

Strategy Plan 2010



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1. Summary



Electricity

Energinet.dk is working with an overall strategic plan to support a significant expansion of wind power in the short, medium and long term.

In Denmark, there is broad political consensus for reducing the emission of greenhouse gases significantly through increased utilisation of renewable energy. During his Opening Day speech to the Danish Parliament in October 2010, the Prime Minister stated that the Government's long-term objective for the energy area is to achieve fossil fuel independence by 2050.

In recent years, the EU has adopted a new role in the energy area. The member states have decided to strengthen their cooperation, and this development is leading to greater integration of European markets, more binding agreements for a common energy and environmental policy and greater regulation and coordination between member states.

In the coming years, the EU is expected to place a particular strategic focus on the following five points:

- Energy efficiencies resulting in energy savings of 20% by 2020
- Development of the single energy market, which ensures competitive prices and supports security of supply

- European cooperation to deliver efficient technologies to the market more rapidly
- Secure supply of energy at fair prices and with a focus on solidarity
- Strong international partnerships and cooperation agreements, especially with neighbouring areas.

Development of the power system – Power System 2025

Energinet.dk is working with an overall strategic plan to support a significant expansion of wind power in the short, medium and long term. Specifically, Energinet.dk is working with plans to develop and expand the power system so that it will be able to handle a situation within the next 10-15 years where wind power generation covers 50% of electricity consumption. To meet this challenge Energinet.dk has implemented a series of initiatives under the overall heading Power System 2025. The objective of this work is to integrate wind power into the power system via market-based solutions while also ensuring a continued

high level of security of supply. The main elements of Power System 2025 are:

- Expansion of the electricity infrastructure: a robust electricity infrastructure is essential for transmitting large amounts of wind energy. Consequently, Energinet.dk is expanding the interconnections and the transmission grid as well as undergrounding and restructuring elements of the transmission grid.
- Increased flexibility in electricity generation and consumption: through targeted work towards ensuring efficient and international markets and increased interaction between the various energy sectors, the preconditions for increased flexibility improve, thus supporting power system balancing. Increased electricity consumption in the heat and transport sectors, for example, will also lead to a reduction in total energy consumption as electricity-based solutions are generally characterised by a high degree of energy efficiency.
- Development and implementation of Smart Grid solutions in Denmark:



intelligent communication between electricity consumption and electricity generation promotes an efficient interaction between consumption and generation based on market price signals.

Although, power system balancing is an important and central element in wind power integration, it is not in itself a sufficient goal for effective wind power integration. The goal is to maximise the market value of wind power, primarily through:

- Efficient domestic utilisation of wind power
- Flexibility in the other electricity-generation units
- Efficient international markets.

Energinet.dk has identified a number of specific means that can contribute to the effective integration of wind power generation in future. These means can be divided into two overall categories: means mainly contributing to power system balancing and means primarily focusing on the integration of electricity into other sectors in the form of potential demand response. At the same time,

the latter of the aforementioned means can also contribute to power system balancing. According to the framework established, the means must function on market terms.

Of the solutions that represent potential short- and long-term means, Energinet.dk will in the coming years place a particular focus on:

- Expansion of interconnections including reinforcement and restructuring of internal transmission grids
- Market coupling
- Development of a Smart Grid
- Flexibility in generation and consumption.

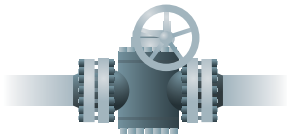
Development of the gas system

Energinet.dk is facing two main challenges in relation to the development of the Danish gas system: to maintain security of supply when Danish natural gas production in the North Sea starts to decline and to prepare for the integration of new renewable energy gases into the gas system. On the background of falling supplies from the North Sea and

market demand, Energinet.dk has chosen to invest in new infrastructure that would facilitate supply to Denmark and Sweden from Germany.

In addition to the capacity increase resulting from the investment in new infrastructure to Germany, there are benefits associated with creating the possibility for importing gas from other sources, eg via a connection to Norwegian gas resources. Moreover, a connection to Norway will have a considerable significance in relation to creating a possibility for sending gas supplies on to the northern European market and the Baltic states, thus contributing to regional security of supply. Energinet.dk has launched a number of initiatives to investigate the physical and commercial possibilities for a Danish-Norwegian gas interconnection.

Natural gas with its relatively low CO₂ emissions can be the fuel that bridges the transition to fossil fuel independence. Consequently, gas can replace fuels with a higher CO₂ content such as oil and coal, as has happened in the United Kingdom. In the long run, the composition and environmental pro-



Gas

Energinet.dk is facing two main challenges in relation to the development of the Danish gas system: to maintain security of supply when Danish natural gas production in the North Sea starts to decline and to prepare for the integration of new renewable energy gases into the gas system.

file of gas will change concurrent with the large-scale conversion of agricultural slurry to biogas, which displaces natural gas.

Today, the biogas produced is exclusively used in local energy generation. On the basis of the Green Growth agreement target to utilise 50% of manure for energy generation by 2020 and a long-term objective of fossil fuel independence, it is relevant to view the potential of biogas in a broader context to ensure that it is used as efficiently as possible.

Energinet.dk will ensure that the market models in the gas area support a socio-economically effective use of biogas. For example, it may be advantageous to upgrade the share of the biogas that cannot be used direct in CHP generation to transport and store the biogas in the gas system. In 2010, Energinet.dk incorporated a biogas market model into its Rules for Gas Transport to support the integration of biogas into the gas transmission network. The model is expected to be supplemented with a documentation scheme in 2011, to be used for trading biogas via the gas network.

Natural gas will play an integral role in the transition to a fossil-fuel free energy system. Moreover, in such an energy system that is independent of fossil fuels, the gas system will still constitute a significant asset. In contrast to electricity and heat, gas is relatively inexpensive to store in very large volumes of energy for extended periods.

The gas system will facilitate better utilisation of renewable energy gases such as biogas, and natural gas will thus act as a stepping stone towards an energy supply that is independent of fossil fuels. Besides contributing to the reduction of CO₂ emissions and power system balancing, increased production of renewable energy gases will also strengthen the Danish level of self-sufficiency.

Development of the gas market should continue to be prioritised in order to secure new opportunities for trading both internally in Denmark and in particular with neighbouring countries to maintain the competition for gas.

2. Framework for Energinet.dk



The formal framework for Energinet.dk is described in the Danish Act on Energinet.dk and is implemented in Energinet.dk's mission:

As the entity responsible for the electricity and natural gas systems, we own the overall energy infrastructure, ensure reliable energy supply and create the framework for well-functioning energy markets and effective integration of renewable energy.

The objective of Energinet.dk is expressed in the vision:

Using international and preferably market-based solutions, we will facilitate the increased use of renewable energy and help to solve the global energy and climate challenges.

In addition to the energy policy objectives in Denmark and the EU, the European TSO cooperation for electricity and gas, ENTSO-E and ENTSOG, helps to form the framework for Energinet.dk's work.

In recent years, security of supply and climate challenges have been focal points of energy policy in both Denmark and the EU. This trend is expected to continue

in the coming years, with a particular emphasis on security of supply and fossil fuel independence.

The production of oil and natural gas in the North Sea is expected to decline so much by 2013 that Denmark, due to the import of coal, will move from being a net exporter of fossil fuels to being a net importer¹.

The supply of energy in Denmark is facing a transition, and the Government's objective is to make the supply of energy independent of fossil fuels by 2050.

Energinet.dk's Strategy Plan 2010 supports the long-term vision of a Denmark that is independent of fossil fuels and links it to specific initiatives that should be implemented in the short and medium term to fulfil this ambition. There is a focus on initiatives that remain robust in the face of leaps in technology and other significant changes on the path to achieving the long-term objective of fossil fuel independence.

¹ 'Denmark's oil and gas production', Danish Energy Agency, 2009.

2.1 Energy policy objectives – Denmark

The current energy agreement is valid from 2008-2011, and a new agreement is expected in the course of 2011. The energy agreement was a first step towards the objective of reducing Denmark's dependence on fossil fuels.

In the autumn of 2010, the Danish Commission on Climate Change Policy (Climate Commission) put forward its proposal showing how the Government's long-term vision of fossil fuel independence could be achieved. The Climate Commission has indicated that a considerable expansion of renewable energy and significant energy efficiencies should be implemented if the Danish energy system is to become independent of fossil fuels in the long term.

During his Opening Day speech to the Danish Parliament in October 2010, the Prime Minister stated that the Government's objective for the energy area is to ensure fossil fuel independence by 2050. The coming energy agreement is therefore expected to form the framework for development in the short and medium term to-



Mission:

As the entity responsible for the electricity and natural gas systems, we own the overall energy infrastructure, ensure reliable energy supply and create the framework for well-functioning energy markets and effective integration of renewable energy.

Vision:

Using international and preferably market-based solutions, we will facilitate the increased use of renewable energy and help to solve the global energy and climate challenges.

wards fossil fuel independence, integration of more renewable energy as well as investment in research, development and demonstration. The long-term vision of fossil fuel independence places considerable demands on the entire Danish energy sector, which has acknowledged its readiness to meet this challenge.

Energy research, development and demonstration (RD&D) are highly prioritised in Danish energy policy. This is evident in the current energy agreement, which provided for a doubling of funding for RD&D. Also under the auspices of the EU, additional funding has been allocated to RD&D in recent years. The intensive building of knowledge and its application are crucial for Denmark's and the EU's competitiveness and technological innovation of energy and climate-friendly technologies.

2.2 Long-term development of the Danish energy system

In 2010, Energinet.dk issued the report 'Energi 2050' (*Energy 2050*) (only available in Danish), which describes four possible tracks for developing the energy system of the future. Similar to the Climate Commission, Energinet.dk views the power

system as the central element in the energy system of the future. The share of energy transmitted via the power system will rise significantly as wind power, which is expected to become the largest renewable energy source in Denmark in the long term, is integrated into the energy system via the power system. Consequently, the power system will become the backbone of the entire energy system.

The electricity market is central to the further development of flexibility in electricity generation and consumption. This significant conversion of the energy system places demands on the development of the electricity market so that in a future characterised by considerable changes in the framework conditions, it will continue to support an effective balancing of electricity generation and consumption.

In the long term, the district heating system is also expected to constitute a vital element in the supply of heat, and central heat pumps are expected to gain a footing in the supply of district heating. Moreover, heat pumps are expected to play a key role in households without collective heating. In the transport sec-

tor, electricity is expected to become the main propellant for road transport, while biofuels is expected to become the primary propellant in heavy-duty road transport segments.

In an energy system characterised by large amounts of wind power, the gas system is well positioned to contribute to the balancing of the fluctuating electricity generation. Gas as a fuel is a form of energy to which most renewable energy resources can be converted. Biogas production is a proven process, just as thermal biomass gasification is also an acknowledged and existing technology. Consequently, a gas system based on renewable energy gases will be relevant in the long term. Fuel cells based on gas are also expected to become competitive for peak-load production in the long term.

2.3 Energy policy objectives – the EU

In recent years, the EU has adopted a new role in the energy area. The member states have decided to strengthen their cooperation, and this development is leading to greater integration of European markets, more binding agreements for



common energy and environmental policy and greater regulation and coordination between member states.

The 20-20-20 targets are the focal point of the common energy policy in the EU. According to the targets, total CO₂ emissions in the EU must be reduced by 20% in 2020 compared with the level in 1990, and the EU's share of renewable energy in 2020 must constitute 20% of its total energy consumption. The target for Denmark is 30%.

In the coming years, the EU is expected to place a particular strategic focus on the following five points:

- Energy efficiencies resulting in energy savings of 20% by 2020
- Development of the single energy market, which ensures competitive prices and supports security of supply
- European cooperation to deliver efficient technologies to the market more rapidly
- Secure supply of energy at fair prices and with a focus on solidarity

- Strong international partnerships and cooperation agreements, especially with neighbouring areas.

In addition, the EU will continue its work to implement the third liberalisation package in the national legislations.

Joint coordination

Coordination of an overall energy policy position will increase the collective influence of the EU on regional and global energy markets and thus contribute to maintaining security of supply in member states.

One example of the EU's efforts to ensure security of energy supply is the adoption of the regulation on security of gas supply. The regulation contains a requirement for member states to ensure gas supplies upon interruption or breakdown of the main source of gas supply and to cooperate regionally to ensure security of supply. The regulation is aimed at preventing any new gas crises from affecting the EU, such as the one between Russia and Ukraine. Gas supply is expected to play a significant role in the proposal for an infrastructure package, which the EU will submit for adoption in 2011.

Investments in infrastructure

Investments in infrastructure are necessary to further develop the single energy market, integrate renewable energy and ensure security of supply.

The coming EU infrastructure package is expected to address the challenges of outdated grids, the need for increased cross-border integration, increased diversification of energy import routes and not least the integration of renewable energy to achieve the target of 20% renewable energy in 2020.

On the electricity side, there is particular focus on establishing an offshore grid in the North Sea as well as securing a robust and integrated infrastructure onshore. On the gas side, the focus is on improving the outdated grids in Eastern Europe and diversifying the gas supply routes. The EU considers gas from the North Sea and particularly from Norway to the Baltic states to be an important element in the diversification of import routes.

The EU has various possibilities for allocating funding to infrastructure projects. So far, approximately DKK 150 million has been allocated annually in the TEN-E



Energinet.dk works determinedly in international forums to influence the decision-making processes in a way that safeguards Energinet.dk's core tasks and Danish interests.

programme, and the EU is expected to present new funding programmes next year. However, the majority of the investments in infrastructure continue to be financed by the TSOs through congestion rents and tariffs.

Moreover, as a part of its European Economic Recovery Plan, the EU has allocated approximately DKK 30 billion to electricity and gas infrastructure, offshore wind farms as well as CO₂ capture and storage. The Recovery Plan focuses on investments in infrastructure that are of key importance to the EU and which can also contribute positively to economic development.

In 2010, Energinet.dk obtained a commitment for funding from the European Economic Recovery Plan for three large infrastructure projects: the establishment of an offshore electricity grid at Kriegers Flak, the establishment of a DC cable between Denmark and the Netherlands with the potential for the additional connection of offshore wind turbines, and an expansion of the gas transmission network between Denmark and Germany. In all, the EU has committed to total funding of approximately DKK 2.5 billion for the three infrastructure projects.

2.4 European TSO organisations

Under the third liberalisation package, two European organisations for TSOs in the EU called ENTSO-E (electricity) and ENTSOG (gas) were established. This has resulted in more committed cooperation than the voluntary regional forms of TSO cooperation that previously existed.

Tasks in the two organisations will be very similar in the coming years. The principal task of the two organisations is to prepare and develop market and technical regulations, and to prepare 10-year grid expansion plans.

Energinet.dk works determinedly in international forums to influence the decision-making processes in a way that safeguards Energinet.dk's core tasks and Danish interests. Energinet.dk assumes a significant role under the auspices of ENTSO and holds key positions in working groups, regional groups, committees and boards within both electricity and gas.

Consolidation of TSOs

Several German electricity TSOs have been sold as a consequence of the implementation of the third liberalisation pack-

age. TSOs in Germany are privately-owned public limited companies, which historically have been part of corporate groups that have produced and traded energy. The German TSO 50Hertz Transmission GmbH, which was formerly owned by Vattenfall, is today part owned by the Belgian TSO Elia. Another German TSO, Transpower Stromübertragungs GmbH, has been taken over by the Dutch TSO TenneT and is now called TenneT TSO GmbH.

On the gas side, the Dutch company Gasunie has taken over the north German TSO BEB, which is today called Gasunie Deutschland.

Transnational ownership constitutes a further push towards more integrated European electricity and gas markets, yet there are also other consequences of a European consolidation of TSOs in Europe. When TSOs near Denmark consolidate, some of them become relatively large while others remain relatively small. Energinet.dk is a relatively small TSO. However, through the targeted investment of significant work resources in ENTSO-E and ENTSOG, Energinet.dk has achieved influence on key decisions within the European TSO cooperation.

3. Development of the power system



Energinet.dk is working with an overall strategic plan to support a significant expansion of wind power in the short, medium and long term. Specifically, Energinet.dk is working on plans to develop and expand the power system so that it will be able to handle a situation within the next 10-15 years where wind power generation covers 50% of Danish electricity consumption. To meet this challenge Energinet.dk has implemented a series of initiatives under the overall heading Power System 2025. The objective of this work is to integrate wind power into the power system via market-based solutions while also ensuring a continued high level of security of supply. The main elements of Power System 2025 are:

- Expansion of the electricity infrastructure: a robust electricity infrastructure is essential for transmitting large amounts of wind energy. Consequently, Energinet.dk is expanding the interconnections and the transmission grid as well as undergrounding and restructuring elements of the transmission grid.
- Increased flexibility in electricity generation and consumption: through targeted work towards ensuring efficient

and international markets and increased interaction between the various energy sectors, the preconditions for increased flexibility improve, thus supporting power system balancing. Increased electricity consumption in the heat and transport sectors, for example, will also lead to a reduction in total energy consumption as electricity-based solutions are generally characterised by a high degree of energy efficiency.

- Development and implementation of Smart Grid solutions in Denmark: intelligent communication between electricity consumption and electricity generation promotes an efficient interaction between consumption and generation based on market price signals.

Within these three main elements, Energinet.dk is working on a number of initiatives and investments in infrastructure to ensure an efficient power system.

To gain practical experience with a power system that contains the elements of Power System 2025, Energinet.dk has initiated a European project entitled EcoGrid EU, in which 14 partners apply for funding from the EU's 7th Framework Programme.

The project is expected to commence at the beginning of 2011, and its purpose is to carry out a full-scale demonstration of the power system of the future. The project will take place on the island of Bornholm and is to demonstrate how a power system with a substantial wind power share can be balanced and controlled through active consumer involvement based on market price signals. In this way, EcoGrid EU can be seen as the prototype of Energinet.dk's vision of how the power system can be organised in 2025.

Research, development and demonstration

A significant conversion and innovation of the power system requires comprehensive and targeted research and development efforts. To make R&D efforts more efficient and targeted, Energinet.dk has prepared a strategy for the ForskEL and ForskVE programmes within the politically established frameworks².

² Energinet.dk's R&D programmes are coordinated with the other Danish programmes. In collaboration with the Danish Energy Agency, the Danish Council for Strategic Research and the Danish National Advanced Technology Foundation, Energinet.dk has published the report 'Energy 2010', which is an annual report providing an overview of the Danish R&D efforts in the energy area.

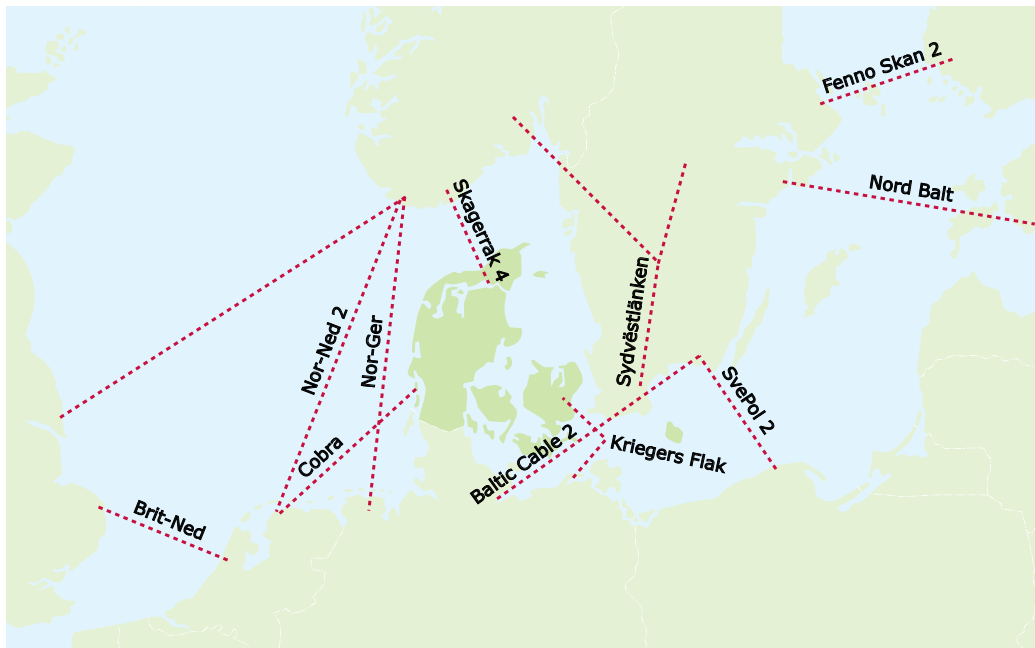


Figure 1 Plans for interconnections between the Nordic region and the Continent.

The strategy focuses on three principal areas, which are expected to have a decisive impact on the future power system design:

- Control and management of the power system
- Environmentally friendly power generation of the future
- Environmental improvements and greater efficiency.

Energinet.dk aims to ensure that all new transmission lines are underground. However, a number of technical challenges should be resolved before long 400 kV AC cables can be integrated into the Danish power system. Against this background, Energinet.dk is financing two research projects at Aalborg University, which together are to afford Energinet.dk the basis for preparing a technical regulation for the planning and design of cable installations in the transmission grid.

Energy is becoming increasingly international, and Energinet.dk has chosen to participate in a number of international collaborations on R&D and standardisation, for example within communication and power system control. Moreover, En-

erginet.dk participates in the International Energy Agency (IEA) as a member of the Executive Committee for power systems and fuel cells.

Energinet.dk participates in the project TWENTIES, which with funding from the EU's 7th Framework Programme will develop, amongst others, new and improved solutions for coordinated operation between large-scale offshore wind farms and thermal electricity-generation units. The project commenced in January 2010 and runs to the end of 2012.

In the future, many of Energinet.dk's international energy R&D activities will take place under the auspices of ENTSO-E and CIGRE. In March 2010, the overall R&D plan for ENTSO-E was released, which focuses particularly on cooperation between TSOs on projects concerning offshore grids and Smart Grid. In cooperation with the EU, the plan has now been translated into a common project plan, which contains projects with a total funding framework of approximately DKK 15 billion until 2018. The implementation of the plan is organised under the heading European Electricity Grid Initiative, which is a collaboration

between the EU, public authorities and TSOs, and in which Energinet.dk participates in the management.

3.1 Security of electricity supply

The Danish power system is closely linked to the power systems of our neighbouring countries, both physically through strong interconnections and commercially through effective coupling of the markets. Therefore, Energinet.dk cooperates on a broad international level with a view to developing robust and holistic solutions addressing both the needs of the individual country and those of a wider region. In connection with the transition from a purely Nordic cooperation in Nordel to a regional cooperation under ENTSO-E, there is a strong emphasis on applying the well-functioning Nordic market concepts and joint planning methods to the new regional cooperation.

As can be seen from the map in Figure 1, there are numerous plans for interconnections between the hydropower of the Nordic region and the Continent. This particularly applies to the connections to and from Norway, which are aimed at utilising



the flexibility of hydropower so that Norway can export regulating services from hydropower for the balancing of wind power in the future.

The expansion of international interconnections plays a significant role in both Denmark and our neighbouring countries. A number of interconnections in northern Europe are planned or under review at present. The precondition for utilising the coupling of markets through reinforced interconnections between countries and regions calls for the implementation of considerable investments in the transmission grids, both internally in Denmark and in our neighbouring countries. A number of our neighbouring countries are expected to reinforce their internal transmission grids. Although the history and causes differ, the objective is the same, namely to create a more cohesive domestic grid that ensures security of supply, facilitates the integration of large amounts of renewable energy, and furthers the development of the single energy market.

The current energy and power balances in Denmark and our neighbouring countries are continuously assessed. This work, which was previously a part of the Nor-

del cooperation, is now carried out in the regional groups under the auspices of ENTSO-E: Regional Group Baltic Sea and Regional Group North Sea.

On the background of this work, Energinet.dk expects that there will be sufficient generation capacity in northern Europe over the next ten years, but Denmark will still need to draw on foreign generation capacity, especially during periods of low wind power generation. However, on a yearly basis Danish electricity generation is expected to be able to cover Danish electricity consumption. Consequently, Energinet.dk is working on several specific projects aimed at ensuring an expansion of interconnections to other countries. These projects are estimated to have a decisive impact on the maintenance of Danish security of supply in future. The projects are described in more detail in section 3.3.

Energinet.dk increasingly views the challenge of maintaining security of supply as a regional one, which reflects the line of thinking increasingly propagated by the EU. Through regional cooperation, the work of maintaining security of supply will become more efficient.

In 2010, Energinet.dk implemented a project for quantifying security of supply. Accordingly, an actual quantification of security of supply and analyses of how security of supply changes when the system changes will be included in Energinet.dk's work to assess the socioeconomics of new electricity infrastructure.

Conventional power stations, which have historically provided ancillary services in the power system, are not expected to play the same central role in energy generation in the long term as they do today.

Energinet.dk has therefore initiated activities aimed at quantifying the need for ancillary services in future and at clarifying how these capabilities should be provided³.

3.2 Means of integrating wind power

Expansion and reinforcement of the power grid along with a wide range of flexible and efficient solutions are key focus areas when large amounts of wind power are to be integrated efficiently into the

³ Ancillary services ensure frequency and voltage stabilisation as well as short-circuit capacity in the power system.

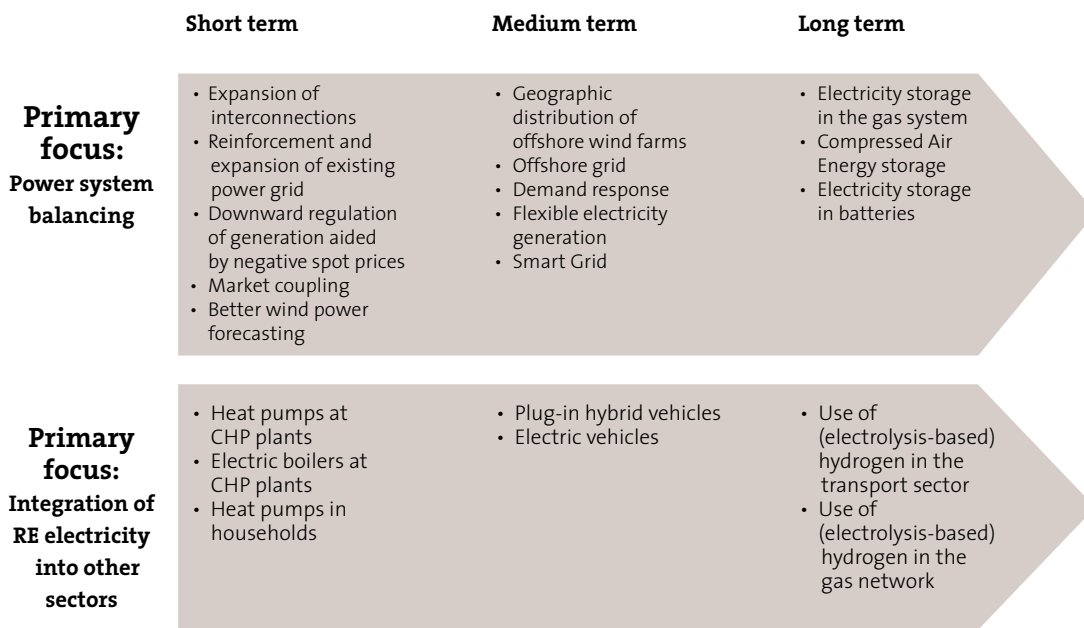


Figure 2 Means of integrating wind power.

power system. Although power system balancing is an important and central element in wind power integration, it is not in itself a sufficient goal for effective wind power integration. The goal is to maximise the market value of wind power, primarily through:

- Efficient domestic utilisation of wind power
- Flexibility in the other electricity-generation units
- Efficient international markets.

A high degree of demand response in combination with a strong international infrastructure and closely coupled markets means that a demand can be created for electricity in those periods when the price is low and wind power often constitutes a relatively large proportion of electricity generation.

Energinet.dk has identified a number of potential means that can contribute to the effective integration of wind power generation in future. These means can be divided into two overall categories: means that mainly contribute to power system balancing and means whose primary focus is the integration of electricity

into other sectors in the form of potential demand response. At the same time, the latter of the aforementioned means can also contribute to power system balancing. According to the framework established, the means must function on market terms.

At the same time, broader use of electricity-based solutions such as heat pumps and electric vehicles in the heat and transport sectors respectively will result in a reduction of CO₂ emissions in non-ETS sectors and lead to increased energy efficiency.

Figure 2 should not be viewed as an overall plan of the possibilities for integrating wind power but rather as an illustration of the range of options available, some of which fall outside the scope of Energinet.dk's direct influence. In recent years, Energinet.dk has placed considerable focus on a number of these means, and several have already been implemented. For example, a number of local CHP plants have established electric boilers, and the possibility for negative prices in the electricity market was implemented at the end of 2009. Moreover, the Skagerrak 4 interconnection, which increases the

exchange capacity to Norway, was finally decided and approved by the authorities in 2010.

Of the solutions that are considered possible means in the short and medium term, Energinet.dk will in the coming years in particular focus on the expansion of interconnections, the work to develop a Smart Grid, flexibility in electricity generation and consumption, and improved market coupling.

Energinet.dk is not yet working determinedly with long-term means such as the storage of electricity, but these means are a focus area in terms of R&D. It is important to emphasise that some of the possible means illustrated in Figure 2 fall within Energinet.dk's core areas and are thus tasks, which Energinet.dk assumes responsibility for undertaking, for example the reinforcement and expansion of the power grid and ensuring an efficient commercial interaction with our neighbouring countries. Other solutions do not fall immediately within the scope of Energinet.dk's direct influence, such as the tax structure, which may have a decisive impact on the potential of new technologies to penetrate the market.



Energinet.dk supports the work of the respective responsible authorities in these areas with a view to implementing the means of integrating wind power.

3.3 Expansion and reinforcement of the power system

Energinet.dk connects the large-scale offshore wind farms to the power grid, and in 2012, the landing facilities for the new offshore wind farm at Anholt will be commissioned. In addition, Energinet.dk is working on a range of projects aimed at making the Danish power system more robust. Energinet.dk is working determinedly to implement the expansions of those international interconnections that are socioeconomically profitable. The same also applies to the domestic grid, which Energinet.dk is working to reinforce at transmission level.

Reinforcement of the 400 kV grid

In 2008, the guidelines for the future expansion of the main electricity transmission grid in Denmark were established in a political agreement. Under the terms of this agreement, all new transmission

lines are to be undergrounded. Furthermore, a decision was taken to upgrade three existing 400 kV overhead line systems, including the connection between Kassø near Aabenraa and Tjele near the city of Viborg. This will reinforce the backbone of the Jutland power grid, and together with the interconnections to Norway, Sweden, Germany and possibly the Netherlands, the new line is to improve the possibilities for electricity exchange with neighbouring areas.

Cable action plan

In 2009, the regional transmission companies, the Danish Energy Association and Energinet.dk prepared the report 'Cable action plan 132-150 kV' for the Danish Minister for Climate and Energy. The plan describes the possibilities of moving from an overhead line system to a fully undergrounded 132-150 kV electricity transmission grid, which is also prepared to handle the significantly increasing amounts of wind power in Denmark. The overall plan calls for the dismantling of approximately 3,200 circuit kilometres of 132-150 kV overhead lines and the undergrounding of approximately 2,900 kilometres of new 132-150 kV cables and is expected to be implemented over a period of 20 years.

The undergrounding of cables allows for the extensive restructuring of the power grid, which will to a larger extent ensure future security of supply and wind power expansion.

Visual enhancement projects

Energinet.dk's Supervisory Board has decided that Energinet.dk should carry out six visual enhancement projects on the 400 kV grid to make the integration of electricity infrastructure into the landscape more harmonious. The visual enhancement projects stem from the political agreement concerning guidelines for the future expansion of the main electricity transmission grid in Denmark.

The six projects were selected on the basis of an assessment of the environmental impacts of the entire 400 kV grid, which takes into consideration people, protected areas, former county landscape designations, coastal zones and coast protection lines⁴. See the location in Figure 3.

⁴ Read about the basis for selecting projects in the report 'Improvement of the visual impact of the 400 kV grid', Energinet.dk and the Danish Environmental Protection Agency, 2009.

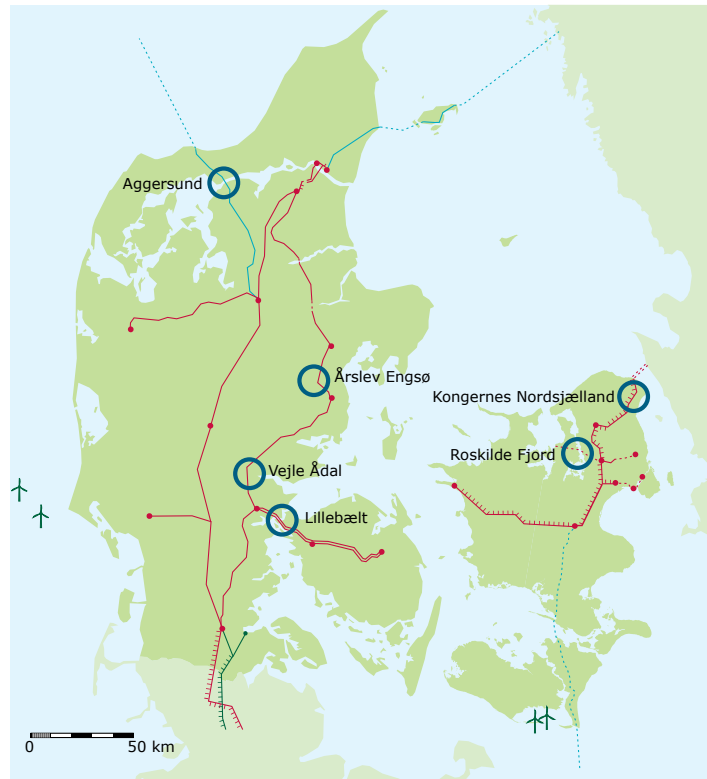


Figure 3 Locations of the six selected visual enhancement projects.

Reinforcement of interconnections

Skagerrak 4

In August 2010, Energinet.dk received permission from the Danish Minister for Climate and Energy to build the Skagerrak 4 interconnection, which will increase the exchange capacity between Denmark and Norway by 700 MW. Similarly, Statnett acquired the necessary approvals from the Norwegian energy authorities in July 2010. Subsequently, the boards of both enterprises have made a final investment decision, and the interconnection is expected to be commissioned by the end of 2014.

Skagerrak 4 increases the possibilities for interaction between generation based on hydropower, wind power and thermal plants while also enhancing the potential to benefit from the demand across a wider geographical area. Consequently, security of supply is strengthened in both Norway and Denmark.

Increased capacity between Jutland and Germany

An increase in the trading capacity between Jutland and Germany is included in the EU's 'Priority Interconnection Plan'

for TEN projects (Trans-European Network). The increase in capacity is thus one of the projects considered by the EU to be a key element for creating a well-functioning single electricity market.

Energinet.dk and the German enterprise TenneT TSO GmbH have signed a statement of intent, which expresses the enterprises' wish to increase the trading capacity between Jutland and Germany from the existing 950/1,500 MW to 1,500/2,000 MW in the north and south-bound directions respectively from 2012. According to the statement, the intention is also to further upgrade the connection to a minimum of 2,500 MW in both directions in 2017.

COBRACable

In 2008, Energinet.dk and the Dutch company TenneT TSO B.V. decided to carry out preliminary investigations into the possibility of constructing an electrical interconnection between Endrup in Jutland and Eemshaven in the Netherlands. The findings of these investigations were presented in the spring of 2009 and formed the basis for the decision to enter into an agreement for a collaboration called COBRACable. The collaboration, which runs for

the period 2009-2012, forms the basis for deciding whether it is socioeconomically attractive to establish a direct electricity interconnection between Denmark and the Netherlands. The interconnection, with an expected transmission capacity of 700 MW, could be commissioned by the end of 2015.

The purpose of COBRACable is to improve cohesion in the European transmission grid by improving the possibility for exchanging electricity and strengthening the infrastructure, security of supply and the market.

At the end of 2009, the COBRACable project applied for funding from the EU's European Economic Recovery Plan, and in 2010, the project was granted approval for funding in the range of DKK 650 million. As an important precondition for the EU funding it was agreed that the project should comprise detailed analyses of the possibilities for connecting an offshore wind farm to the cable. The cable route will pass through Danish, German and Dutch waters.



Kriegers Flak

The Danish section of Kriegers Flak, which is a relatively shallow area in the Baltic Sea, was nominated in the 2008 Action Plan for Offshore Wind Power (Havmølle-handlingsplanen) as one of several potential sites for offshore wind farms around Denmark. The waters at Kriegers Flak are exceptional, as both Sweden and Germany have also selected the area for the placing of offshore wind farms. The installed capacity potential at Kriegers Flak is estimated to be up to 1,800 MW. By interconnecting and possibly reinforcing the landing facilities of the respective offshore wind farms, Kriegers Flak has the potential to become the world's first international offshore electricity grid. An offshore grid that can be utilised for both bringing ashore electricity generation from offshore wind farms and for exchanging electricity between Denmark, Sweden and Germany.

The EU views a combined, international grid solution at Kriegers Flak as a pilot project of great importance for Europe's efforts to achieve the 20-20-20 targets. The three TSOs submitted a joint application to the European Economic Recovery Plan in July 2009.

Sweden pulled out of the project in January 2010 because with the current subsidy scheme for wind power in Sweden there are no immediate prospects for Swedish offshore wind turbines at Kriegers Flak. The application for EU funding was subsequently amended to only include the Danish and German sections, and in October 2010, the parties entered into the so-called Grant Agreement, of approximately DKK 1.1 billion. The work is based on a timetable, by which the project is expected to be concluded in 2016.

3.4 Offshore grid

Offshore wind turbines play a decisive role in relation to the EU 20-20-20 targets. In the North Sea alone, ENTSO-E's North Sea group expects an installed offshore wind turbine capacity of between 25,000-50,000 MW by 2020. Combined with land-based wind turbines, this constitutes a total installed wind capacity of 100,000-150,000 MW in the ten countries around the North Sea. In this regard, Energinet.dk is attracting widespread international attention as some of its projects are considered pilot projects for the future development which the EU expects to occur in the North Sea.

The Kriegers Flak project is highlighted as the most important because it shows in practice which challenges should be resolved to enable a bi- or trilateral connection between international offshore wind farms. In connection with the project, a number of issues need to be addressed such as discussions about support systems, market rules, legal issues and not least clarification of the various technical challenges.

Energinet.dk supports the Danish participation in the North-Sea-Countries-Offshore Grid Initiative, which is a cooperation agreement between ten countries in the region to jointly analyse the perspectives and possibilities of an offshore grid in the North Sea. Similarly, Energinet.dk actively contributes to the fact-finding work in ENTSO-E's regional North Sea group, whose main task is to prepare a plan for an offshore grid in the North Sea. The offshore grid is to connect the many coming offshore wind farms and function as interconnection between the countries around the North Sea.



Consequently, demand response creates a considerable added value for wind power, which could potentially reduce the PSO-financed subsidies for wind power generation.

3.5 Flexible electricity generation

With the expected wind power expansion in Denmark, the Danish power system will experience more hours when substantial wind power generation leads to situations where total electricity generation potentially exceeds the total demand and the capacity on interconnections to other countries. These situations arise mostly in the night-time hours during the winter months when the weather conditions can be windy and consumption is low. Therefore, there is a need for market-based incentives that can lead to even greater flexibility in power generation than is the case today.

Negative spot prices

Negative spot prices were introduced on the common Nordic power exchange in November 2009, where previously a fixed price floor existed to prevent the electricity price from falling below zero. The price floor is currently set at DKK -1,500/MWh. From the introduction of negative spot prices and up to 1 October 2010, there were five and 18 hours of negative prices in Eastern and Western Denmark, respectively. During the hours when the electricity

price becomes negative, total electricity generation typically consists of substantial wind power generation together with considerable generation from adjustable power stations and local CHP plants. With the previous price floor of DKK zero in the common Nordic market, the power stations and local CHP plants continued to generate electricity because of the relatively high costs associated with starting and stopping the generation.

When the electricity price is negative, framework conditions increasingly require electricity producers to adjust their generation according to demand. Moreover, offshore wind farms and many land-based wind turbines are controllable today. Consequently, the introduction of negative prices should mobilise the flexibility of both producers and consumers in future so that the market can manage situations that would have previously required the intervention of Energinet.dk to maintain the necessary balance between consumption and generation.

3.6 Demand response

In 2009, Energinet.dk issued the report 'Efficient use of wind-based electrici-

ty in Denmark', which analysed the perspectives of an interaction between wind power expansion and an increased flexible utilisation of electricity in the heat and transport sectors in the form of heat pumps and electric vehicles. Besides contributing to the reduction of CO₂ emissions in non-ETS sectors, demand response is also instrumental in balancing the power system.

At the same time, opportunities for consumers to avail of potentially fluctuating electricity prices improve, which means that the average market price of wind power increases, as demand is created in those periods when wind power generation is relatively high. This should ultimately reduce the need to shut down wind turbines. Consequently, demand response creates a considerable added value for wind power, which could potentially reduce the PSO-financed subsidies for wind power generation.

By way of supporting the development of an intelligent interaction between the power system and new forms of demand response, Energinet.dk is conducting in collaboration with two ForskEL projects trials on the intelligent control of heat



pumps in 300-400 houses in Denmark. The project is the largest of its kind in the world and runs for the period 2010-2012.

In addition, Energinet.dk's ForskEL programme supports the EDISON project, which runs for a period of three years and is aimed at developing effective system and market solutions for the interaction between the power system and electric vehicles. Several Danish and international players are participating in the project.

In recent years, there has also been considerable growth in the number of electric boilers installed at local CHP plants, and the installed capacity is expected to exceed 170 MW by the end of 2010. All of the electric boilers actively participate in the spot market, and the majority of them are also expected to participate in the frequency reserves market.

3.7 Electricity market

The electricity market is an effective tool for ensuring that there is always balance between consumption and generation in the power system. Traditionally, the markets have ensured that generation is adapted to consumption, thereby mini-

mising the total costs of covering electricity consumption. This paradigm is challenged by a future in which generation increasingly stems from fluctuating, renewable energy sources.

Activation of demand response is one of the main elements, which can ensure continued balance between electricity generation and consumption. The new paradigm for the supply of electricity asserts that electricity consumption should be increasingly adapted to electricity generation. New types of demand response should react to market price signals via intelligent control mechanisms. Energinet.dk is working in concert with the authorities and industry players to ensure that all end consumers, in the long term, can be charged according to dynamic market prices and tariffs constantly reflecting the costs in the transmission and distribution systems.

The increase in fluctuating electricity generation concurrent with demand response from electric vehicles and heat pumps, for example, can be a challenge to manage in the hour market in future. Substantial variations in consumption in connection with change of hour can af-

fect the stability of the power system and the load on the distribution network, and as a result a number of adjustments to the current market model may be required to maintain a secure and efficient supply of electricity.

Energinet.dk will analyse alternatives to the current market model on both the wholesale and the retail side to ensure an efficient market function upon an increased share of wind power in the power system. This will be done with a strong focus on international harmonisation so that the advantages of participating in the international electricity market are maintained. Today, bids - which must be based on a one-hour time resolution - must be submitted to the European power exchanges not later than at 12.00 on the day before the day of operation. When large amounts of wind power are present in the power system, it could be advantageous to move the time for submitting bids closer to the operating hour, thus reducing imbalances due to forecast errors. Similarly, a time resolution of less than one hour increases the efficiency of the market. Both will require international acceptance and harmonisation.



Smart Grid connects generators of electricity, consumers of electricity and those that do both – in order to efficiently deliver sustainable, cost-effective and secure electricity supplies.

Market coupling

In addition to expanding the electricity infrastructure as well as ensuring flexibility in electricity generation and consumption, Energinet.dk is also working determinedly towards an even closer coupling of electricity markets in Europe. This work is essential for securing an effective integration of large amounts of wind power. Through closely coupled markets, wind power can be sold in those areas where the willingness to pay is strongest. At the same time, this ensures more accurate pricing in Europe and clear signals about the need for new transmission and generation capacity. Thus, market coupling is also a key element for supporting future security of supply.

In November 2009, market coupling between the Nordic region and Germany commenced through European Market Coupling Company (EMCC), which administers electricity trading between Denmark and Germany. The EMCC is a joint venture company established by Energinet.dk and the north German TSOs, 50Hertz Transmission and TenneT GmbH, along with the two power exchanges Nord Pool Spot and the EEX in Germany.

Since the end of 2009, Energinet.dk has chaired a regional working group under ENTSO-E, which is charged with developing and implementing a northwest European market coupling, ie a coupling of the markets in the Nordic region, France, Belgium, the Netherlands and Germany. The market coupling was launched in November 2010.

Power system balancing through efficient markets during the day of operation

The efficient international spot market for electricity ensures that balance between consumption and generation in the main system can be expected on the day before the day of operation. In the markets after the spot market (regulating power market and to a lesser extent Elbas) the final balance is created when, for example, an overdue wind front or a breakdown at a power station creates a shortfall of electricity, and other sources of generation have to be deployed or consumption must be deferred. Due to the integration of more wind power, it may be necessary to increase the number of available units in the regulating power market and the international cooperation on power system balancing during the day of operation.

The interaction and cooperation with TSOs in neighbouring countries is becoming increasingly more essential and central to a continued safe and efficient handling of system operation. Energinet.dk has intensified its cooperation with neighbouring countries on the development of system operation and will continue to do so. In particular, within such themes as system balancing and system reserves, there is a large potential that can be utilised across national borders. Specific efforts are being made to increasingly counterbalance conflicting imbalances across borders in order to avoid conflicting activation of reserves.

Another substantial initiative is to have small units, including consumption, to contribute with regulating power on market terms, and Energinet.dk is working both nationally and in cooperation with neighbouring TSOs to further this initiative.

Establishment of a Nordic retail market

The continued development of the common Nordic electricity market is a key issue for the Nordic Council of Ministers, and the Council views the cooperation between the Nordic TSOs as pivotal to this



development. The Nordic Council of Ministers supports, amongst others, the vision of a common Nordic retail market for electricity. Energinet.dk views this goal as a key element that strengthens competition in the retail market. Energinet.dk is actively participating in the cooperation with Danish and Nordic authorities to identify the key market processes that need to be harmonised in the endeavours to create the common retail market. In addition, Energinet.dk is working on establishing a DataHub, which is to administer exchanges of data between all the players in the electricity market. The DataHub is expected to be launched in 2012 and is seen as an important element in the Danish preparations for joining a common Nordic retail market.

In NordREG, which is a collaboration of Nordic energy regulators, an action plan has been prepared for implementing a common Nordic market. The plan covers the period up to 2015, when the common Nordic end-user market is expected to come into effect. Energinet.dk has participated in the working group together with Nordic TSOs, which resulted in a proposal for NordREG.

3.8 Smart Grid

The Smart Grid concept has become widespread in recent years and in various contexts the concept is used with widely differing definitions. There are numerous descriptions and definitions of what a Smart Grid is. Energinet.dk works with Smart Grid based on the following definition:

Intelligent power systems that via efficient markets can integrate the behaviour and actions of all connected users through the utilisation of advanced metering, control and regulation technologies. Smart Grid connects generators of electricity, consumers of electricity and those that do both – in order to efficiently deliver sustainable, cost-effective and secure electricity supplies.

The development and implementation of a Smart Grid in Denmark is a key element in establishing an efficient interaction between electricity generation and consumption. In 2010, Energinet.dk collaborated with the Danish Energy Association in preparing the report 'Smart Grid in Denmark', which illustrates the substantial economic benefits of developing an intelligent power system in Denmark.

Energinet.dk has commenced an extensive programme of internal development work under the heading 'Koncept for styring af elsystemet' (*Concept for controlling the power system*). The aim of this work is to identify the challenges of operating the Danish power system with a wind power share of minimum of 50% as well as possible solutions.

The specification of open standards for communication between players and units in the power system is central to the further development of an efficient and flexible Smart Grid power system in Denmark. Energinet.dk is involved in several national and international standardisation tasks.

4. Development of the gas system



By virtue of its large production of natural gas from the Danish North Sea fields, Denmark has historically enjoyed a privileged position in relation to gas. However, the main challenge facing the Danish gas system today is one of declining natural gas production from the Danish North Sea gas fields. Consequently, Energinet.dk is expanding the gas infrastructure in the coming years to enable the import of gas to Denmark and thus maintain security of gas supply.

Moreover, Energinet.dk is focusing on facilitating the integration of new renewable energy gases into the gas system. both with a view to supplementing natural gas in the short and medium term and in preparation for a long-term conversion to a gas system based on renewable energy gases, which can supplement and balance the fluctuating electricity generation.

In addition to ensuring security of gas supply by expanding the infrastructure and furthering the integration of renewable energy gases into the gas network, Energinet.dk aims at developing an efficient gas market that through integration follows the prices in the northwest European gas market.

Research, development and demonstration

Since 2007, Energinet.dk has invited applications for the ForskNG programme, which aims to develop the Danish gas system with a view to enabling the use of new renewable energy gases. So far, the framework for the ForskNG programme has been DKK 4-5 million annually. More detailed clarification of the future frameworks for R&D efforts in the area of gas will provide for stronger and more targeted initiatives in future.

Energinet.dk is also a partner in a European project idea for LNG⁵ in shipping. The project emanates from the EU Baltic Sea strategy and is coordinated by the Danish Maritime Authority. The project places great emphasis on the environmental advantages, primarily in the form of reduced sulphur and NO_x emissions, which will result from the use of gas in shipping.

4.1 Security of natural gas supply

Energinet.dk is responsible for and works

⁵ LNG is natural gas that is converted into a liquid by cooling it to minus 163° C.

specifically to ensure continued access to gas in a future where Denmark is not self-sufficient in natural gas.

Denmark has been self-sufficient in natural gas since 1983, and the transmission system has been expanded on the basis of supply solely derived from the North Sea.

In 2010, the Danish Energy Agency prepared a projection of the gas consumption in Denmark. According to this projection and based on the anticipated gas reserves, Danish gas production is expected to cover consumption in Denmark and Sweden until around 2017. This is based on the assumption that all available gas in the North Sea will be supplied to the Danish and Swedish markets. There are considerable uncertainties associated with the expectations for both consumption and production, and there is therefore a need to expand the gas infrastructure.

In 2010, the Climate and Energy Minister approved an application from Energinet.dk to expand the gas infrastructure between Denmark and Germany to enable the import of gas from Germany to



Denmark. The project is funded with approximately DKK 740 million from the European Economic Recovery Plan. The gas in the north German system consists of Norwegian, Dutch, Russian and German gas together with gas imported as LNG. The Norwegian fields have reserves for the next 50 years or more, while the Russian reserves are estimated to be several times greater. In the long term, there will probably be additional gas from Russia in the north German system, due in part to the ongoing establishment of Nord Stream, from which Dong Energy has also purchased large amounts of gas.

A new EU security of supply regulation entails changes and stricter requirements in a number of areas relating to the current handling of emergency supplies of natural gas in the EU member states. The main objective of the new regulation is to improve security of supply in member states by ensuring sufficient capacity in the systems and regional cooperation on emergency supply. In addition, the new regulation ensures that the EU plays a central and governing role in serious cases of emergency supply impacting part or all of the union.

The regulation introduces a minimum standard for handling the emergency supply task in the EU, which resembles the Danish model, although the number of consumers to be covered is smaller in the regulation than in the existing model. Moreover, the use of market-based mechanisms regularly implemented by Energinet.dk will continue.

4.2 Expansion and reinforcement of the gas system

On the background of falling supplies from the North Sea and market demand, Energinet.dk has chosen to invest in new infrastructure that facilitates supply to Denmark and Sweden from Germany from October 2013. At the same time, initiatives have been implemented which through temporary technical solutions in the north German system have enabled small supplies from Germany already from October 2010.

Expansion of the Danish transmission system to Germany in 2013 will provide sufficient capacity in the system for many years after 2013. Thus, players in

the gas market will be able to choose between different supply routes, ie gas via Germany or via the North Sea.

Energinet.dk is implementing the expansion of the gas transmission network through activities such as the construction of a compressor station in Egtved, which is designed to increase the gas pressure from the level at which the gas is received from Germany to a pressure in the Danish gas transmission network which ensures the necessary flow of gas. In addition to the compressor station, Energinet.dk is laying a new gas transmission pipeline from the Danish-German border to Egtved. A pipeline from Ellund/Frøslev to Egtved exists today, through which gas from the North Sea has so far been exported to Germany. However, the capacity of this line does not facilitate the import of gas in sufficient amounts, and it is therefore necessary to supplement the existing pipeline with a parallel connection.

Connection to Norway

In addition to the capacity increase resulting from the investment in new infrastructure to Germany, there are benefits associated with creating the



Figure 4 Alternatives for transporting Norwegian gas to Denmark.

possibility of importing gas from other sources, eg via a connection to Norwegian gas resources. This could, for example, facilitate compliance with the security of gas supply regulation, which requires that it be possible to replace the largest supply resource, which in the long term will be the import from Germany, as the production from Danish North Sea fields declines. Moreover, a connection to Norway will have a considerable significance in relation to creating a possibility of sending gas supplies on to the northern European market and the Baltic states, thus contributing to regional security of supply.

Energinet.dk has launched a number of initiatives to investigate the physical and commercial possibilities for a Danish–Norwegian gas connection. This includes dialogue with all relevant players on the Norwegian and Danish sides, as well as close cooperation with the Norwegian system operator, Gassco, and the Danish authorities.

Overall, Energinet.dk has identified three different alternatives for transporting Norwegian gas to Denmark, Sweden and on to the northern European gas market.

These alternatives, which can be seen in Figure 4, should be considered as general technical descriptions of possible future connections. Alternative 1 is currently being analysed more thoroughly than the other alternatives, which are presently considered more uncertain.

Alternative 1 is a connection between one of the existing Norwegian offshore pipelines and the Danish offshore system. This can be done in several different ways with various possible capacities. Limitations in the Norwegian system mean that the capacity of the possible alternatives is approximately 1–3 billion m³/year. Consequently, this solution only supports supply to the Danish and Swedish markets and possibly continued deliveries to the Netherlands via the NOGAT connection.

Alternative 2 is a connection from the Norwegian gas system further up in the system to the Danish onshore system. The capacity of this alternative is approximately 7 billion m³/year, and it will facilitate the transit of small amounts of gas to Germany and/or Poland.

Alternative 3 is a new and significantly larger interconnection from Norway to Denmark. This could be a connection from a collection point/hub in the Nordic system (offshore or onshore) to, for example, northern Jutland. The potential capacity of this type of connection (10–25 billion m³/year) will, apart from supplying Denmark and Sweden, be sufficient to facilitate the transit of considerable amounts of gas to Poland, Germany or other countries in northern Europe.

The need for gas storage capacity

The gas storage facilities in Stenlille and Lille Torup are an integral part of the Danish gas system in terms of market, capacity, security of supply and operation. The storage facilities have a combined storage volume of approximately 1,050 million Nm³. Energinet.dk holds reserves in the order of 250 million Nm³ for emergency supply situations, while the rest of the volume totalling approximately 800 million Nm³ is sold to the commercial players.

As TSO, Energinet.dk constantly assesses the need for storage capacity in relation to security of supply, including in relation to complying with the EU regulation on



security of gas supply. However, it is up to the commercial owners of the gas storage facilities to take final investment decisions based on Energinet.dk's demand for emergency supplies and the market players' demand for seasonal and load balancing.

When the supplies from the North Sea are phased out, the need for storage volume and capacity may rise while expansions of the gas infrastructure to other countries will, from a purely Danish perspective and other things being equal, reduce the requirement for gas storage capacity. If the gas system in the long term is to be increasingly utilised as reserve/peak load to ensure balancing and security of supply in a power system based on wind power, the additional demand for storage will arise.

4.3 The role of the gas system

Approval of the expansion to Germany, which facilitates the import of gas from Europe as the Danish production from the North Sea fields declines, ensures a stable gas supply for many years ahead. Alternatively, an accelerated conversion

of current natural gas consumption to other fuels in line with the expected rapid fall in natural gas production will lead to high socioeconomic costs.

Natural gas with its relatively low CO₂ emissions can be the fuel that bridges the transition to fossil fuel independence. Consequently, gas can replace fuels with relatively higher CO₂ content such as oil and coal. In the long run, the composition and environmental profile of gas will change concurrent with the large-scale conversion of agricultural slurry to biogas, which displaces natural gas. Furthermore, thermally gasified biomass and hydrogen produced through electrolysis can in the long term be transported via the gas transmission network.

Natural gas will play an integral role in the transition to a fossil-fuel free energy system. Moreover, in such an energy system that is independent of fossil fuels, the gas system will still constitute a significant asset. In contrast to electricity and heat, gas is relatively inexpensive to store in very large volumes of energy for extended periods. Transport and distribution of gas are competitive with

other forms of energy transmission when the necessary infrastructure has already been established, as it has in Denmark. This means that large amounts of energy can be transported at low costs with limited loss of energy. The gas system has thus a great potential to accommodate the efficient storage of wind power generation.

The gas system will facilitate better utilisation of renewable energy gases such as biogas, and natural gas will thus act as a stepping stone towards an energy supply that is independent of fossil fuels. Besides contributing to the reduction of CO₂ emissions and power system balancing, increased production of renewable energy gases will also strengthen Danish self-sufficiency.

4.4 Integration of biogas into the gas network

Today, the biogas produced is exclusively utilised in local energy generation, which seen in the light of the Danish biogas production, which has until now been relatively limited, has been a logical and natural development. On the basis of the Green Growth agreement tar-



Energinet.dk ensures security of natural gas supply by erecting a compressor station in Egtved, for example.

get to utilise 50% of manure for energy generation by 2020 and a long-term objective of fossil fuel independence, it is relevant to view the potential of biogas in a broader context to ensure that it is used as efficiently as possible.

Existing biogas plants seasonally adjust biogas production to a lesser extent. Increased seasonal adjustment will create a better link between the production profile and the CHP plants' consumption profile over the year. Consequently, opportunities for selling biogas directly will improve.

The market potential of biogas could be enhanced by upgrading and transporting the biogas in the gas system. In this way, the content of CO₂ in the raw gas is removed to leave a sufficiently high-quality bio methane gas that can be transported in the gas transmission network. Consequently, by utilising the flexibility of the gas system, biogas can gain access to numerous commercial outlets and the potential for full flexibility between production and consumption, which will support an increased integration of more wind power into the energy systems.

In the report 'Lokal anvendelse kontra opgradering - en samfundsøkonomisk analyse' (*Local utilisation versus upgrading – a socioeconomic analysis*) (only available in Danish), Energinet.dk compared the local utilisation of biogas with the regional utilisation of it after it has been upgraded and sold via the gas system. The analyses in the report reveal that it is socioeconomically beneficial to upgrade the share of biogas that cannot be used in local CHP. However, local utilisation is as expected more profitable if there is a significant demand for district heating compared with biogas production. Through upgrading, the biogas producers gain access to alternative commercial outlets at other CHP plants and potentially - in the long term - in the transport sector.

Energinet.dk will ensure that the market models in the gas area support a socioeconomically effective use of biogas. In 2010, Energinet.dk incorporated a biogas market model in its Rules for Gas Transport to support the integration of biogas into the gas transmission network. The model is expected to be supplemented with a documentation scheme in 2011, to be used for trading biogas via the gas

network. This work is coordinated with other EU countries that have launched similar initiatives.

4.5 Gas market

Several new wholesalers (shippers) become active in the Danish gas market to the benefit of competition.

In the autumn and winter of 2009/2010, Nord Pool Gas had its breakthrough in the Danish gas market. This positive development began in October 2009, when approximately 100 trades were conducted. Since then, the number of trades has risen substantially, peaking at over 800 trades in March 2010. In terms of volume, almost 9% of Danish consumption was traded at Nord Pool Gas from January 2010 to June 2010, compared with approximately 1% in the previous period. Energinet.dk will prioritise continued cooperation with Nord Pool Gas on the development of trading possibilities to establish the largest possible liquidity in the transparent gas market.

Market integration

Energinet.dk's reinforcement of the gas infrastructure to Germany facilitates the physical transmission of gas in both



directions. This will ensure the readiness of the physical framework for greater integration between the Danish and northwest European wholesale and retail markets. Increased integration with the natural gas markets of other EU member states will generate a number of opportunities for achieving a more efficient natural gas market in Denmark.

Energinet.dk has, together with the Gasunie TSOs – Gasunie Deutschland and Gas Transport Services – taken the next step towards an integrated northwest European gas market by establishing the platform Link4Hubs, which brings three gas markets of three different countries closer together. Using Link4Hubs, it will be possible for the first time in Europe to purchase an uninterrupted, bundled service by which shippers can purchase the possibility to transport gas across several national borders in Europe in one transaction.

The fundamental thinking behind this collaboration is that shippers via a common platform transport gas from a virtual Link4Hubs trading point in Denmark to a virtual Link4Hubs trading point in northern Germany or the

Netherlands without having to reserve capacity in and out of the respective countries; and that nomination of the gas occurs automatically upon reservation of the service. The service is offered in Denmark, northern Germany and the Netherlands with the possibility for more TSOs or countries to connect to it.

Development of the gas market should continue to be prioritised in order to secure new opportunities for trading both internally in Denmark and in particular with neighbouring countries to maintain the competition for gas.