential solutions to the challenges facing Energinet.dk, including to ensure efficient operation and expansion of the electricity system in future and to provide open and equal access for all users.

The third phase includes the practical demonstration of technologies and solutions.

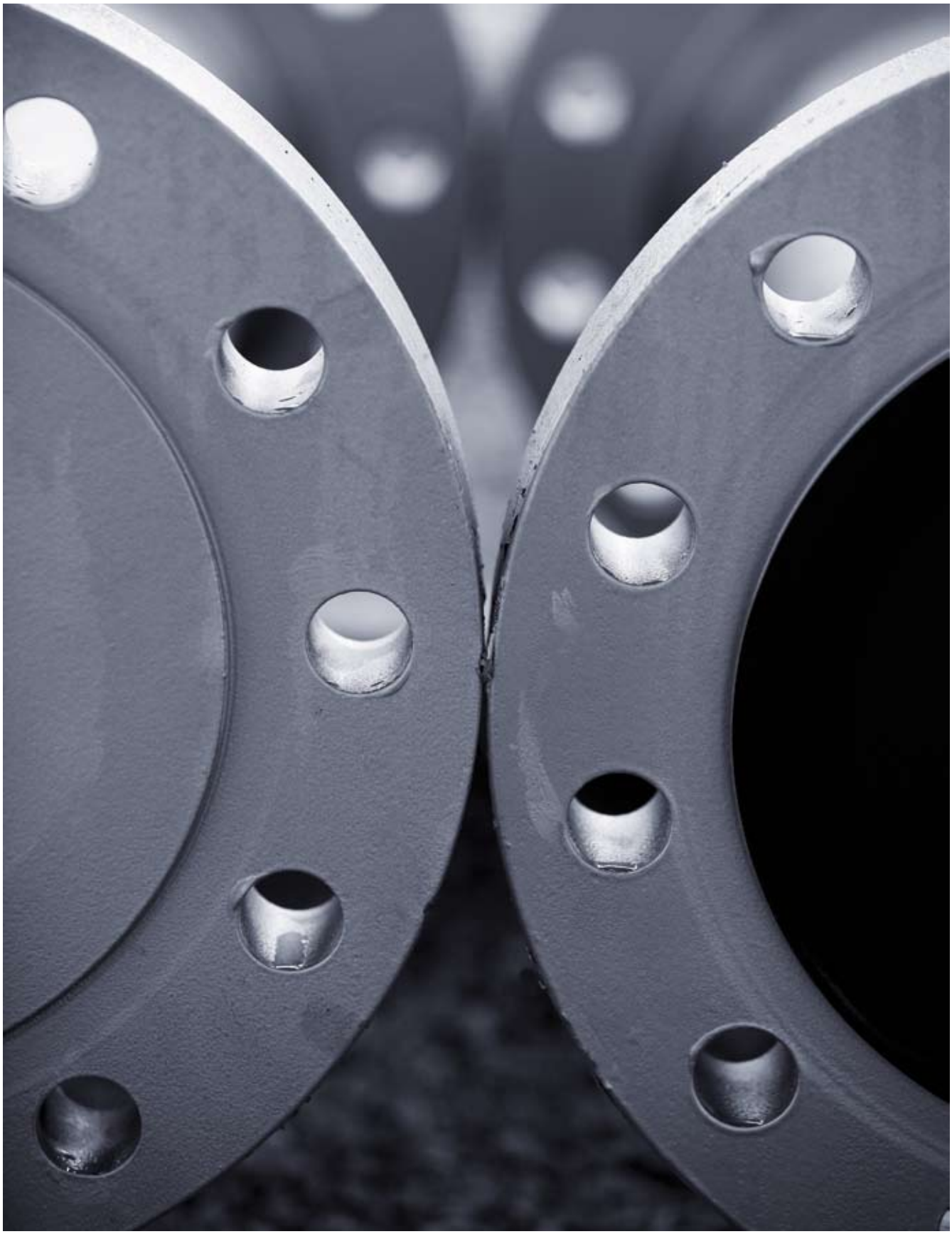
Applying the Danish experience gained from large-scale integration of wind power at European level holds much promise. The central issue will be to develop a safe and cost-effective distributed energy system that is conceptually sustainable and of durable design for all of the EU. The recommended solutions must be validated and demonstrated on a large scale in Denmark before any implementation in the entire European system.

13.2.3 The Cell project

The Cell project is one of Energinet.dk's internal development projects that works with intelligent mobilisation of distributed electricity generation – a new, promising system and control architecture where the local grids constitute cells responsible for the supervision and management of selected functions at local production and grid units.

The project is being implemented in close cooperation with SYD ENERGI Net, Dansk Energi Forskning og Udvikling, Spirae Inc., Energynautics G.m.b.H. and the generator owners in the Holsted grid area under the 150/60 kV Holsted substation in SYD ENERGI's grid area.

In 2006, a data monitoring system known as the Cell Monitoring System was installed at two substations, two CHP plants and four wind turbines in one of the test areas (Billund and Hejnsvig). Furthermore, the first cell regulator prototype was tested at the grid simulation laboratory at Colorado State University. The results of the data collection and the laboratory tests are positive and promise well for the future mobilisation of distributed electricity generation.



14. References

The reports and notes below are available at Energinet.dk's website (www.energinet.dk).
Please note that they are only available in Danish.

- Analyseforudsætninger 2007-2016
- Analyseforudsætninger for regeringens: "En visionær dansk energipolitik 2025"
- Scenarierapport, fase 1
- Årsrapport, beredskab
- Miljørapport 2007

Appendix

Appendix 1: Analyses of "A visionary Danish energy policy 2025"

This Appendix presents results of the analyses of "A visionary Danish energy policy 2025".

1.1. Assumptions

The government's objective for the period up to 2025 is to achieve annual energy savings in end consumption of 1.25% against a scenario without energy savings initiatives. Even with strengthened electricity savings initiatives, the consequences of these assumptions will be an increase in electricity consumption from 35 TWh in 2005 to 38 TWh in 2025.

A number of production assumptions have been established concerning new plants and plants to be scrapped. They are based on the Danish Energy Authority's assumptions from the base projection of January 2007.

Table 1: Assumptions concerning new interconnections according to alternative 0 and alternative 1, respectively.

		Alternative 0	Alternative 1
Great Belt		600 MW	1,200 MW
Germany-Western Denmark	Imports:	950 MW	2,500 MW
	Exports:	1,500 MW	2,500 MW
Norway –Western Denmark		1,000 MW	1,600 MW

The projection of the prices of coal and oil in the analyses is based on the IEA "World Energy Outlook, 2006". This corresponds to the Danish Energy Authority's report on assumptions for socioeconomic analyses in the energy area issued in January 2007.

A more detailed description of the assumptions used can be found in the report on the analysis assumptions for the government's energy strategy: A visionary Danish energy policy 2025".

Projections for the period 2007-2016 are described in Environmental Report 2007.

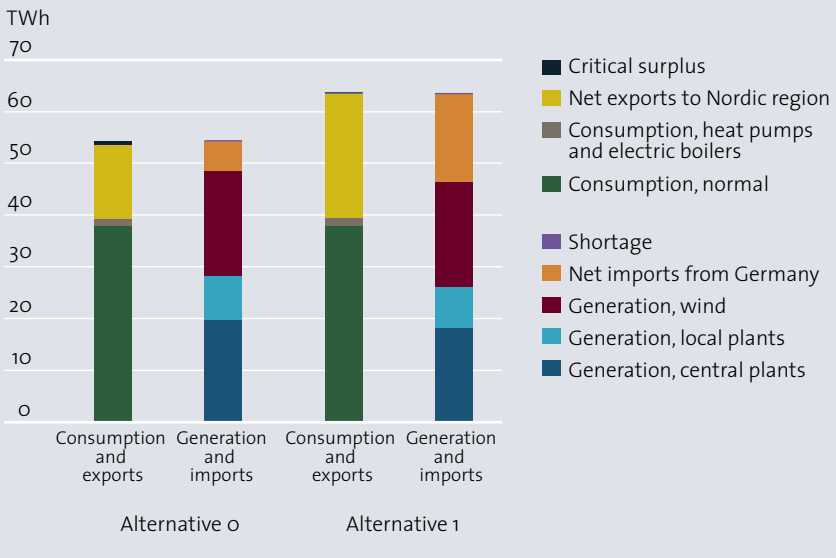
1.2. Two alternatives

Two alternatives are being investigated:

Alternative 0 comprises the existing electricity transmission grid, including the present interconnections with neighbouring areas and the decided Great Belt Power Link 1. Alternative 1 comprises not only existing and decided interconnections, but also the establishment of Great Belt Power Link 2 (600 MW assumed in operation in 2018) and Skagerrak 4 between Jutland and Norway (600 MW assumed in operation from 2013). In addition, the interconnection between Germany and Jutland will be upgraded to 2,000 MW in 2015 and to a total of 2,500 MW in both directions in 2025.

Alternative 1 is one of several opportunities for interconnection expansion. Skagerrak 4 is among Nordel's priority cross-sections, and the expansion of the interconnection between Jutland and Germany is among the EU's priority TEN projects (Trans-European Network). Another expansion across the Great Belt is at this point deemed to be realistic by

Figure 1: Electricity consumption, electricity generation and exchange for 2025. Exports and any critical electricity surplus have been added to the consumption column, while imports and any shortage have been added to the generation column.



Critical electricity surplus
Critical electricity surplus means the surplus electricity generation which cannot be sold in a particular area and which cannot be exported from the area.

Critical electricity surplus is a calculation concept that will never be used in practice as electricity generation must at all times equal electricity consumption, including net exports. In case of a critical electricity surplus, generation therefore has to be reduced.

2025 as it will support the domestic use of renewable energy and the security of supply within the Danish borders.

1.3. Energy balance, fuel consumption and emissions

Based on the assumptions concerning electricity and district heating consumption, production capacity, price level and interconnections, assessments have been made of the consequences of "A visionary Danish energy policy 2025" for the energy balance, the fuel consumption, the emissions, the power balance, the need for ancillary services and the transmission grid.

1.3.1 Energy balance

The electricity system balance of production, consumption and international exchanges must be maintained under all operating conditions, and the resulting energy balance has therefore been assessed for the two alternatives.

Figure 1 shows energy balances in 2025 for alternatives 0 and 1. The values are stated as annual sums of calculated hourly values.

Imbalances in individual hours are stated as either "critical electricity surplus" or "shortage".

It can be seen that the main difference between the two alternatives is the volume of international trading. The stronger interconnections of alternative 1 lead to a considerable increase in both imports and exports and a moderate reduction of production at central and local CHP plants.

Alternative 0 comprises imports from Germany of 5.7 TWh and exports to the Nordic region of 14.2 TWh. It includes a critical electricity surplus of 0.7 TWh, distributed on approx. 900 hours. The largest surplus in any one hour amounts to 2,215 MW, and in over 260 hours it exceeds 1,000 MW.

In alternative 1 the international energy exchanges have increased considerably, but the pattern of imports from Germany and exports to the Nordic region remains the same. The critical electricity surplus is reduced to 25 GWh over approx. 100 hours, and the largest surplus in any one hour is 625 MW.

The volume of electricity generated from wind power is expected to increase from 6.6 TWh in 2005 to 20.2 TWh in 2025, corresponding to 51% of electricity consumption. Electricity generation based on wind turbines constitutes approx. 44% of the total electricity generation.

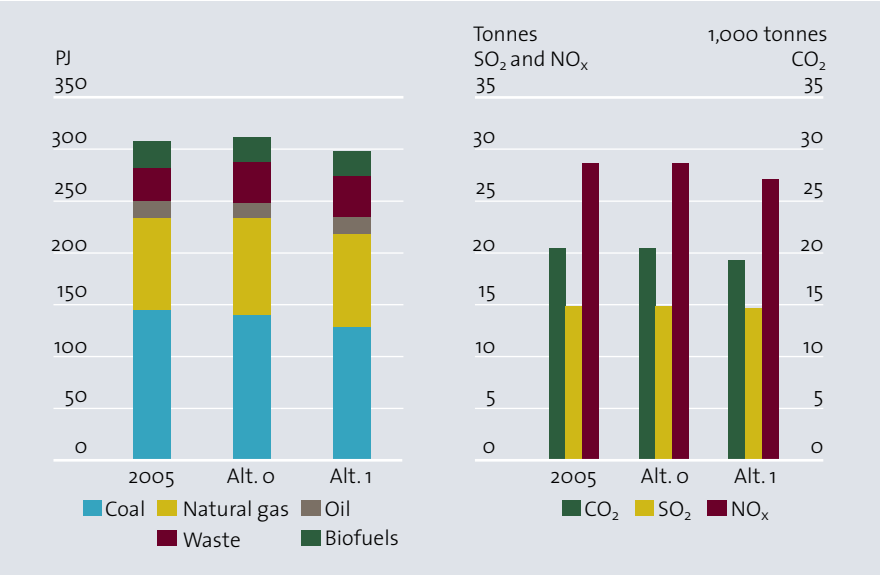
With alternative 0, wind turbine expansion thus results in considerable critical electricity surplus and system imbalance which must be compensated for by other means, while the stronger interconnections of alternative 1 make it possible to maintain system balance to a much larger extent.

1.3.2 Fuel consumption and emissions

In order to see how the electricity and CHP industry contributes to realising the objectives of constant energy consumption, long-term phasing out of fossil fuels (15% reduction by 2025) and environment, "A visionary Danish energy policy 2025" has been assessed in terms of its consequences for fuel consumption and emissions.

Developments in fuel consumption and emissions in 2025 can be seen in Figure 2 for alternative 0 and alternative 1, respectively. Furthermore, fuel consumption is shown for 2005, which was close to a normal year with relatively modest exports of 1.4 TWh. As can be seen, fossil

Figure 2: Fuel consumption for electricity and CHP generation and emissions of SO_2, NO_x (measured in tonnes) and CO_2 (measured in 1,000 tonnes) in 2005, alternative 0 and alternative 1 for 2025.



fuel consumption in the electricity and CHP industry is at roughly the same level as in 2005.

As the fuel mix will not change substantially from 2005 to 2025, neither will emissions. It should be noted that CO_2 emissions per produced unit in Denmark will fall from 500 g/kWh in 2005 to 420 g/kWh in 2025, which is primarily due to the increase in wind power generation from 6.7 TWh in 2005 to 20.2 TWh in 2025.

Thus, at the given assumptions the electricity and CHP industry will not contribute to any appreciable extent to fulfilling the government's objective of reducing Danish fossil fuel consumption by 15% up to 2025.

National emissions and fossil fuel consumption will not decrease despite the massive wind power expansion for reasons of increasing electricity consumption and growing exports. Given the assumption of a CO_2 allowance price of DKK 150/tonne in 2025, renovated Danish high-efficiency coal-fired power stations will be competitive in the international electricity market. At the assumed fuel prices of coal (DKK 18/GJ) and natural gas (DKK 46/GJ) coal-based electricity generation, for instance, will be cheaper than natural gas-based electricity generation at CO_2 allowance prices of less than approx. DKK 500/tonne.

Reserves
Risk of outages of production units and interconnections and uncertainty of consumption and wind power forecasts involve a need for upward and downward regulation reserves, which can be activated at all times by TSOs to balance the system.

Regulating power
Regulating power is the actual upward and downward regulation service activated by the order of TSOs.

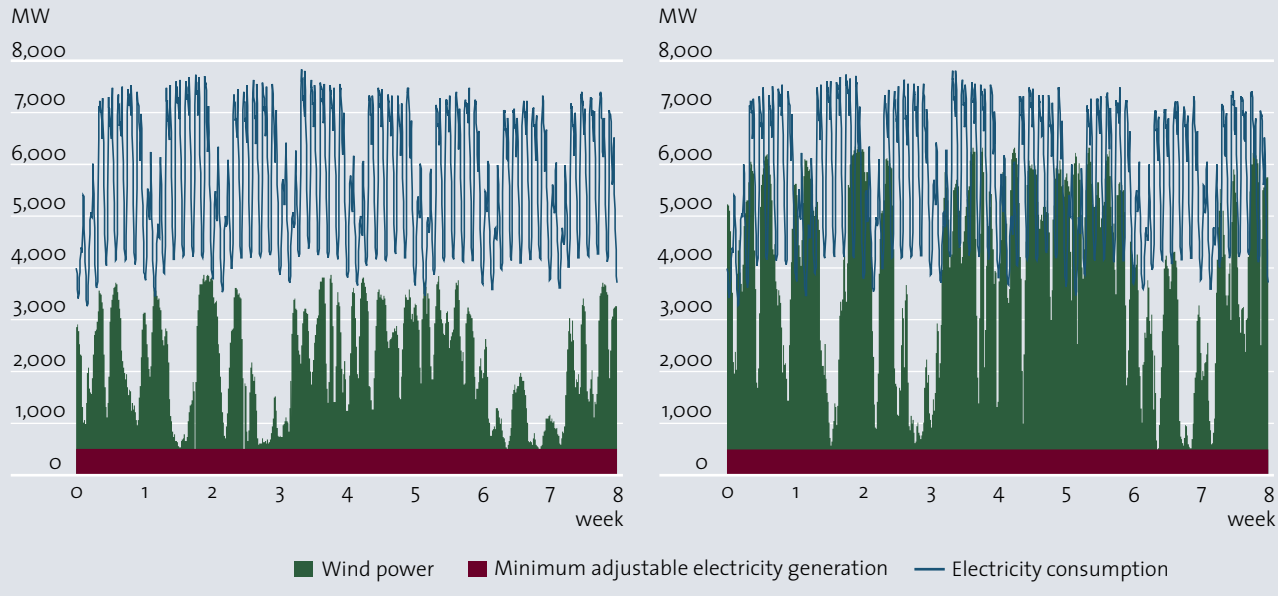
Alternative 1 provides for higher exports than alternative 0 due to the increased capacity of the interconnections. Increased cross-border trading in 2025 is a precondition if the Danish system is to balance at the large wind power share while maximising the value of wind power. The trading growth from alternative 0 to alternative 1 (see Figure 1) is solely due to the expansion of the interconnections to Norway and Germany and across the Great Belt.

As Denmark is an integral part of the European electricity market, a separate calculation of the environmental impact of the Danish renewable energy expansion is not possible. Such a calculation must necessarily include the reduced emission from the displaced generation in the importing country. All other things being equal, increased Danish generation of renewable energy will primarily displace fossil fuel-based electricity generation in the interconnected market area.

1.4. Balancing the electricity system

The electricity system requires a constant accurate balance between production and consumption. It is therefore necessary always to have reserve capacity available that can provide the required regulating power at short notice. The growing share of wind power is accompanied by an

Figure 3: Consequences for system balance of a further 3,000 MW wind power in the system. The minimum adjustable electricity generation is necessary to regulate and stabilise the electricity system.



increasing need for reserve capacity, which is necessary to ensure that it is always possible to balance the entire system.

Today, regulating power is supplied from central and local production plants in Denmark and from abroad.

Figure 3 shows the consequences for the system balance of a 3,000 MW wind power expansion compared to the situation today. It is assumed that the necessary share of other electricity generation may be reduced to 500 MW in total, which is highly optimistic. Even at this assumption it can be seen that wind power will exceed domestic demand for many hours. The function of the thermal production plant will change from basic and medium to peak-load production and to regulating power and exports. Future demand for new thermal plants will therefore be for quickly regulating units with relatively few annual hours of operation.

Uncertainty of wind forecasts contributes to increasing the need for regulation – in special cases the gap from one hour to the next may be up to 75% of the installed wind turbine capacity.

Adjusting for the uncertainties of the forecasts requires sufficient available regulating power. An increased volume of wind power would require larger available volumes of regulating power, and it would be necessary to reserve the volume (purchase reserves) that cannot automatically be expected to be available when the need arises.

In order to maintain the voltage in the electricity system the required number of units with voltage-control properties must be available, ie units capable of using/producing reactive power (Mvar). Today, this is done by means of different

Reactive power
Reactive power takes up capacity in the power grid. At the same time, it is a precondition for maintaining voltage and for restoring the voltage after serious system disturbances such as blackouts.

electrical components and central power stations. In the light of the expectations for the phasing out of several central power stations, it will be necessary to establish other types of reactive resources in the long term.

To withstand faults and other dynamic incidents in the electricity transmission grid it is currently necessary to keep a minimum of central power stations in operation in each synchronous area (Eastern and Western Denmark). In a future where wind power alone will be able to cover electricity consumption for part of the time, it is expected that several central power stations will be stopped for shorter or longer periods of time. This will have a direct effect on the dynamic properties of the electricity system as those production units have a number of principal system properties. To achieve the same system security these properties will have to be supplied by alternative electrical components, eg synchronous compensators and power-electronic units. Future offshore wind farms are not expected to contribute system capabilities to any significant extent.

In the event of major interruptions of supplies, special resources are required to re-establish supplies. Normal electricity-generating plants need electricity to restart electricity generation. Therefore, in a total blackout, access to current either from abroad or from special emergency start units capable of black start is necessary.

1.5. Consequences for the power balance

The assumption of approx. 6,500 MW wind power in 2025 means that a substantial part of the present basis for business of the central and local CHP plants has been taken over by wind turbines. As a consequence, several of those plants may no longer be profitable in their present form and will therefore be scrapped.

At the given assumptions there will be a conventional production capacity (coal, gas, biomass) in 2025 of approx. 6,400 MW and a maximum consumption of approx. 7,200 MW, corresponding to a 10-year winter. Thus, conventional domestic plants will no longer be capable of covering the maximum consumption, and part of the power will have to come from wind turbines or from abroad.

The power demand has been calculated for a so-called 10-year winter without taking account of reserve capacity. If reserve capacity is set aside, the balance will be further weakened.

While the wind turbines reduce the traditional power stations' share of the domestic electricity market, the need for regulating services and thus the basis of business for plants that are suitable for supplying them increases. The above-mentioned power balances do not include contributions from new plants of this type.

Based on the above, Energinet.dk will assess the measures required to ensure long-term access to sufficient generation capacity with the necessary power regulating capabilities.

n-1 principle
The n-1 principle means that electricity system operation must be maintainable in the event of an outage of any grid component (line, transformer or generator). In practice this means that outage of a single grid component must not lead to persistent overload of the remaining grid components or give rise to instability in the electricity system.

Table 2: Number of hours of overload of the 400 kV grid in Central Jutland in alternatives 0 and 1 with an intact grid and with the outage of a single grid component, respectively.

	Alternative 0	Alternative 1
	Hours	Hours
Outage of a single grid component (n-1)	1,600	8,200
Intact grid	0	2,500

1.6. Electricity transmission grid in 2025

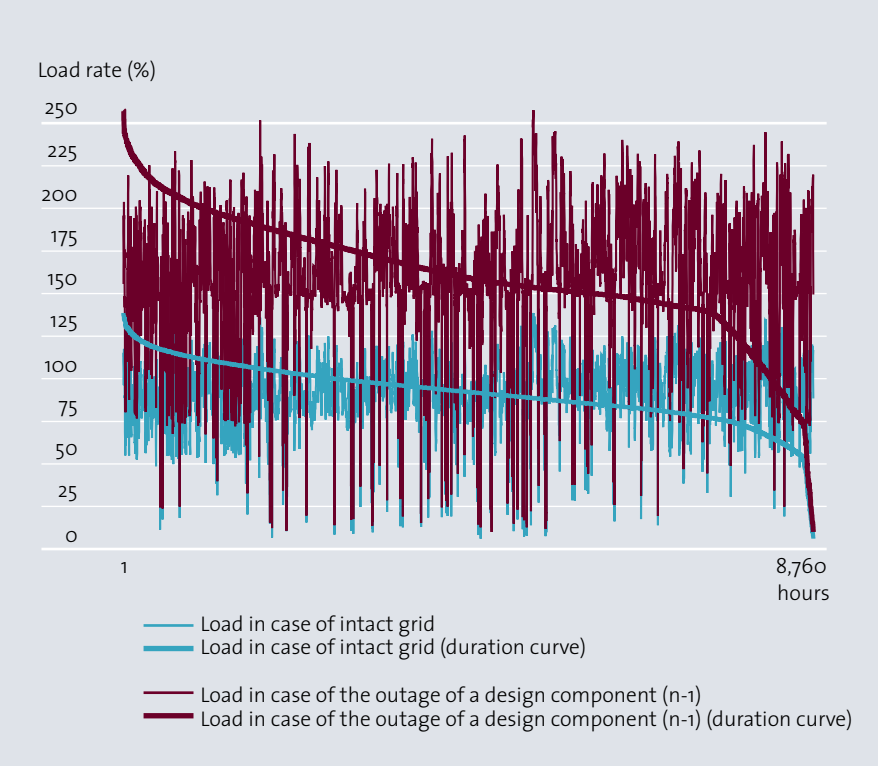
In the period up until 2025, two factors will be of vital importance to the development of the electricity transmission grid: grid connection of offshore wind farms and power exchanges with neighbouring areas.

The analyses assume that new offshore wind farms will be established with two 200 MW wind farms at Anholt, five 200 MW wind farms at Horns Rev and three 200 MW wind farms at Jammerbugten. While connection of the offshore wind farms at Jammerbugten and Anholt does not require actual reinforcement of the transmission grid, the location at Horns Rev does.

The electricity generated at Horns Rev and the other production in Western Jutland exceeds local consumption most of the time. There is a local surplus of electric power that must be used in the large consumption centres to the north and along the east coast of Jutland. So the power needs to be transported across Jutland and to the north.

The concentration of offshore wind turbines at Horns Rev is thus a key reason for the grid overload. The electricity generation at Horns Rev combined with exchanges with neighbouring countries creates a need for reinforcement and expansion of the transmission grid in Jutland. The planned expansion with onshore wind turbines may also lead to a need for transmission grid reinforcements, but the details cannot be specified until the geographical location of the new turbines has been determined.

Figure 4: Simulated load on the 400 kV Central Jutland power line in 2025 - alternative 1.



1.6.1. Overloads in alternative 0

According to alternative 0, maximum load in the 400 kV grid in Central Jutland often occurs in peak-load situations of northbound power transmission via the interconnections with a significant wind power contribution to generation. According to alternative 0, the 400 kV grid in Central Jutland will be subject to overload for approx. 1,600 hours a year. On Zealand, the 132 kV grid located in Southern Zealand will primarily be overloaded in situations with major wind power generation contributions often exceeding local electricity consumption. Thus, the 132 kV grid has to transmit large volumes of power from areas with a local power surplus to other areas with a local power deficit – typically in Central Zealand or in the metropolitan area.

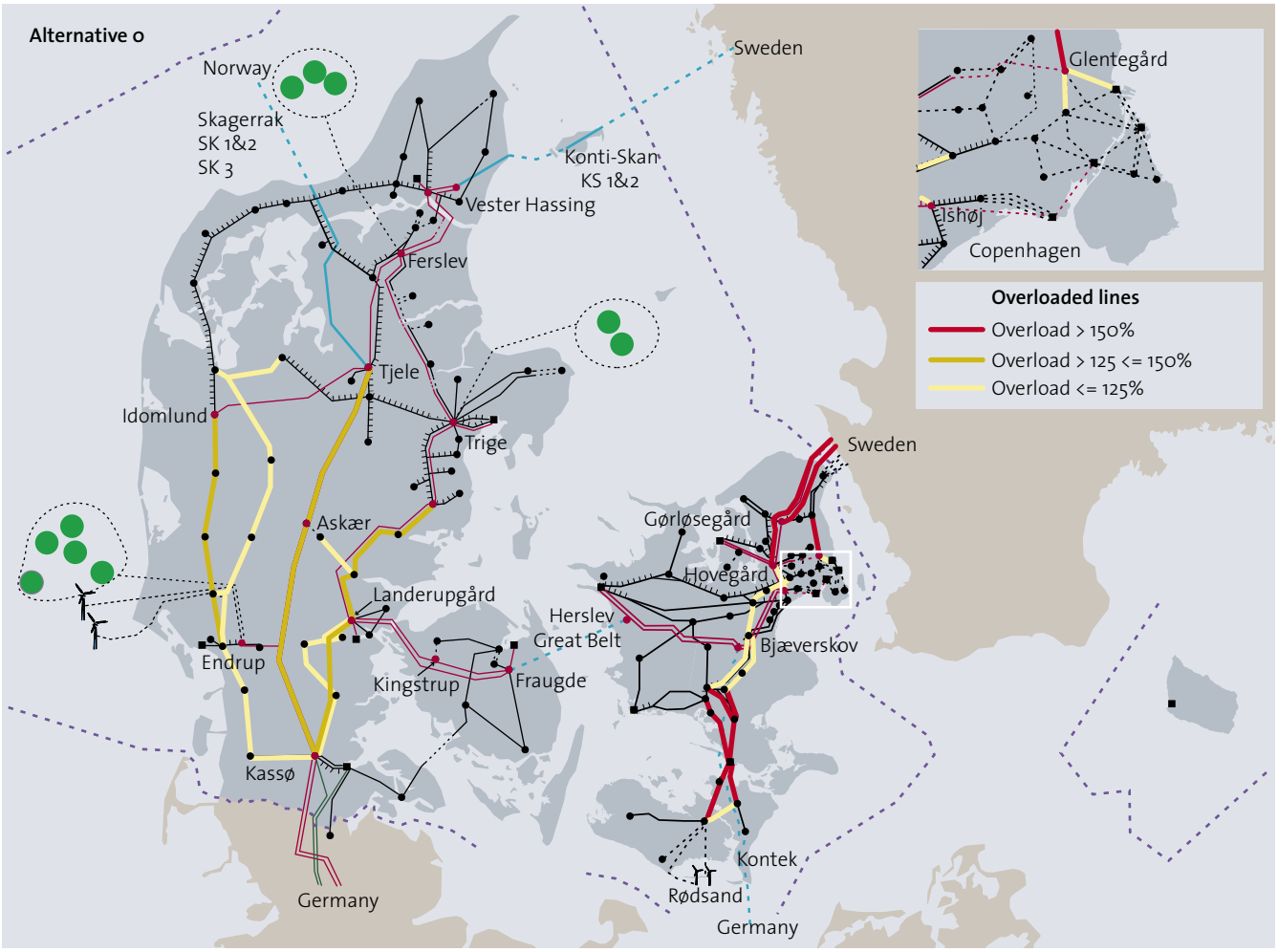
1.6.2 Overloads in alternative 1

According to alternative 1 the 400 kV grid in Central Jutland will be subject to overload for approx. 8,200 hours a year in case of the outage of a design component (see Table 2). Furthermore, the grid will be overloaded for approx. 2,700 hours in case of an intact grid, which emphasises the need for grid reinforcement. Thus, the overload issue is aggravated in alternative 1 in that the increased transfer capacity via the interconnections with the neighbouring countries and via the interconnection between Western and Eastern Denmark will lead to increased northbound and eastbound power transmission. The overloads typically occur in peak-load situations and in connection with northbound power transmission via the interconnections, full exchange across the Great Belt Power Link towards Zealand and with a major wind power contribution to generation.

Figure 4 shows a simulation of the load on the 400 kV interconnection in Central Jutland on the section between Kassø and Tjele. The calculation has been made hour by hour in 2025 for alternative 1. The figure shows the load with an intact grid and with the outage of a grid component. The extent of the overload has been quantified by converting the calculated hourly values into a duration curve. A load rate of 100% corresponds to the nominal transmission capacity of the interconnection.

The figure shows a load of up to 260% on the 400 kV power line, ie an overload of 160% in relation to the nominal transmis-

Figure 5: Grid overloads according to alternative 0. It should be noted that the overloads illustrate the problem before measures have been taken to reduce them.



sion capacity of the overhead line. Even with an intact grid the line is overloaded.

It should be noted that overload situations of the extent described above will never occur in practice as countermeasures would be introduced before they arise. Especially in alternative 1 the overloads are of an extent that exceeds the physical capacity of the grid. There would be a high risk of system failure and permanent damage to lines and other installations. In practice, it would not be possible to realise alternative 1 without expanding and reinforcing the national electricity transmission grid.

1.6.3. Need for new infrastructure

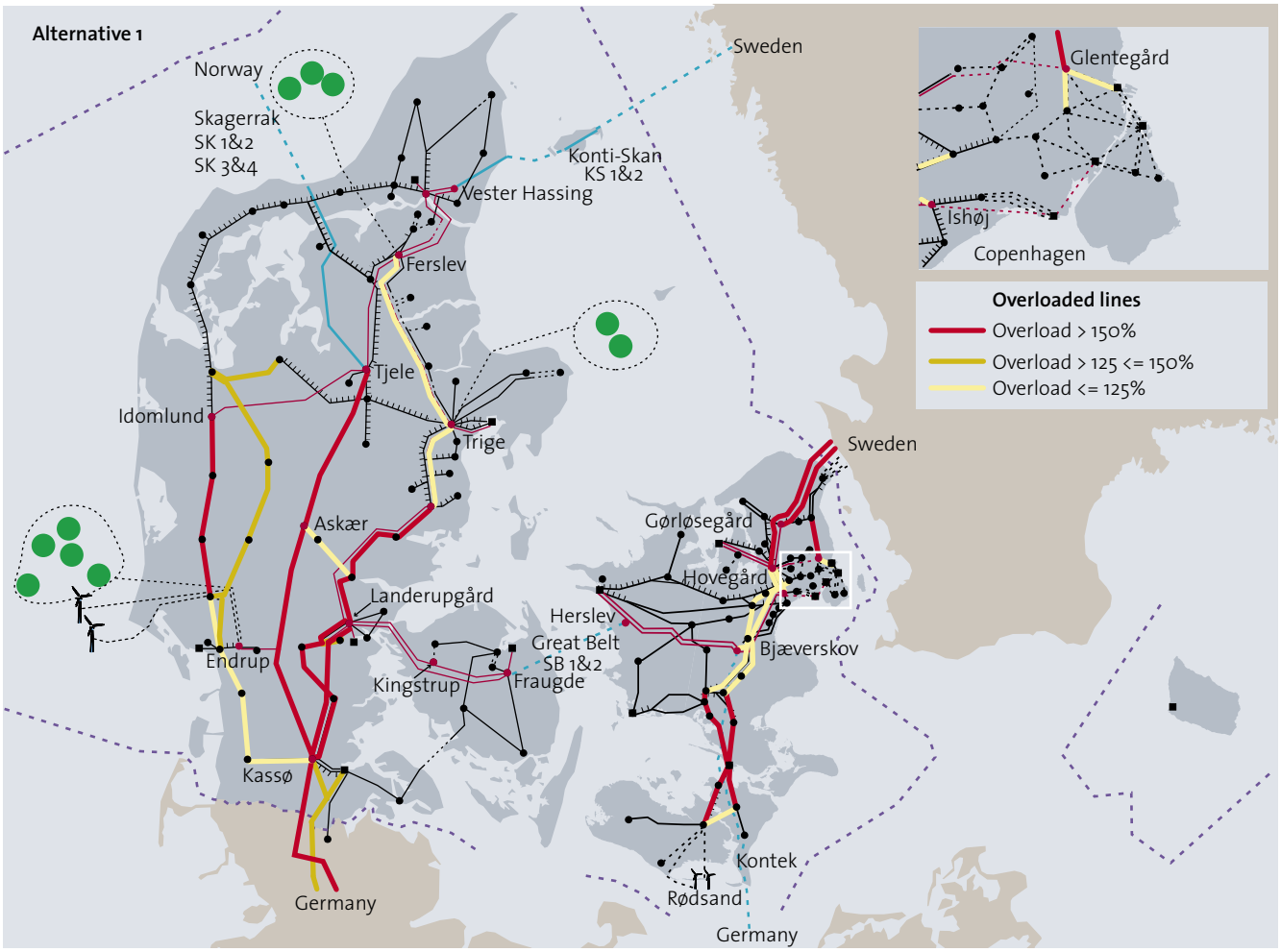
Figures 5 and 6 illustrate the components that are overloaded in case of an outage of a single component (n-1). The overloads shown typically occur in case of the outage of a vital component (eg a 400 kV line or a transformer) whereby the remaining transmission grid has to transmit even larger volumes of energy and is therefore overloaded.

Without reinforcement of the grid, power transmission will lead to overloading of the 150 kV grid in Western Jutland and the 400 kV grid in Central and Eastern Jutland. The 400 kV grid in Central Jutland in particular will be subjected to a heavy load. The same applies to the 132 kV grid in Southern Zealand and the 400 kV grid in Northern Zealand.

The overall situation is that wind power is the main cause of overloads in the eastbound/westbound direction. In addition to wind power, in the northbound/southbound direction the power exchanges via the interconnections to the neighbouring countries also cause the grid to be overloaded.

Alternatives 0 and 1 both emphasise the need for a new infrastructure. Where and to what extent an expansion of the domestic transmission grid will be

Figure 6: Grid overloads according to alternative 1. It should be noted that the overloads illustrate the problem before measures have been taken to reduce them.



necessary depends on the alternative considered. The increased interconnection capacity of alternative 1 will create a greater need for reinforcement than alternative 0. Exchanges with the neighbouring countries are already a precondition for reliable operations and a well-functioning market today. A larger share of wind power will further increase this tendency.

Fjordvejen 1-11
DK-7000 Fredericia
Tlf. +45 70 10 22 44
Fax +45 76 24 51 80
info@energinet.dk
www.energinet.dk

New address after 1 January 2008
Tonne Kjærsvej 65, DK-7000 Fredericia

Photos:
Ole Christiansen

Layout:
Corporate Communications, Energinet.dk

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ENERGINET.DK

Fjordvejen 1-11
DK-7000 Fredericia
Tlf. +45 70 10 22 44
Fax +45 76 24 51 80

info@energinet.dk
www.energinet.dk

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Tonne Kjærsvej 65
DK-7000 Fredericia