System Plan 2015

Electricity and Gas in Denmark

ENERGINET.DK

System Plan 2015

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Introduction

Energinet.dk owns, operates and develops the Danish electricity and gas transmission grids, which also link Denmark to the electricity and gas systems in our neighbouring countries. Energinet.dk's core task is security of supply, which means that Energinet.dk is responsible for coherent and holistic planning to ensure a well-functioning overall electricity and gas system, thereby guaranteeing the supply of electricity and gas to people and businesses, now and in the future. Energinet.dk is also responsible for creating the right framework for well-functioning electricity and gas markets to ensure fair prices for consumers and energy producers through competition and equal terms. Finally, on behalf of society, Energinet.dk performs a number of tasks supporting the energy policy ambition of a green transition, administers subsidies for research, development and demonstration projects and disburses funding for environmentally friendly energy.

System Plan 2015 – Electricity and Gas in Denmark provides an account of how Energinet.dk handles and solves the tasks imposed on Energinet.dk by the legislation within the electricity and gas sectors. System Plan 2015 – Electricity and Gas in Denmark is an annual report from Energinet.dk to the Danish Energy Agency. Previously, this reporting was divided into the reports 'System Plan' and 'Gas in Denmark'. As of 2015, these reports have been merged into one.

Reader's overview

The chapter on holistic planning describes the international and national frameworks for Energinet.dk's tasks, including development trends towards increased regional cooperation, increased efficiency improvement requirements and specification of the Danish government's ownership policy. Energinet.dk is already actively involved in European partnerships within the electricity and gas sectors, but the demand for regional and European solutions will be even higher in the future.

The theme chapter on the green transition provides an outline of Energinet.dk's Energy Concept 2030 analysis, which identifies measures that can reduce the costs of the transition of the Danish energy system to renewable energy. Improved utilisation of Danish wind resources, international cooperation, flexible electricity consumption and integration of the electricity, gas, heating and transport systems are paths to a more robust, fossil-free Danish energy system. The goal of making the transition cheap and robust requires strong analysis tools. Energinet.dk has developed a number of indicators which relatively simply can qualify the debate on an economically viable transition.

Danish and pan-European market development within the electricity and gas sectors must ensure that competition is the market driver that makes the transition to fossil-free energy supply affordable and efficient. In the theme on the market development for electricity and gas, a status is provided on the progress we have made so far in terms of subjecting trading in electricity, gas and ancillary services to competition and developing trade relations across national borders. The conclusion is that much has changed over the last few years with regard to market formation in the wholesale and retail markets for electricity and gas, but that considerable efforts are still required with a view to exploiting the full potential of the market mechanisms.

The Danish electricity infrastructure, including cable connections to other countries, is already undergoing a transition to a future where wind turbines will be the dominant electricity-generating facilities. In the future, the electricity infrastructure must handle both fluctuating electricity generation from wind and solar power, and especially wind turbines are often located at a significant distance from the large electricity-consuming urban communities. The chapter on electricity facilities accounts for the planning of expansion and conversion of Danish electricity facilities, including international connections, and also provides an overview of maintenance work.

The preconditions for maintaining a high level of security of electricity supply in Denmark are changing at the moment. Generation from thermal power stations is declining and being replaced by wind and solar power-based non-dispatchable electricity-generating facilities. The presentation in the chapter on security of electricity supply is a short extract of the separate security of electricity supply report presented by Energinet.dk in August 2015.

The chapter on the operation of the electricity system provides an account of how the national control centre at Energinet.dk in Erritsø ensures stable grid operation within any given delivery hour as well as ensuring the presence of the necessary electricity generation capacity. Efficient operations are maintained in Denmark – even with an already high level of wind energy in the system. Expectations are that increased cooperation across national borders will further boost efficiency.

The Danish gas infrastructure is largely fully expanded, but must be adapted to the changed conditions in the coming years. Declining natural gas production in the North Sea may entail that connections to other countries will have to be established in the long term. Also, new biogas upgrading facilities are currently being constructed for the production of bio natural gas, which requires continued development of the gas infrastructure to ensure that the existing gas grid in Denmark can also be used for collecting, storing and distributing new RE gas types in the future. These are the main themes in the chapter on gas facilities.

For a number of years since the launch of oil and gas extraction in the North Sea, Denmark has been self-sufficient in natural gas. The supply of natural gas from the North Sea is expected to decline, and based on the currently known reserves, production in the Danish part of the North Sea is expected to come to an end in 2045-2050. However, the main conclusion in the chapter on security of gas supply is that, as a result of the Danish-German gas pipeline, security of supply in Denmark will be better than ever in 2016 despite a future declining North Sea production. The main challenge in the future lies in handling any international crises that may arise.

The chapter on the operation of the gas system accounts for the adaptation to future conditions. The consumption of gas in Denmark is declining concurrently with the gas origins changing. Historically, Denmark has received gas from the North Sea with a uniform composition and quality. In future, Denmark will to a higher extent receive gas of varying quality from Norway, Germany, the Netherlands and Russia, or as upgraded RE gas and possibly LNG. Declining consumption and varying gas qualities place new demands on the operation of the Danish gas system.

An overview of the relevant background material mentioned in the text is provided at the end of the System Plan.

Holistic planning

Energinet.dk is responsible for implementing coherent and holistic planning for the Danish electricity and gas transmission grids. The planning task in respect of the grids is not an isolated technical exercise, but must be seen in light of the overall objectives and structures defined by the Danish and European society for the future.

Political framework

A central element in Energinet.dk's work is that the decisions made are always supported by strong cost-benefit analyses, which are to ensure a cost-effective transition. Security of supply is, among other things, dependent on Energinet.dk making the right investments in the energy infrastructure at the right time. Energinet.dk is not allowed to generate a profit, but must instead always choose the socio economically most advantageous solution on the path towards an economically viable green transition.

In step with the energy markets to a greater extent being developed in an international context, the infrastructure required to ensure well-functioning energy markets is also turning into an international task. This means that the cost-benefit calculations must also have an increased focus on regional solutions in relation to the expansion of the infrastructure. In the past year, Energinet.dk has been working on an increased regional approach, both in the cost-benefit analyses and in the specific investment decisions.

Closer regional cooperation

With its publication this year of the Energy Union paper, the European Commission has set a new tone in the European cooperation. The overall objective is still to achieve the greatest possible harmonisation and cooperation at a European level, but there is an increasing focus on regional initiatives as an important stepping stone on the development path from national to European energy policy and control. Denmark and Energinet.dk already participate in many different regional projects, working groups and initiatives; see Table 1. On the electricity side, the regionalisation began in 2000 when Denmark was integrated as part of the Nordic electricity market through the Nordic power exchange Nord Pool Spot. From 2009, the Danish electricity market was connected to Germany, and since then, this development has been strengthened on an ongoing basis. With the common northwestern European market coupling in the day-ahead market in February 2014, the Nordic electricity market has been fully integrated into a common European market. The same development is on the way in the intraday market. On the gas side, the commitment to the PRISMA capacity platform helps support the European market development, and the cooperation with the sys-

Table 1: Danish and European cooperative bodies in which Energinet.dk is actively involved as a TSO (Transmission System Operator)

COOPERATIVE BODIES FOR ELECTRICITY	
ENTSO-E	European Network of Transmission System Operators for Electricity. European network of electricity TSOs that solves tasks imposed by legislation (TYNDP, network codes etc.) as well as acting as a cooperative body for the TSOs. Energinet.dk is a member of ENTSO-E and currently holds the presidency.
TSC	TSO Security Cooperation. Operational cooperation between 13 TSOs. Energinet.dk is a member.
TSCNET Services GmbH	Service company formed under the TSC cooperation, which supplies operating data and operational analyses. Energinet.dk is co-owner (8%) and customer.
Nord Pool Spot AS	Nordic power exchange. Energinet.dk is co-owner (19%) and customer.
JAO	Joint Allocation Office (formerly CASC). Electricity capacity allocation company. Energinet.dk is co-owner and customer.
COOPERATIVE BODIES FOR GAS	
ENTSOG	European Network of Transmission System Operators for Gas. European network of gas TSOs that solves tasks imposed by legislation (eg TYNDP, network codes). Energinet.dk is a member.
GIE	Gas Infrastructure Europe. European cooperative body and interest group representing gas TSOs, gas storage system operators and LNG terminal operators. Energinet.dk is a member.
PRISMA European Capacity Platform GmbH	Gas capacity allocation platform. Energinet.dk is co-owner (7%) and customer.
Gaspoint Nordic A/S	Nordic gas exchange. Energinet.dk is co-founder, co-owner (50%) and customer.
Dansk Gasteknisk Center a/s	Danish Gas Technology Centre. Energinet.dk is co-owner (16%).

tems in the neighbouring countries also plays a significant role.

The share of renewable fluctuating energy has increased significantly over the past few years. This has resulted in a reduction in both the electricity price and the delivery hours for thermal electricity generation in the Danish energy system. One consequence of this has been the phasing out of a number of thermal power stations as a result of deteriorating operating economy. Energinet.dk's work over the past year has therefore had considerable focus on generation adequacy. This development and the concern about adequate capacity are also reflected in the discussions in the neighbouring countries. In connection with considerations concerning the development of the electricity market in Germany, the German Federal Ministry for Economic Affairs and Energy has initiated a dialogue with the neighbouring countries on increased regional cooperation. This regional cooperation has resulted in a common declaration, 'Joint Declaration for Regional Cooperation', which was signed in connection with the Energy Council meeting in June 2015, where the 12 signatory states submitted a declaration of intent aiming to ensure the continued implementation of a single European energy market and joint trading, including in power shortage situations.

Through ENTSO-E and in particular the participation in regional groups for the Baltic Sea and the North Sea, respectively, Energinet.dk has contributed to an improved TYNDP 2014 (Ten-Year Network Development Plan), which describes the expansion of the electricity and gas infrastructure in Europe up to 2030.

In respect of ENTSO-E, the preparation of common European network codes is well underway. This is well in line with the European Commission pressing for increased operational cooperation among the TSOs through so-called 'Regional Security Cooperation Initiatives' (RSCI). These RSCIs must, among other things, be the starting point for a common regional analysis of security of supply in the future.

In ENTSOG, the work on developing common European rules for gas transport has almost been completed. In the past year, special focus has been on developing the tariff structure rules, which are ready to be finalised following negotiations among the member states. Gradually as the most important network codes fall into place, focus will to a higher extent be on monitoring the implementation of the codes.

Improved energy efficiency at EU level

The European Parliament's plan for a 20% reduction of the EU's energy consumption by 2020 is underpinned by

the EU's Energy Efficiency Directive, which obliges the member states to assess the potential for and promote energy efficiency in their electricity and gas infrastructure. On this basis, the Danish Energy Agency, in cooperation with trade organisations and Energinet.dk, has performed an assessment of the potential for energy efficiency in the electricity and gas infrastructure in Denmark.

In terms of transmission, Energinet.dk already utilises a method which, among other things, includes loss optimisation as a factor in the economic evaluation of a project when investments are made in new and existing plants in the grids. The method identifies profitable investments in energy efficiency in the transmission grids and ensures that the economy in new measures is evaluated on an ongoing basis.

The distribution grids are regulated as private enterprises that maximise their earnings within the applicable regulatory framework, and they are thus presumed to implement cost-effective energy efficiency improvements in the grids. In addition, the distribution companies have the possibility of including energy savings in the grid in connection with their energy saving obligations, and, finally, electricity distributors have an incentive to invest in energy efficient measures as a result of their revenue cap adjustment.

Increased efficiency improvement requirements in Denmark

Concurrently with Energinet.dk to an increasing extent taking part in regional cooperation, Denmark has launched a number of projects to ensure efficiency in the energy sector through a review of electricity regulations and a gas modernisation analysis.

The implementation of the Committee for the Regulation of Electricity's (*Elreguleringsudvalget*) recommendations will result in a higher degree of clarity regarding Energinet.dk's institutional framework through financial regulation, regulatory framework control of the task portfolio, participation in international benchmarking etc. Energinet.dk must also continue to work on clarifying its governance and its governance rationale, so that it is clear to stakeholders and the world at large how and with which optimisation criteria Energinet.dk creates value for society.

The gas modernisation analysis aims at optimising the market rules in the retail market, for example by implementing some of the market development recommendations from the committee for review of electricity regulations in the gas market as well. This may, for example, involve the development of a wholesale model and improved data handling. Focus is also on the issue of whether incentives and the gas infrastructure support the

Table 2: Energinet.dk's planning reports, analyses and regulations

ANALYSIS		
Analysis assumptions	Expected development in Denmark in a 20-year time frame.	Annually
Energy system analyses	Energy scenarios for Denmark as part of a European energy system and a global market – time frame up to 2050.	Continuously
Market analyses	Development opportunities for Danish and pan-European markets towards 2050, eg Market Model 2.0.	Continuously
Current thematic analyses	Separate analyses on current subjects.	Continuously
PLANNING		
Strategy plan	Objectives, commitments and strategy.	Every third year
Installation report	Completed, ongoing, planned and potential electricity and gas projects in a ten-year time frame.	Annually
Network development plan	Planning of the electricity supply grid above 100 kV and international connections (cables) in a 20-year time frame.	Every other year
Security of supply reports for electricity and gas	Challenges and possible approaches to maintaining a high level of security of supply of electricity and gas in Denmark.	Annually
Environmental report	Environmental aspects of the expansion of the electricity and CHP system.	Annually
R&D	Strategy for research, development and demonstration.	Annual review
OPERATIONS		
Regulations, instructions and rules	Rules of action for market and operations.	Continuously

green transition. The analysis is expected to be completed in 2015.

Government's ownership policy
In April 2015, the Ministry of Finance published an updated version of the 'Government's Ownership Policy' (*Statens Ejerskabspolitik*). The Danish government's ownership policy specifies the parameters according to which the government's ownership of state-owned enterprises must be managed. The policy consists to a large extent of already applicable principles put into writing.
The updated policy emphasises the minister's overall oversight responsibility for the development of the enterprise.

It is an important part of the ownership policy that, when a decision has been made on the strategic framework for the enterprise, the strategic objectives must be pursued on the basis of a clear arm's length principle between owner and enterprise. The minister's role in respect of the ownership policy is thus to determine the overall strategic framework for the enterprise's business activities.

Energinet.dk's planning activities

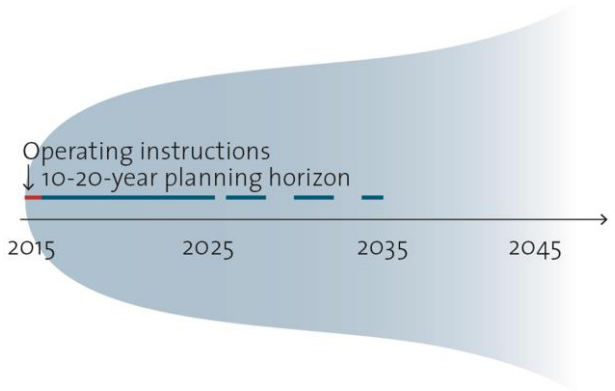
At the moment, Denmark and the rest of Europe are undergoing a development where the fossil fuel-based energy system must be transformed into a sustainable and fossil-free system. Concurrently with the expectation of a transition from the old system to a new, sustainable energy system, Danish society also expects the security of supply to be maintained.

Energinet.dk's planning must accommodate both the national objective of a long-term transition to renewable energy while at the same time ensuring a high level of security of supply of electricity and gas – and everything at the lowest possible socio economic costs. The planning efforts thus cover the day-to-day operation of the existing system in the short term as well as the long-term objectives for a new, sustainable energy system, see Table 2.

Operations
In the most important areas, the operational framework is defined in technical regulations and market regulations, which are two different types of guidelines aimed at the market participants in the electricity system.

Grid companies' and commercial market participants' rights and obligations in the electricity market in Denmark are regulated by the market regulations. The market regulations are guidelines which are necessary for the functioning of the electricity market and for settlement being carried out correctly. The market regulations cover, for example, terms of change of supplier, handling of

Figure 1: Time frames for operation, planning and analysis



notifications and schedules, balance settlement as well as standards for the transfer of data between market participants. The regulations are aimed primarily at balance responsible parties (BRPs), balance suppliers and grid companies. Grid companies' and commercial market participants' rights and obligations in the electricity market in Denmark are also regulated by the market regulations.

The technical regulations are guidelines which are important for the physical operation of and system security for the interconnected high-voltage grid with connected plants. The technical regulations are typically aimed at plant owners and operators. International obligations in respect of physical system operation are typically implemented in technical regulations. The regulations are implemented operationally in Energinet.dk's operating instructions.

The overall market terms in the gas market are described in the 'Rules for Gas Transport' – commonly referred to as RfG. In addition to the Rules for Gas Transport, Energinet.dk has developed supplementary rules on transfers that regulate secondary trading in transport capacity in the transmission system via Energinet.dk's Capacity Transfer Facility (CTF) and secondary trading in natural gas in the transmission system via Energinet.dk's Gas Transfer Facility (GTF).

Planning

Energinet.dk's planning has a time perspective of 10 to 20 years and is based directly on the more long-term analyses. The planning work in respect of infrastructure, market development, security of supply, system operation and environmental-, research- and development activities must bridge the gap between the long-term objective of a transition of the energy system and the 'immediate' objective of security of supply.

As a result of the uncertainty associated with the analysis of the future Danish energy system, it is a challenge in the planning that, on the one hand, it is necessary to make specific investment decisions already at this point in time to underpin the politically agreed measures for a transition to renewable energy while, on the other hand, having to ensure as far as possible that the investments are robust vis-à-vis the uncertainty factors that the future holds.

Analyses

A thorough analysis is a necessary prerequisite for successful planning. Energinet.dk's analyses have a time frame up to 2050 and are aimed at the overall future Danish energy system covering all part elements. For example, developments within electrification, heating, transport, industrial process heating, RE gas, fossil fuels and biofuels have an impact on the preconditions for the

development of the main electricity and gas transmission grids. It is thus a prerequisite for the ability to assess the design of the future electricity and gas infrastructure that the overall scope of and the connection to the future Danish- and European energy system are included in the assessment.

However, there are uncertainties associated with analyses as it is difficult to predict the international price development, technology developments, other countries' future actions etc. up to 2050 and beyond. The analysis results therefore constitute an outcome space within which the Danish energy system in 2050 and the route to be followed may end up in different system variations depending on, for example, future political decisions, technological advances and other countries' decisions; see Figure 1.

Energy database

Energinet.dk has a strategic objective of ensuring that data on energy and the energy system must be brought into play to a much higher extent for the purpose of creating value for and innovation in society. Intentions are that Energinet.dk's future energy database in the long term will contain both factual historical and current data on the energy system as well as, for example, scenarios and analysis assumptions that have a significant bearing on the long-term investments in the industry.

The energy database is expected to only contain data which are not confidential or which have been aggregated to a level where they can be published. This gives external and internal stakeholders access to the same data. The aim is primarily data which are already published. But data will be much more accessible, and it will be possible to retrieve data dynamically, thus making applications of any kind capable of bringing the latest and updated data into play. An obvious example is energy prices, which, through the energy database, can be communicated all the way to the customers via the market participants' applications. The same goes for updated analysis assumptions, which can be brought directly into play. Easy access to data stimulates innovative use, and the possibilities are endless.

The development of the energy database will start at year-end 2015, and the plan is for the project to be carried out in an open dialogue with external stakeholders. Future users of data from the energy database will thus get the opportunity to influence the development and thereby contribute to a pragmatic development process where usefulness and value creation are in focus.

Research, development and demonstration

To ensure progress in the economically viable green transition, Energinet.dk is embarking on a huge and complex task, which requires that Energinet.dk thinks

long-term and focuses on developing tomorrow's solutions today. A number of the technologies, solutions and concepts that will be supporting the green transition are already known. However, some questions and challenges still need to be addressed. Research-, Development- and Demonstration (RD&D) activities are therefore an essential element in the transition to a green energy system in balance. New technologies, new ways of operating the systems, integration of energy systems and new market models will simply be a prerequisite for the ability to convert the energy system to being independent of fossil fuels in less than 35 years. This must even take place simultaneously with the security of supply being maintained at the same high level as today.

In addition, the green transition must be economically viable and affordable for society. RD&D must contribute to minimising the technological risk and thus encourage private investors to identify business models that can support the financing of the green transition.
To ensure that these challenges are addressed, Energinet.dk prepared an RD&D strategy in 2015 which identifies a number of strategic measures both in relation to Energinet.dk's own RD&D activities, which collectively are called ForskIN, and the activities carried out under the ForskEL programme.

The ForskEL programme is a PSO-financed RD&D programme that grants funding for external projects which, with focus on the electricity system, develop solutions for an economically viable green transition of the energy system. An effect assessment was carried out in 2015 of the three energy research programmes under the Danish Ministry of Energy, Utilities and Climate, including ForskEL. In this assessment, it was concluded, among other things, that the ForskEL programme to a very high extent contributes to maintaining the security of supply and promoting the green transition. Forty-seven per cent of the evaluated ForskEL projects focused on the development of solutions supporting flexibility in tomorrow's energy system.

Theme:
The green transition

Energinet.dk is responsible for ensuring efficient operation and expansion of the main electricity and gas infrastructure and for ensuring open and equal access for all users of the grids. Based on this responsibility, Energinet.dk must implement coherent and holistic planning which can form the basis for the assessment of current and future market conditions, the infrastructure, security of supply, system operation and R&D activities.

Energy Concept 2030

Denmark has a political vision of converting the energy supply to independence from fossil fuels. There is broad political consensus that the energy supply in Denmark must be based on renewable energy in 2050. It is also a high political priority that this transition must take place without putting Denmark's competitiveness under pressure due to rising prices of energy services, and that a high level of security of supply must be maintained. Finally, it is a political desire that Denmark in this transition maintains a development environment for green growth.

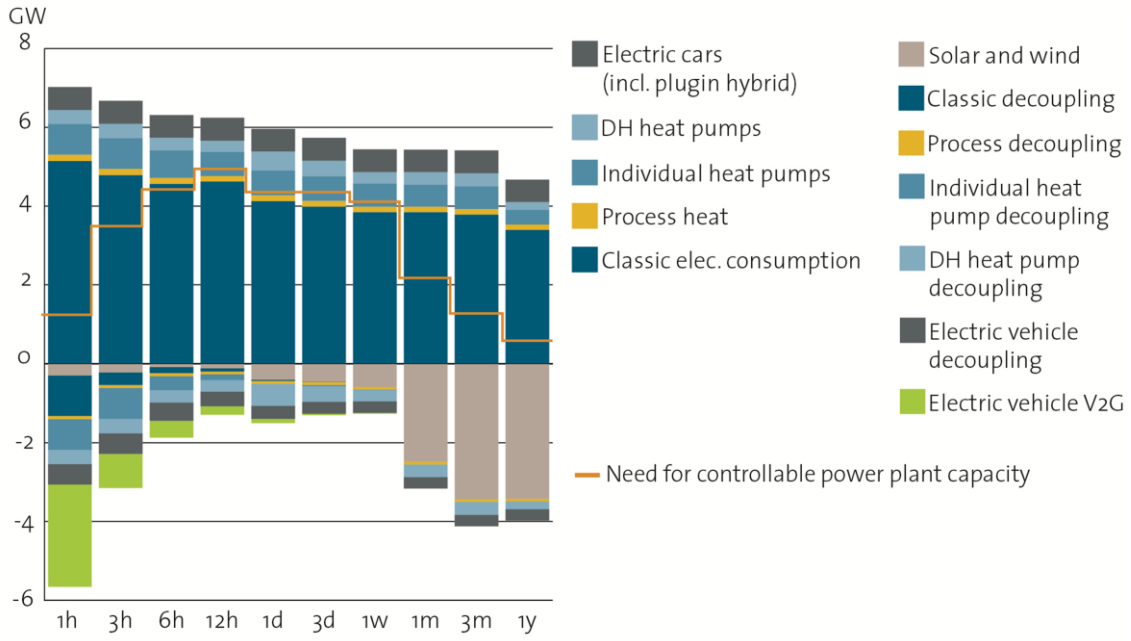
The energy agreement analyses in continuation of the current energy agreement estimated that a transition of the energy supply to wind power as the primary renewable energy source will be about 8% costlier than a fossil reference in 2050. In the coming years, one of the most important tasks within the energy area will be to identify ideas, opportunities and methods that can contribute to reducing the economic costs of a transition to renewable energy, so that the sustainable energy supply is economically competitive with the current fossil energy system.

With the Energy Concept 2030 analysis, Energinet.dk has pointed out areas requiring more detailed investigation in the future for the purpose of reducing the cost of energy from an RE system.

Overall, Energinet.dk estimates that a number of system measures can make the wind scenario from the energy agreement analyses more cost-effective, thus ensuring more competitiveness when using a fossil reference. The measures are furthermore expected to reduce costs (albeit to a lesser degree) if Denmark chooses a scenario with a limited expansion of wind power and instead increases the volumes of imported biomass or continue using small volumes of fossil fuels. These are measures which make the Danish energy system robust, regardless of how large volumes of wind power are supplied to the region by the international development.

The following highlights a number of key points from Energy Concept 2030 which may be potential ways to further improve the RE system.

Figure 2: Need for dispatchable power station capacity during periods with few wind and solar power resources.



The columns above the x-axis indicate electricity consumption broken down by type during periods of down to one hour and up to one year. The columns below the x-axis indicate RE electricity generation and interruptible (flexible) electricity consumption during the same periods. The difference between the electricity consumption and the volume of the RE electricity generation and interruptible electricity consumption in the individual period corresponds to the demand for dispatchable power station capacity.

Improved utilisation of wind resources

Denmark has come far with regard to installing wind power onshore and offshore (see the chapter on security of electricity supply). It is a known fact that Denmark still has substantial capacity for installing offshore wind turbines, and offshore projects totalling around 1,400-1,600 MW are currently underway. There is also a large socio economic potential for more wind power onshore, as land-based wind, in particular, is deemed to be one of the most cost-effective energy resources for electricity generation.

Nevertheless, when the share of wind power in the energy system increases, the integration of wind power can raise the total system costs. In particular, the costs of electricity capacity as backup for wind power, reinforcement of the electricity infrastructure and balancing of the electricity system contribute to making a wind scenario with very large wind power volumes more expensive than a fossil reference scenario. Therefore, system measures aimed at reducing these costs are essential.

Within the framework of Energy Concept 2030, Energinet.dk has analysed system measures in a scenario with very large volumes of fluctuating wind power, among other things with a view to assessing the competitiveness and robustness of the scenario in the face of changing conditions. Together, the analysed system efficiency measures can reduce the need for wind energy by 15-25% relative to the traditional wind scenarios, without using additional biomass. Furthermore, the report suggests that the potential for effective utilisation of relatively cheap land-based wind may be considerably higher than the energy scenarios' bid of 3,500 MW, which points in the direction of improved utilisation of wind resources in Denmark and fewer investments required in relatively more expensive offshore wind power. These are all conditions that can contribute to making the green transition affordable.

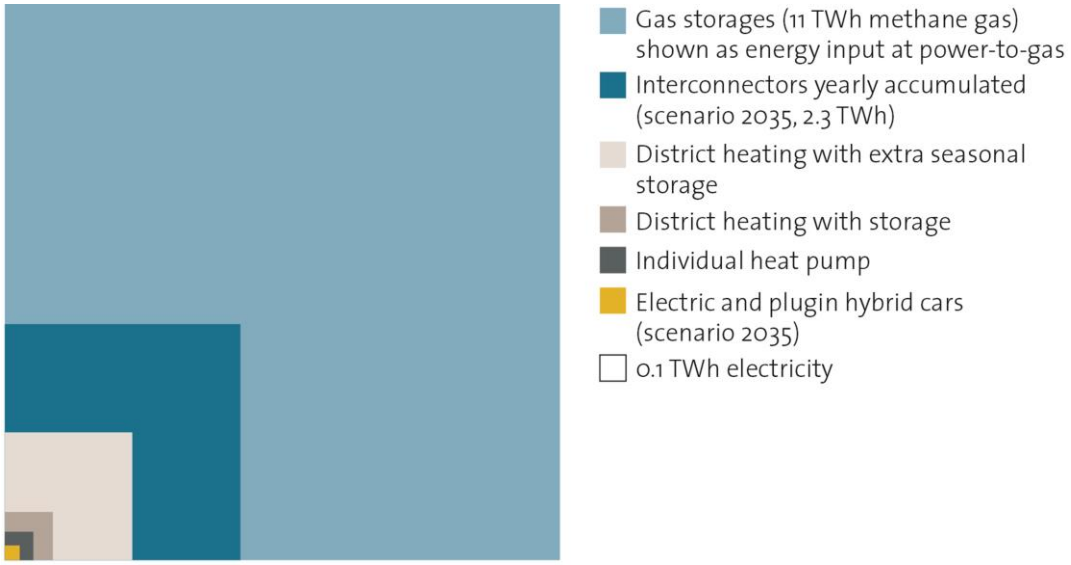
Electricity supply during periods with few wind and solar power resources

Analyses have been conducted of ten-year historical consumption and generation time series for wind and solar power in Denmark and Europe[1]. These show that there are periods of more than one week's duration with very low electricity generation from both wind and solar power; see Figure 2.

Working with scenarios in a European context is therefore key to the system choice to be made in Denmark. Energinet.dk's cooperation with ENTSO-E and in the e-

[1] Time series from Pan-European Climate Database.

Figure 3: Various storage option capacities



Highway2050[2] project has formed the basis for a number of assessments of the future framework conditions up until 2035 and 2050. In the analysis, emphasis has been placed on combining these international scenarios with the extensive analyses of ten years of detailed European time series for wind and photovoltaics, for the purpose of being able, to a higher extent, to minimise the costs of the Danish system and ensuring that Denmark's energy supply is robust. The analysis also provides strong knowledge about Denmark's and other countries' power situation in cases where the wind power-dominated Europe in 2035/2050 is exposed to particularly extreme weeks with low electricity generation from wind and solar power. The findings indicate that particularly the Nordic region and to some extent the UK can strengthen generation adequacy via international connections during these periods.

In more extreme and long periods of time (months) with relatively low generation from wind power, the energy consumption for electricity generation falls within the amount of energy which can be supplied from the Danish gas storage facilities; see Figure 3. This means that there is sufficient energy in these storage facilities to ensure the security of supply, provided that power station capacity is available.

Capacity from our international connections is a cost-effective solution; however, in order to be robust in the face of the uncertainty which may exist in the long term in terms of capacity abroad, it is also important to have sufficient flexibility to be able to establish additional cheap peak-load electricity generation capacity in Denmark at a response time of relatively few years.

Flexible consumption

The analyses also suggest the expediency of a combination of flexible electricity consumption particularly capable of providing peak-load generation over minutes and hours and international market integration capable of making capacity available over several days. The realisation of these measures has the potential to reduce the need for backup capacity (thermal power stations) by 25-35% relative to a classic approach with peak-load capacity.

Gas

The role of the gas system is expected to change dramatically over the coming decades. An effective electric technology within both heating and process heating can significantly reduce the need for natural gas. The analysis

[2] The e-Highway2050 project is supported by the EU and is aimed at developing a methodology to support the planning of a pan-European transmission grid with focus on security of supply of RE electricity and pan-European market integration.

also shows that gas CHP plants are in operation to a relatively limited extent during normal wind periods due to large volumes of wind power/a large number of photovoltaic cells and central heat pumps. However, during special periods with low electricity generation from wind/solar power in large geographical areas in Northern Europe (see the analysis of time series for wind and photovoltaics), gas for peak-load generation for both combined heat and power and process heat is crucial to ensuring cost stability in the energy supply. The gas grid must therefore be optimised economically and operationally for this new role.

District heating

In an energy system with large volumes of wind power, base-load combined heat and power generation will decline; however, the possibilities of, for example, energy efficient heat pumps, utilisation of surplus heat from fuel production, industrial process heat, solar heat and peak-load electricity generation assign a very important role to the heating system in terms of ensuring high system robustness and energy efficiency. The district heating systems will therefore become important in relation to exploiting the increasing quantity of surplus heat from different processes in the future energy system, and the need for utilising primary fuel resources such as biomass for heat generation will therefore be reduced.

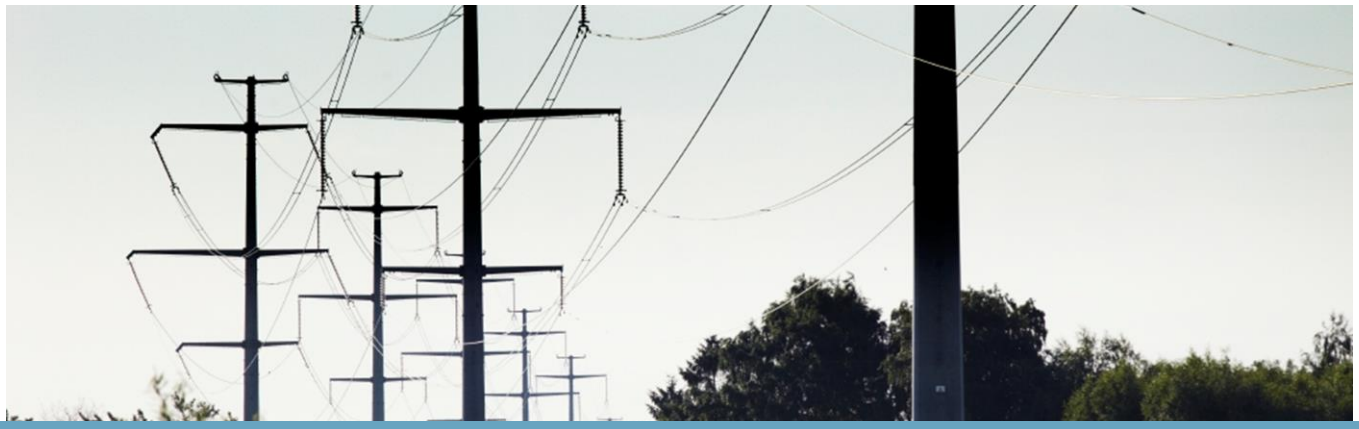
Robust Danish energy system

The analyses show that important storage capacity for energy is available in the gas and heating systems. Increased interaction between the energy systems (electricity, gas and heating) can make an RE-based energy system more robust in a cost-effective manner, and many of the measures described in Energy Concept 2030 are based on this idea. But reaping the benefits of this flexibility presents a number of challenges in respect of the control and stability of the energy system.

Indicators for a socio economically viable transition

An effective transition requires strong interaction between the different energy systems. In-depth analyses, assessments and dialogue about the future development of the overall interconnected energy system are therefore required to enable Energinet.dk to ensure cost-effective and timely investments in both transmission grids and security of supply of electricity and gas.

Traditionally, the progress in the transition to renewable energy is often assessed solely on the basis of the energy system's RE percentage, which may result in a simplified, one-dimensional description of the RE system. In contrast, Energy Concept 2030 shows that increasing the cost effectiveness of the future RE system is a complex task, where conflicting aspects must often be weighed up



against each other, and where concepts such as economics, efficiency, flexibility, electrification etc. must be handled and assessed in a broader context.

Having recognised the complexity of working with RE scenario analyses, Energinet.dk is in the process of developing so-called 'transition indicators' which, in a clear manner, are to help manage the complexity and provide a more balanced characteristic of RE scenarios. In addition to a calculation of the RE percentage, the transition indicators must therefore also provide a more qualitative description based on other relevant parameters.

Energinet.dk deems that three special core indicators are essential in the assessment of and dialogue on the transition of the energy supply.

One indicator of the RE share of the entire energy supply is the traditional indicator which generally and quantitatively describes how large a share of Denmark's energy consumption consists of renewable energy.

An indicator of energy efficiency in the entire energy supply will be a more qualitative indicator describing 'our mileage per litre'. The indicator must describe the relationship between energy input (gross energy consumption) and the energy utilised for the requested energy services; for example how much input energy needs to be filled in the tank in order to create the energy required to move a vehicle weighing one tonne one kilometre, or how much input energy in a normal-temperature year it takes to heat, for example, 100 m^2 to 20 degrees Celsius.

It will probably be expedient to have an indicator of electrification, which can be seen as a sub-indicator of energy efficiency improvement. Electrification of, for example, heating with heat pumps and electricity for transport are highly energy efficient technologies, which is why the development within electrification will have a very large impact on the development in energy efficiency.

An indicator of flexibility in the electricity system will be another valuable qualitative indicator of the transition of the energy supply. Fluctuating electricity generation from wind and solar power is expected to be the cornerstone of the transition of the Danish and European energy supply to renewable energy. Land-based wind is, for example, the cheapest form of new electricity generation already today, given the fact that the electricity generation can be integrated cost-effectively. With the large shares of electricity generation from wind and solar power, it can thus be expected that the flexibility in the electricity system will increasingly become the 'resource' limiting the transition. The electricity generation from wind and solar power in itself will be cheap, but the price

of the integration – the flexibility – will determine how cost-effective the transition to renewable energy will be. Flexibility in the electricity system may come from both flexible electricity generation and flexible electricity consumption as well as from increased electricity interchange between regions and countries – particularly in cases of differences in generation and consumption patterns.

From a purely methodological perspective, the calculation of the indicators is basically expected to be carried out by assigning different weights (qualities) to different technologies with respect to, for example, renewable energy, electrification, efficiency and flexibility. Different technology mixes in an energy system will therefore result in different outcomes on the indicators mentioned above.

The indicators are expected to be ready for use in the course of 2016.

Theme: Market development for electricity and gas

In the performance if its tasks, Energinet.dk must contribute to ensuring that the best possible conditions are established for competition in the markets for electricity generation and gas production and for trading in electricity and gas.

Energy Union

As the energy area was not originally a part of the EU's Treaty basis, the EU was prevented from developing an actual coherent energy policy. In step with energy and climate policy issues becoming ever more urgent, however, the EU has gradually been given a bigger role. In 1988, the European Commission formulated its first initiatives for what was to become the internal energy market, but because the energy area was not yet at that time a part of the Treaty basis, the European Commission had to use the general rules on the free movement of goods and competition as the basis. From the outset, the energy policy was thus characterised by the European Commission's Directorate-General for Competition, and focus was on liberalising the monopolies that dominated both the electricity and gas sectors.

It was not until the Lisbon Treaty entered into force in 2009 that the EU energy policy was incorporated in the Treaty basis, and the EU thus got the opportunity to work with broader energy policy agendas. Article 194 of the Lisbon Treaty now grants the EU competence to ensure the functioning of the energy market, ensure security of supply, promote energy efficiency and energy savings and the development of renewable forms of energy, and promote the interconnection of the national transmission grids.

Apart from the fact that the Lisbon Treaty maintains that the member states have the right to determine the general structure of their national energy supply, the Treaty now opens up for the EU developing an actual broad-spectred energy policy – and this is reflected in the European Commission's proposal regarding the Energy Union.

The Energy Union is based on three objectives: security of supply, sustainability and efficiency/competitiveness. To reach these objectives, the Energy Union focuses on five dimensions:

- Energy security, solidarity and trust
- The internal energy market
- Energy efficiency
- Decarbonisation
- Research, innovation and competitiveness

The European Commission's Energy Union proposal contains a number of overall political objectives as well as 15 action points showing the specific initiatives the European Commission intends to take. Several of the 15 action

Figure 4: Capacities on international cable connections which can contribute to realising the intentions of the Energy Union

Table 3: Transmission capacity for electricity (MW)

EXISTING	Exports	Imports
East Denmark-Sweden	1,700	1,300
East Denmark-Germany (Kontek)	600	600
West Denmark-Norway (Skagerrak)	1,700	1,700
West Denmark-Sweden (Konti-Skan)	740	680
West Denmark-Germany (East) I	1,640	1,500
Great Belt	600	600
Bornholm-Sweden	60	60
UNDER CONSTRUCTION	**Exports**	**Imports**
West Denmark-Netherlands (COBRA)	700	700
East Denmark-Germany (Kriegers Flak)	400	400
West Denmark-Germany (East) II	860	1,000
BEING INVESTIGATED	**Exports**	**Imports**
West Denmark-UK (Viking)	1,400	1,400
West Denmark-Germany (West)	500-1,000	500-1,000

points have an impact on Energinet.dk. The action points which demand special attention in relation to Energinet.dk's activities and tasks are described in the following.

Security of natural gas supply
The EU's gas imports must be diversified and thus become less dependent on individual import routes, and the gas system must be made more resilient to supply disruptions. The European Commission will present a proposal for revising the security of natural gas supply regulation addressing both these issues in 2015-2016. The proposal may result in changes in the Danish emergency supply concept for natural gas.

Infrastructure
The right infrastructure is a precondition for the internal energy market, for the integration of fluctuating renewable energy and for the security of supply.
The idea is that the financial support from the EU's various infrastructure funds must be used as a lever to get private investors (pension funds etc.) to invest in electricity and gas infrastructure.

The European Commission will convene a dedicated Energy Infrastructure Forum in Copenhagen where the member states, the regulators, the ENTSOs and relevant regional cooperation groups must meet to discuss and ensure progress in the infrastructure development. It is important for Energinet.dk that methods and processes be developed that underpin the regional approach to optimised planning of the energy infrastructure. This need is current as Energinet.dk is already strongly involved in the expansion of international cable connections; see Figure 4 and Table 3.

Security of electricity supply and the electricity market
The European Commission will implement two significant legislative initiatives already in 2016, where the Commission will propose new regulation of security of electricity supply and the electricity market. These two initiatives are to ensure that the internal energy market is developed so that it meets the objective of ensuring consumers cheap electricity and is able to handle the ever-increasing volume of renewable energy without compromising security of supply. In particular, the European Commission wishes to avoid the development of different and mutually uncoordinated capacity markets in the member states. The European Commission's initiatives are in line with Energinet.dk's own analyses and assessments of the need for adaptations of the market model for electricity.

Regionalisation
The European Commission finds it important to promote market integration through regional initiatives, and the

Commission will actively support and engage in regional cooperation bodies. The structure of the regional cooperation is not clear at present, but could, for example, be in the form of regional service companies (eg JAO and TSC, both of which Energinet.dk is the co-owner of) or in the form of binding cooperation agreements. The Danish energy system is a small system with many international connections, and Energinet.dk therefore finds the regional development positive.

Regulation

The European Commission will review the regulatory framework for the development of the internal energy market in 2015-2016 and proposes that both ACER[3], ENTSO-E and ENTSOG should be strengthened. An important element in the practical development of the internal energy market is the implementation of the network codes which are to harmonise the member states' rules on the use of the markets, the connection of plants to the grids and the practical operation of the system. As concerns Energinet.dk, a strengthening of the European bodies will have an impact on how we work in an international context, meaning that Energinet.dk targets its efforts to obtain the greatest possible influence.

[3] ACER stands for Agency for the Cooperation of Energy Regulators. ACER's objective is to promote the cooperation between national energy regulators and make decisions in the event of disputes between these as well as working towards the completion of a single EU energy market for electricity and natural gas.

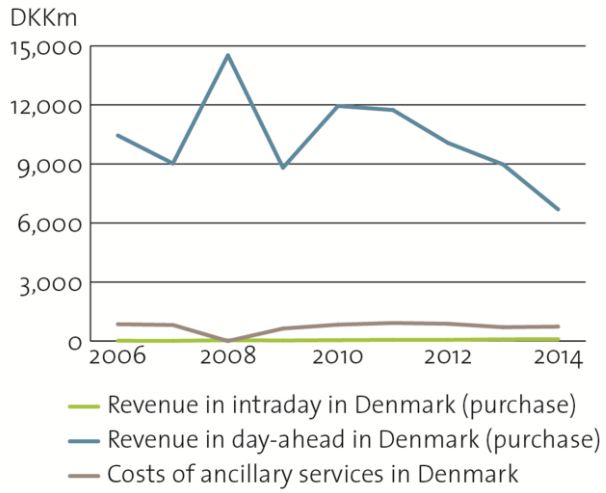
Developments in Denmark

The purchase and sale of electricity and the ancillary services which the grid needs to ensure stability take place either on open exchanges with a large number of market participants or as calls for tenders with the participation of a limited number of market participants. Today, most of the electricity trading takes place on open exchanges. The following sections focus on the progress we have made as concerns the completion of the market for this part of the electricity trading and in terms of opening it up for competition.

The first part of the liberalisation of the electricity and gas sectors was launched in 1999 and actualised in 2002 when the electricity and gas markets were required to ensure:

- Greater freedom of choice in connection with the purchase of electricity and gas for households and businesses
- More competitive Danish energy prices compared with other countries
- More environment for the money for the Danish society.

Figure 5: Revenue in the electricity markets



All electricity consumers have been free to choose supplier since 2003, and all gas consumers have similarly been able to freely choose supplier since 2004. At this point, it would be natural to provide a status on the last more than ten years of work on creating a market for electricity and gas trading in Denmark. A natural starting point would be to compare the electricity and gas prices today with the prices before the liberalisation of the markets. But a calculation like that is not of much use, as electricity and gas prices are to a higher extent determined by fuel prices, the weather and political objectives rather than by the liberalisation. It is therefore not possible to determine what the prices would have been today without the liberalisation.

Instead, a status on the market formation is provided in the following by looking at simple indicators for the electricity and gas trading in the wholesale and retail markets:

- Degree of international market integration
- Price transparency
- Number of changes of supplier
- Market concentration

Electricity trading in the wholesale market

The technical and organisational conditions for establishing a common European electricity price exist today. It can be concluded that the wholesale market for electricity (the day-ahead market), which accounts for the vast majority of the revenue in the electricity markets (Figure 5), is characterised by international competition and price transparency. And it is only a question of time before the intraday market will follow suit, as network codes for the electricity market are expected to be implemented in stages, with deadlines in 2018, 2020 and 2023, respectively (see the theme on network codes, pages 24-25).

NETWORK CODES

FACT BOX ON ELECTRICITY AND GAS NETWORK CODES

A number of European network codes (NC) and binding guidelines are currently being developed. A network code is a European legal instrument intended to establish common European rules for everyone involved in operating, planning or using the European electricity and gas systems. Such rules are a condition for a well-functioning internal market across national borders. Network codes are adopted as regulations under the control of the European Parliament and of the Council and will, after entering into force, have direct effect in all member states.

Implementation of network codes

In step with network codes entering into force as regulations, methods and solutions must be prepared, submitted for public consultation, approved by national regulators and subsequently implemented. In practice, the TSOs, including Energinet.dk, have therefore already initiated quite a bit of work at national, regional and European level in order to meet both current and future requirements.

Market and operational network codes, in particular, place requirements on regional and European solutions. Energinet.dk is therefore actively involved in relevant projects under ENTSO-E and ENTSOG. Moreover, on the electricity side, a close cooperation has been established between the Nordic TSOs with a view to solving the regional tasks, including cooperation with NordREG to ensure early involvement of the regulators. Similarly, Energinet.dk is cooperating with TSOs in other regional groups; for example, a regional group of TSOs from both the Nordic region and the continent is being established. On the gas side, the TSOs participate in the Gas Regional Initiative (GRI), where national regulators, the European Commission, member states and TSOs participate in regional groupings to resolve regional gas-related issues. Denmark participates in GRI NW, and Energinet.dk participates in this group via ENTSOG.

Danish market participants have the opportunity to comment on the future solutions via regional and European consultations. Energinet.dk will provide information about these in relevant forums and on Energinet.dk's website. In addition, several stakeholder committees will be established at European level, where Danish market participants can keep up-to-date through their European trade associations.

NETWORK CODES

ELECTRICITY SYSTEM		Category	Effective date (E=expected)	Implementation
Capacity Allocation and Congestion and Management Procedures for capacity calculation, day-ahead and intraday markets		Market	14 Aug. 2015	In stages: 2015-2020
Forward Capacity Allocation Procedures for the purchase of transmission rights via explicit auction			2016 (E)	In stages: 2016-2018
Electricity Balancing Procedures for the establishment of a common European balance market			2017 (E)	In stages: 2017-2023
Requirements for Generators Determination of network codes concerning requirements for grid con-		Connection	2016 (E)	No later than three years
Demand Connection Determination of network codes for connection			2016 (E)	No later than three years
HVDC Connections and DC Connected Power Park Modules Connection of transmission systems with high-voltage direct current			2016 (E)	No later than three years
Operational Security Determines safety requirements during normal operation	To be gathered under one NC by the European	Operation	2016 (E)	No later than 18 months
Operational Planning and Scheduling Lays down requirements for operational planning			2016 (E)	No later than 18 months
Load Frequency Control and Reserves Procedures for power balancing and required reserves			2016 (E)	No later than 18 months
Emergency and Restoration Requirements for alert state operation, blackout and restoration			2016 (E)	In stages: 2016-2021
GAS SYSTEM		**Category**	**Effective date (E=expected)**	**Implementation**
Congestion Management Procedures Procedures for congestion management at border points		Market	Aug. 2012	Oct. 2013
Capacity Allocation Mechanism Procedures for capacity auctions at existing border points			Oct. 2013	Nov. 2015
Balancing Network Rules Procedures for gas system balancing			Mar. 2014	Oct. 2015
Incremental Proposal Procedures for capacity auctions at expanded and new border points			Mid-2016 (E)	2017 (E)
Tariff Network Code Procedures for harmonising tariff structures			Beginning of 2016 (E)	2017 (E)
Interoperability Rules Procedures for interoperability between two adjacent gas systems		Operation	Apr. 2015	May 2016

Figure 6: Common price formation in European countries, May 2014

International markets create competition
The EU's third liberalisation package from 2009 contributes to creating a well-functioning internal energy market with greater competition. Energinet.dk is cooperating actively with European TSOs, exchanges and authorities on creating international markets, and Energinet.dk is, for example, responsible for preparing market regulations describing the specific market conditions in Denmark.

On the day-ahead market for electricity, Europe has come a long way towards creating a common market. In 2015, 19 countries are utilising the same price calculation. One common price calculation and harmonised market rules ensure that electricity flows across the national borders from low-price areas to high-price areas. In this way, consumers are offered the cheapest possible electricity overall, and electricity generators engage in competition with each other across national borders. Previously, the individual country or region typically had its own price calculation, which sometimes resulted in suboptimal utilisation of European resources. For example, the electricity between Denmark and Germany flowed the wrong way (from a high-price area to a low-price area) 20-30% of the time before the market coupling.

Between 6.00 and 7.00 on 15 May 2014, the same price was seen for the very first time in the day-ahead market from Portugal in the southwest to Scandinavia in the north and the Baltic States in the east. So far, it is far from every day that a common electricity price is established in such a large geographical area as the one shown in Figure 6. But the price formation on 15 May 2014 is proof that the technical and organisational conditions for a common European price formation exists today. However, constraints in the European infrastructure mean that a common price formation is not the normal situation. The infrastructure can be improved through increased investments, but using expansion as the solution to all infrastructural constraints will most likely not be economically viable.

Similarly, Energinet.dk is cooperating with European TSOs, exchanges and authorities on interconnecting the European intraday markets. However, it will be a number of years before the intraday markets in the participating countries are interconnected.

Transparent prices
Transparent prices contribute to well-functioning markets as the market participants are facing the same price signal. One indicator for transparency may be the share of the consumption which is traded in the same marketplace, eg on an exchange. In the first years after the liberalisation (2000-2004), the share of the total electricity

trading on Nord Pool Spot's day-ahead market[4] was relatively low, but since 2005, this share has been roughly 90% of the consumption, which indicates a high level of transparency in the day-ahead market.

Integration of wind power

It is crucial to the integration of wind power that the generation from wind turbines follows the market signals. Previously, the generation from wind turbines was inflexible. Today, Denmark's 400 MW onshore and 600 MW offshore wind power offer their flexibility in the regulating power market, where wind turbine owners are rewarded for switching off the wind turbines in situations where there is a surplus of wind energy in the system. In several other countries, eg Germany, wind turbine owners are penalised if they do not supply the exact volume agreed. The lack of German infrastructure capacity has resulted in an increasing number of situations with internal German congestion caused by high wind power generation. This opens up new market opportunities for Danish wind turbine owners, as the Danish wind turbine flexibility can help solve the German problems.

[4] The day-ahead and intraday markets are described in further detail in the chapter on electricity system operation, pages 49-52.

Market development in general

One of the challenges in the future will be to balance supply and demand at a time when a very large part of the electricity generation is being transferred to non-dispatchable renewable electricity-generating facilities such as wind power and photovoltaic cells. Even though the expansion of wind power capacity over the past years has been significant, and even though capacity at the thermal electricity-generating facilities has been declining, the thermal power stations are still responsible for a very significant proportion of the Danish electricity generation capacity. Nevertheless, a continued development in this direction will entail the need to develop new market models in the electricity field that can incorporate a changed weighting in the generation capacities between dispatchable and non-dispatchable electricity generation in Denmark.

In cooperation with other Danish energy market participants, Energinet.dk has worked on developing a new market model, Market Model 2.0, to also ensure the ability in future to create balance between consumption and generation on an economically optimum basis. The work on developing and preparing recommendations for a new market model in cooperation with Danish energy market participants was completed in 2015 with a number of specific recommendations, for example recommending the use of strategic reserves as the basis for

solving possible capacity shortage problems in East Denmark after 2025. Lack of capacity can partly be covered by flexible consumption, and Energinet.dk is therefore working, in a dialogue with the industry and at international level, on establishing the framework and changing the rules which can make the electricity market more accessible for flexible consumption. In the short term, Energinet.dk will analyse and identify the system critical properties that will be needed in the future electricity system. Based on the scope of the needs, it must be assessed how they can be satisfied in an expedient manner and whether a solution complies with the common European network codes.
There is still a lot of work to be done with regard to the future implementation of a new market model.

Trading in ancillary services

Energinet.dk purchases ancillary services to maintain stability in the electricity grid. The most important ancillary services in West Denmark are supplied from manual (FRR-M), primary (FCR) and secondary (FRR-A) reserves. In East Denmark, ancillary services are supplied from manual reserves, frequency-controlled normal operation reserves (FCR-N) and frequency-controlled disturbance reserves (FCR-D). The reason for the difference between East and West Denmark is that the two parts of the country belong to two different synchronous areas which are balanced in different ways.

Common Nordic regulating power market
Regulating power is traded on the common Nordic regulating power market through the Nordic Operational Information System (NOIS). Market participants supplying manual reserves are under an obligation to submit bids on the regulating power market on the day before the day of operation. Alternatively, a market participant which is not a contractual supplier of manual reserves may submit a voluntary regulating power bid up to 45 minutes before the delivery hour. All bids are settled in the same way and at the marginal price, ie the price of the highest accepted bid.

Reserves
The majority of the Danish reserves consist of manual reserves. In brief, manual reserves are power stations which can commence operations at fifteen minutes' notice if Energinet.dk assesses that there is a need to supplement the generation from power stations, local CHP plants, wind turbines etc. to maintain the security of supply.

In East Denmark, Energinet.dk has concluded bilateral agreements for the periods 2011-2015 and 2016-2020. In West Denmark, the manual reserves are purchased at daily auctions. The marginal price is used for settlement with the market participants. The purchase of the primary reserves takes place at one daily auction for the following

day of operation. The auctions are divided into six blocks. All accepted bids receive an availability payment corresponding to the marginal price at the auction.

A proportion of the primary reserves (FCR) and all the secondary reserves (FRR-A) have been purchased under a five-year agreement with suppliers in Norway from 2015-2019 as part of the agreement on the establishment of the Skagerrak 4 connection. The connection was commissioned at the turn of the year.

Supply ability contracts
Supply ability contracts constitute a new ancillary service product in Denmark. In West Denmark, the supply ability contracts ensure that the market for secondary reserves is maintained, with the demand generally being met by the supplies agreed via the Skagerrak 4 connection. In East Denmark, the supply ability contracts are preparing the market participants for the future market for secondary reserves (FRR-A) in the Nordic region. The supply ability contracts are offered at monthly auctions, where bids are selected on the basis of the price and are settled as pay-as-bid.

The purchases of frequency-controlled normal operation reserves (FCR-N) and frequency-controlled disturbance reserves (FCR-D) in East Denmark are made for each reserve via a two-part auction process, with the majority of the total requirement being purchased two days before the day of operation, and the remaining quantity being purchased the day before the day of operation. The auction takes place in a common East Denmark-Swedish market, where the availability payment for FCR-N and FCR-D corresponds to the price the market participant has bid (pay-as-bid). The subsequent payment for activation corresponds to the regulating power price.

Trading in properties required to maintain power system stability
Properties required to maintain power system stability have historically been procured via activation of thermal power stations. For many years, Energinet.dk has periodically used monthly tenders to purchase these services. Since April 2015, it has been a fixed procedure each month to purchase the properties required to maintain power system stability in order to create transparency regarding need and activation. In addition, forced operation can be used as a tool to procure the properties required to maintain power system stability, when the market has not activated the thermal power stations.

Table 4: Hubs for electricity, regulating power and ancillary services

MARKETS	
Electricity	Electricity is traded on Nord Pool Spot, which is a European exchange for trading in electricity in both the day-ahead and intraday markets. Nord Pool covers an area corresponding to the countries Norway, Sweden, Denmark, Finland, Germany, the UK, Estonia, Latvia and Lithuania. Nord Pool Spot is located in Oslo and is owned by Statnett SF, Svenska Kraftnät, Fingrid Oyj, Energinet.dk and the Baltic TSOs Elering, Litgrid and Augstsprieguma tikls.
Regulating power	Regulating power is either traded as contractual manual reserves with daily auctions prior to the day of operation or as voluntary bids from other market participants. The Nordic Operational Information System (NOIS) supports the exchange for trading in regulating power in the Nordic region.
Ancillary services	The operation of the electricity grid requires the purchase of ancillary services from, for example, manual reserves, primary reserves (frequency stabilisation), secondary reserves (primary reserve load shedding), frequency-controlled normal operation reserves (automatic frequency control) and frequency-controlled disturbance reserves (eg in the event of line or transformer outage). For some of the services, there are only a few possible suppliers. The services are therefore purchased by Energinet.dk by offering the tasks at auctions. There may be daily auctions for some services, while for other services, an auction may concern a long-term contract. The auctions are held by Energinet.dk.

Strategic reserves
In addition, Energinet.dk purchases so-called strategic reserves. Strategic reserves are available if something unexpected happens – for example in the event of outage of a power station or an international connection. Strategic reserves can either be a power station that Energinet.dk can activate or be large consumers or groups of electricity consumers which make themselves available and which can interrupt their consumption if requested by Energinet.dk. Energinet.dk purchases strategic reserves through tenders, which is described in further detail in the chapter on security of electricity supply.

New ancillary services strategy
Energinet.dk has prepared a new ancillary services strategy, as ancillary services play a significant role in the development and operation of the electricity system and thus in respect of Energinet.dk's ability to meet its commitments regarding security of supply and an economically viable green transition. Energinet.dk will ensure that the necessary functionality can be procured in an economically optimum manner. The strategy focuses on ensuring transparency and internationalisation of the markets. In the coming years, network codes will promote this internationalisation, which offers Energinet.dk the opportunity to procure ancillary services abroad while strengthening Danish suppliers through improved sales opportunities.

Electricity trading in the retail market

There is still a way to go before the retail market for electricity is fully liberalised and efficient.Together with the Wholesale Model, however, the future initiatives constitute a very important step in the direction towards increased competition, innovation and product offering in a market where it will be easier for consumers to make an informed and active choice.

Change of supplier and market concentration
All electricity consumers in Denmark have been able to freely choose supplier since 2003. In the beginning, less than 2% of the consumers changed supplier each year, while this percentage is expected to reach approx. 7.5% in 2015.But the share of changes of supplier in Denmark is still lower than in Norway and Sweden. Large consumers perform significantly more changes of supplier than small consumers. The low number of changes of supplier among small consumers may reflect the fact that the retail market is still characterised by the former local distributors in the grid areas.

The HHI Index (Herfindahl-Hirschman Index) is a measure of market concentration, where 1 corresponds to only one supplier controlling the entire market (monopoly),

while a lower index indicates that the customers are distributed on several suppliers. The European Commission interprets an HHI Index of less than 0.2 as an indication of markets with well-functioning competition. The market concentration in the Danish retail market distributed on grid areas is typically higher than 0.7. The market concentration is, however, declining.

Retail market development in Denmark
The retail market for electricity in Denmark is currently undergoing radical changes, both in relation to the market participants and particularly in relation to the consumers, who are now assumed to actively relate to their electricity consumption. These changes constitute significant steps towards a fully liberalised retail market for electricity.

The first major change is linked to the DataHub, which was commissioned in 2013. The DataHub is a central IT system in the electricity market which handles metered data and automates key market processes such as changes of electricity supplier. Energinet.dk is responsible for developing and operating the DataHub. The purpose of the DataHub is to ensure a central and neutral communication platform and to standardise processes and time limits in the electricity market. The DataHub has made it easier for new market participants to establish themselves in the market and thereby contribute to creating more competition. The number of active balance suppliers has increased, which may reflect the fact that barriers to entry in the retail market have been lowered.

Wholesale Model – brand-new retail market model
A new market model (the Wholesale Model) will be introduced in April 2016. Briefly, this means that, in future, customers must receive one single invoice for both distribution and consumption of electricity.Together with easier access to usage data, the Wholesale Model is to make it easier for customers to understand and act in the electricity market. With the introduction of the Wholesale Model, the regulated default supply products will be phased out, which means that customers must actively choose electricity supplier if they want to continue having power in their sockets. A new settlement method (flex-settlement) will also be introduced, which makes it possible for ordinary households to be charged on an hourly basis, ie based on their consumption on an hour-by-hour basis. Consumers may thus benefit from using electricity when it is cheap and also from cutting their consumption when electricity is expensive. The framework has thus been created for electricity consumers' ability in future to base their electricity consumption on demand response and to contribute to the overall balancing of the electricity system.

Table 5: Natural gas hubs

MARKETS	
PRISMA	Common European capacity platform for the purchase and sale of bundled transport capacity at the border points in the EU. Energinet.dk has established the platform in cooperation with large TSOs in Austria, Belgium, Germany, France and Italy.
Gas hubs	Virtual handover points for trading in gas. Today, there are a number of natural gas hubs in Europe, with the two most liquid hubs being British NBP and Dutch TTF.
Gaspoint Nordic	Gas exchange in Denmark. Gaspoint Nordic is an actual marketplace for gas that can ensure open and transparent pricing in Denmark. Trading on Gaspoint Nordic takes place anonymously as the gas exchange is the counterparty in all transactions. Agreements on transferring gas between two shippers on the gas exchange takes place via the Exchange Transfer Facility (ETF), which is a new virtual trading point in the Danish gas market. Gaspoint Nordic is located in Brøndby.
GTF	Gas Transfer Facility. Handles bilateral gas trade agreements. GTF gives shippers the opportunity to trade natural gas with each other. Before and during the gas day, Energinet.dk can support transactions involving large gas volumes to be transferred between two shippers. GTF is facilitated by Energinet.dk.

Through close dialogue and cooperation with both authorities and the market participants, Energinet.dk is responsible for converting the legislation into the market rules that define the framework for how the retail market is to function. Particularly the implementation of the DataHub and the Wholesale Model has resulted in significant changes in the market rules – changes which have been implemented in close cooperation with the market participants and the authorities. In autumn 2015, Energinet.dk launched a retail market forum, which is to ensure a continued close dialogue about the future development of the framework for the retail market. In addition to the operation of the DataHub and the responsibility for the market regulations, Energinet.dk also performs market settlement of market participants in the electricity market.

International developments

The developments in the retail markets in the Nordic countries are similar in many areas. Denmark is the only Nordic country to have a data hub, but in the course of the next few years, similar central data solutions will be implemented by the TSOs in our neighbouring countries. Energinet.dk continuously coordinates the development with the Nordic TSOs and contributes to the Danish experience with the DataHub being utilised in the Nordic region. This is done specifically by the central business processes in the Danish DataHub constituting the basis for the development of the Nordic hubs. A close regional cooperation on the development of data hubs and the retail markets is an important element on the path towards international market harmonisation.

At European level, the development of the retail markets carries more weight than previously. A closer coupling between the wholesale markets and the retail markets is the next step in relation to completing the internal market for energy and creating liberalised and market-driven support for and green transition of the energy system, both at national and European level. In the latest European proposal from the European Commission, it is pointed out that a key part of the solution to a liberalised and flexible retail market is to be found in neutral data handling. In this context, Denmark's DataHub and the future Nordic data hubs are good examples of Nordic pioneering solutions.

Gas trading in the wholesale market

The northwestern European wholesale market for gas is well-functioning with relatively identical prices at the different hubs, where increasing gas volumes are traded at market-driven and transparent prices. But there is still some way to go before all gas trading is market-driven, as up to half of the Danish gas traded is still traded bilaterally.

Well-functioning northwestern European gas market
After the introduction of the third liberalisation package concerning gas, the development of the gas markets is at different stages in Europe. Northwestern Europe, including Denmark, is characterised by well-functioning and coherent markets with a high degree of correlation between hub prices and joint selling of capacity at the border points via PRISMA. Liquidity at the hubs is improving year by year; however, so far only the British NBP and the Dutch TTF can call themselves genuinely liquid.

Southwestern Europe has not quite come that far, but is on the way, and several countries in the region have become part of PRISMA. Among the Eastern European EU countries, only a handful are currently in the process of establishing hubs, and the market mechanisms are therefore less developed.

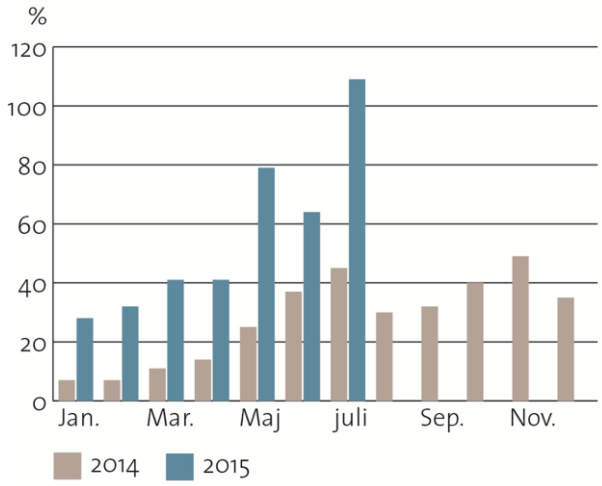
Increased price transparency
Historically, the gas market has primarily been characterised by long-term oil-indexed gas contracts, where the price was unknown by all but the parties involved. Such contracts still exist, but increasing gas volumes are traded at hubs, which helps increase price transparency. An increasing number of hub-based end-user contracts are also being concluded, which must be interpreted as a sign that the market participants find the hub-fixed prices credible. This positive trend is seen clearly in Denmark, where an increasing number of long-term contracts are not renewed, but are instead replaced by day-ahead trading on Gaspoint Nordic.

Increased transport capacity utilised by the market
The 2014/2015 winter was relatively warm, resulting in a reduction in gas consumption in Denmark and Sweden. As the flow from the North Sea was relatively high at the same time, this meant that there was plenty of gas in the Danish market. This was, among other things, clearly reflected in the flow direction between Germany and Denmark which, with the exception of a few days with maintenance work in the North Sea, was southbound across the Ellund border point during the entire winter.

The primary objective of the Ellund-Egtved expansion was to establish northbound capacity, but it had the secondary effect that the southbound capacity was increased and that the commercial capacity could thereby be increased to more than double. Shortly after the expansion, the gas market demanded and utilised the increased southbound capacity.

Massive increase on gas exchange
In the first seven months of the year, the volume traded on Gaspoint Nordic was on average equivalent to about 50% of the Danish gas consumption. This is a significant increase on 2013 and 2014, where the share after the first

Figure 7: Share of Danish gas consumption traded on Gaspoint Nordic – comparison of 2013 and 2014



seven months of the year was approx. 20%. The day-ahead trading still accounts for the majority of the total trading on Gaspoint Nordic. The price difference between Denmark and Germany is still minimal, which indicates a well-functioning market. Since 1 January 2015, Energinet.dk and EEX have shared ownership of Gaspoint Nordic, each with an ownership share of 50% of the shares. Both the Danish and German competition authorities have approved the transaction.

Bilateral market

On the bilateral market (GTF), we saw a sharp drop in volumes traded in 2013. The level was maintained in 2014, but the trend is once more on the decline in 2015. The drop in volumes traded can partially be explained by the increasing volumes traded on Gaspoint Nordic.

Network codes in the gas sector

Four out of five gas network codes at European level have now entered into force. This concerns the network codes Capacity Allocation Mechanism (procedures for capacity allocation), Congestion Management Procedures (procedures for managing congestion), Balancing Network Rules (procedures for balancing) and Interoperability Rules (procedures for data exchange and technical cooperation between TSOs).

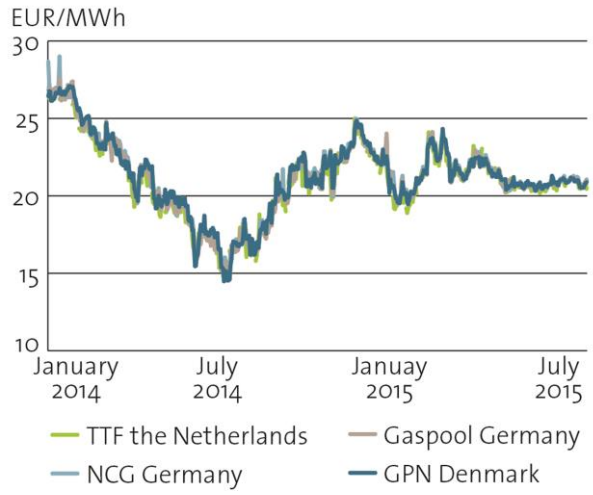
As far as Denmark is concerned, most of the capacity allocation procedures were introduced back in 2013 when Energinet.dk and a number of other European TSOs launched the common European capacity trading platform PRISMA. The only thing remaining to be done is the introduction of auctions for within-day capacity, which will be in place before the deadline of 1 November 2015. Energinet.dk has offered within-day capacity since early 2014, although only on a first come, first served basis.

The procedures for a more market-based balancing system were introduced at Energinet.dk on 1 October 2014. These procedures give the market a greater role in balancing the physical system. Energinet.dk will only interact, by way of trading on the gas exchange, if the total market imbalance exceeds the calculated flexibility on the day.

Gas trading in the retail market

There are a total of around 400,000 metering sites in Denmark. Most customers are aware of the possibility of changing gas supplier, but less than one fourth have actually tried changing gas supplier (Epinion survey carried out in October 2013 for the Danish Energy Regulatory Authority, based on 1,000 respondents).

Figure 8: Gas price development 2014-2015 at selected European gas hubs



First ten years of the liberalisation

There are still new gas suppliers which establish themselves in the gas market. In 2015, Energinet.dk' register of market participants listed 18 active suppliers of gas to private consumers and businesses.

Mobility, as expressed by consumers' knowledge of and willingness to change gas supplier, can, however, still be improved. Even though most consumers are now aware of their options, the consumers obtain no major financial benefit by changing supplier. The one gas supplier with supply obligation licence offers prices of natural gas at the same level as the other gas suppliers. The consumers can compare the gas suppliers' prices on Gasprisguiden.dk, which is administered by Energinet.dk.

Energinet.dk will continue the close cooperation with the distribution companies, which was established more than ten years ago. In addition, we have established a number of cooperation forums with the gas suppliers, which will be maintained or extended to ensure the best possible implementation of the gas modernisation analysis. The intention is that the gas modernisation analysis and the recommendations of the Committee for the Regulation of Electricity will form the basis of a proposed model for improved regulation of the gas sector.

Electricity facilities

Energinet.dk is responsible for planning the expansion of the electricity transmission grid. Energinet.dk's plans and specific solutions for the expansion and conversion of the transmission grid are based on Energinet.dk's analyses concerning the long-term considerations which the transmission grid must also be able to handle in connection with the transition of the energy system (see the chapter on the green transition). The plans are prepared on the basis of predefined and published design criteria which apply to the Danish transmission grid above 100 kV and are recommended for the 50 kV and 60 kV level.

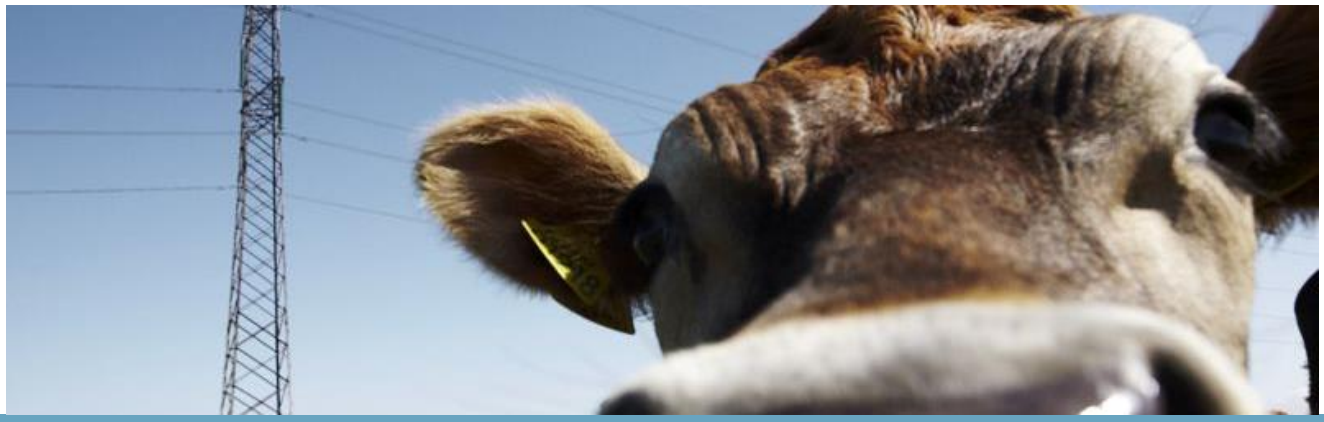
The grid dimensioning criteria must, among other things, ensure that:

- Consumers as far as possible and at any time are supplied via the underlying distribution system and distribution grids
- The Danish electricity market functions, including, in general, that the national generation capacity can be utilised effectively and, specifically, that generation from renewable energy sources can be integrated in the system
- The international electricity market functions, including that the international connections can be used optimally
- There is access to ancillary services when and where they are needed.

The grid dimensioning criteria are based on international regulations issued by ENTSO-E and, together with Energinet.dk's operating practices and requirements for plant layout, they make up the foundation for secure, cost-effective and environmentally friendly electricity supply. The detailed planning of specific projects also incorporates environmental considerations, for example by minimising landscape impacts, as well as incorporating contingency preparedness.

The use of grid dimensioning criteria serves to identify needs for changes in the transmission grid and ensures that a chosen solution can meet the technical requirements. Changes in the national transmission grid are carried out in accordance with the applicable principles of cable laying and transmission grid expansion issued by the authorities, and the solutions are sought implemented with as little as possible impact on the visual environment in connection with the establishment of new plants.

Energinet.dk expands international connections based on economic criteria and expands and converts the national grid based on the cost-effectiveness principle, i.e. the economically cheapest solution which also meets the technical requirements laid down.



Planning of conversion and expansion

As part of the overall grid planning, Energinet.dk prepares a n annual Installation Report with a 10-year time frame as well as preparing a Network Development Plan with a 20-year time frame every other year. At present, the Network Development Plan is awaiting clarification in respect of the Cable Action Plan before being completed.

Purpose of the plans

The plans serve several different purposes, including:

- Ensuring timely launch of projects as the need arises. The plans provide important input to Energinet.dk's portfolio management.
- Ensuring current expansion and conversion solutions which also fit into a coherent long-term plan for the transmission grid.
- Creating an overview of Energinet.dk's projects and their status from idea to commissioned plant.

In general, the Network Development Plan identifies future potential projects, and the plan provides input to Energinet.dk's portfolio management. The results of the Network Development Plan are based on the applicable policy framework as well as on Energinet.dk's analysis assumptions and grid dimensioning criteria.

The Installation Report provides an annual status on the implementation of projects. The Network Development Plan for possible future construction projects as well as the current status on completed, ongoing and planned construction projects via Energinet.dk's portfolio management constitute the input to the Installation Report.

There is continuous coordination between the Network Development Plan, the Installation Report and portfolio management to ensure that the most up-to-date information is available everywhere. In addition to the fixed plans for expansions and conversions, new projects may be established at any time as a consequence of specific plans for, for example, new consumption as well as additional wind power and photovoltaic cells.

Content of the Network Development Plan

Energinet.dk's Network Development Plan is a 20-year plan focusing on the need for developing the internal Danish transmission grid, where possible interconnections to neighbouring countries are included as a prerequisite. The premises of the plan are the political objectives of undergrounding the transmission grid and expanding wind power capacity, which most recently were amended in connection with the energy agreement from March 2012, and which are now being investigated. The final plan awaits this clarification.

Long-term transmission grid structure in 2035
The long-term grid structure sets the framework for the launch of maturation projects and the choice of solutions that fit into an interconnected grid structure for the overall transmission grid above 100 kV. The projects in the Network Development Plan comprise both undergrounding of the overhead lines as well as expansions and reinvestments, and they are included in Energinet.dk's project portfolio for future maturation projects. Gradually as the projects become current, maturation projects are launched in which detailed analyses are performed and documentation and business cases are prepared for further consideration by and approval from Energinet.dk's Supervisory Board and the Danish Energy Agency or the minister.

Content of the Installation Report
The Installation Report is a source of reference of completed, ongoing, planned and potential transmission projects. The Installation Report has a ten-year time frame and is updated once a year with publication in December. The Installation Report presents the current status and provides an overview of the overall economy.

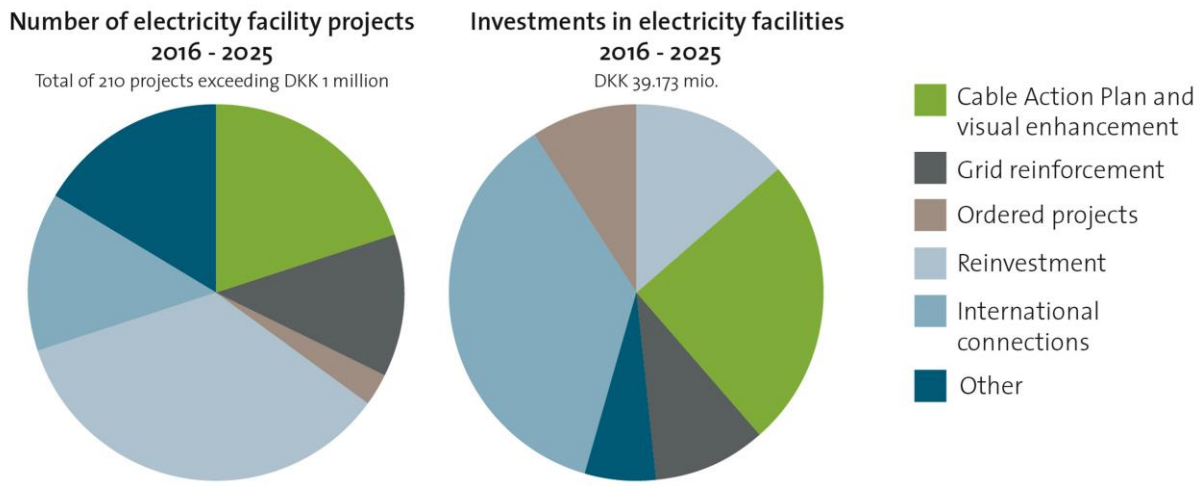
Input to the Installation Report:
- Development plans for international connections
- Results from the latest Network Development Plan, including reinvestments
- Analyses
- Expansion needs occasioned by developments in the distribution grid
- Energinet.dk's portfolio management.

The Installation Report is prepared by Energinet.dk, is published on Energinet.dk's website and is submitted to the Danish Energy Agency and the Danish Energy Regulatory Authority upon completion. The Installation Report is used in connection with the Danish Energy Agency's approval of specific projects.

European grid planning

Every two years, the European network of transmission system operators for electricity ENTSO-E publishes a Ten-Year Network Development Plan (TYNDP). The European Ten-Year Plan is prepared on the basis of investment plans for six European regions and provides a summary of the main electricity infrastructure projects of pan-European significance. The projects typically concern interconnections between countries or between different price areas as well as national connections with common regional or common European significance. Denmark contributes to regional investment plans in the North Sea and Baltic Sea regions and thus also to the pan-European Ten-Year Plan.

Figure 9: Number of conversion and expansion projects and investment costs for electricity facilities up to 2025



Energinet.dk's latest Network Development Plan is used as a source of reference in the regional work process. Conversely, projects from the Ten-Year Plan are communicated to the national Network Development Plan. This ensures continuity and consistency between the Danish Network Development Plan and the international plans at the various levels.

In the Ten-Year Plan, all European projects have been analysed using a common methodology where harmonised indicators are included in a cost-benefit analysis. The methodology has been developed and adopted by ENTSO-E and approved by the European Commission. Based on the cost-benefit analysis, the Ten-Year Plan from 2014 identified an investment potential of DKK 1,125 billion for upgrading and expansion of approx. 50,000 km high-voltage overhead lines distributed on approx. 120 transmission projects up to 2030. The Ten-Year Plan is used as a reference plan and is not binding in respect of the implementation of the projects. The national TSOs and regulators may have other considerations to take into account in the decision-making phase concerning the individual projects.

PCI projects

The projects which have been analysed in the Ten-Year Plan may apply to the European Commission for status as PCI (Projects of Common Interest). Projects with PCI status may offer advantages, for example in relation to fast-track approval procedures, public authority treatment and access to financial backing. The next update of projects with PCI status takes place at year-end 2015.

Denmark's projects with PCI status comprise the COBRA connection between Jutland and the Netherlands, the expansion of the Jutland-Germany interconnections and the Kriegers Flak project. Viking Link may potentially become a PCI project in connection with the next update (if relevant, see theme pages in the section on construction projects being matured).

Regional investment plans 2015

ENTSO-E has published the six regional investment plans for 2015 and submitted them to the stakeholders for comment. Energinet.dk has contributed to the two investment plans in the North Sea and Baltic Sea regional groups. The six investment plans follow up on the Ten-Year Plan published in 2014 and have sown the seeds of the coming Ten-Year Plan 2016.

Ongoing conversions and expansions

The existing transmission grid, which was mainly constructed in the 1960s and 1970s, is facing major reinvestments while also needing major conversions as a result of the transition to renewable energy. All in all,

investments of upwards of DKK 39 billion are required up until 2025; see Figure 9.

Where the purpose of the transmission grid a generation ago was to distribute the electricity generated by large central power stations to consumers, the transmission grid must in the future collect energy from RE facilities without compromising security of supply. This results in a portfolio of activities reflecting the consideration for maintenance as well as the consideration for the transition to renewable energy (see the chapter on the green transition):

1. Connection of offshore wind turbines to the electricity grid
2. Regular reinvestments in the transmission grid, in substations, in overhead line systems and in cable installations
3. New international connections
4. Reinforcement of the domestic electricity transmission grid
5. Undergrounding and visual enhancement in the electricity grid.

As concerns security of supply in the future electricity system, the projects in categories 1-4 are crucial. The size of a project is not necessarily indicative of its importance in respect of security of supply; the project portfolio's composition and prioritisation indicates the importance.

For example, a poorly maintained substation component in the Copenhagen area could have a major impact on security of electricity supply for many people. As concerns the integration of renewable energy, the connection of offshore wind farms, new international connections and expansions in the domestic electricity grid constitute important means to achieving the objective.

Energinet.dk obtained PAS55 certification in 2015 and is audited regularly in respect of its prioritisation, risk assessment and project execution. Energinet.dk's objective of reducing unit costs in investments by 15% is to ensure that Energinet.dk is among the three best European countries in 2020 in the benchmark of European transmission companies.

Maintenance of the electricity grid

The maintenance of Energinet.dk's electricity facilities is based on condition-based maintenance. Condition-based maintenance is based on criticality figures in the transmission system components. This means that the components are not necessarily replaced on the basis of predefined intervals, but that a specific status and risk assessment of the physical condition of the components is performed.

Compared with scheduled maintenance, condition-based maintenance results in significantly reduced expenses.

The prerequisite for performing condition-based maintenance is that a large amount of data about the transmission grid is updated on an ongoing basis, is systematised and is assessed in information systems that can be shared between the various market participants involved in the maintenance work.

The maintenance work is also subject to the PAS55 certification. The work is planned on the basis of the asset management principles of a risk-based approach to maintenance, a systematic approach to documentation as well as continuous optimisation and improvement of processes.

Connection of generators and consumers

In connection with the expansion and operation of the transmission grid, Energinet.dk must ensure that generators and consumers can be connected to the grid on equal terms and under predefined conditions.

CONSTRUCTION PROJECTS BEING MATURED

Based on the Installation Report and the TYNDP process, a number of projects are normally selected for a further maturation process. During the maturation process, it is clarified whether the economic and technical preconditions for the projects are viable, and whether the market participants involved are able to enter into binding agreements. Prior to establishing new transmission grids and implementing significant changes in existing grids, the plan for such establishment or changes must be submitted for approval to the Danish Minister for Energy, Utilities and Climate if the investment exceeds DKK 100 million, and to the Danish Energy Agency if the investment is less than DKK 100 million.

Viking Link

In November 2013, Energinet.dk and National Grid Interconnector Holdings (NGIH) initiated the Viking Link maturation project, which is to explore the possibilities and value of establishing an electricity connection between Denmark and the UK. The investigations carried out show a significant positive effect of a Danish-British connection on the economy. Such a connection would also constitute an important step towards increased market integration in Europe, and would boost competition in both the Nordic and British electricity markets. A Danish-British connection is also expected to generate market value, primarily through exports to the UK of energy produced in Denmark.

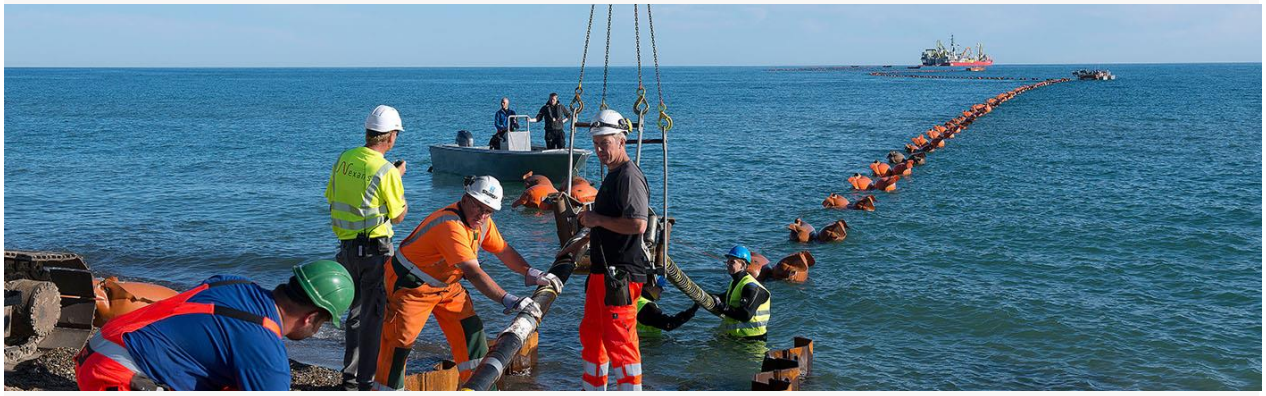
In August 2014, the UK regulator Ofgem announced the rollout of a new regulatory regime in the UK which is to secure investments for UK developers. In September 2014, National Grid submitted an application to Ofgem for coming under the new regulatory regime in the UK. In March 2015, Ofgem presented the results of their initial assessments of Viking Link, and the preliminary assessment is positive in respect of Viking Link coming under the future regulation. Viking Link will undergo a final assessment at Ofgem in 2017. Viking Link is expected to have a transmission capacity of 1,400 MW. The result of the maturation process is expected to be available before the end of 2015.

East and west coast

In January 2015, Energinet.dk's Supervisory Board approved the upgrading of the existing 220 kV lines on the east coast of Jutland to a new 400 kV connection between Kassø and the Danish-German border. The connection is to be established as a double-circuit line and is to constitute the Danish part of the reinforcement between Kassø and Dollern south of the Elbe in Germany. According to the plan, the new 400 kV connection will be completed in 2020 and will increase capacity between West Denmark and Germany from 1,500/1,640 MW to 2,500 MW in both directions.

Assessments are also currently being carried out of the possibility of further increasing capacity between Denmark and Germany. Specifically, the economic consequences of a possible future 400 kV connection along the west coast of Jutland are assessed. This connection will be able to increase capacity to 3,500 MW in both directions. The analyses take place in cooperation with TenneT TSO GmbH, which is working on similar German projects. The result of the maturation process is expected to be available before the end of 2015.

CONSTRUCTION PROJECTS BEING MATURED



Future supplies to Copenhagen secured

Today, supplies to Copenhagen primarily come from two 400 kV connections from the Ishøjgård and Hovegård substations west of Copenhagen as well as from Amager Power Station. Moreover, some reserve supply is received via a 132 kV cable connection from west Copenhagen and North Zealand, which, however, is not sufficient if two of the main supply sources fail.

Due to the market situation, power station capacity is expected to be reduced in Copenhagen over the coming years, which means that alternative supplies to Copenhagen need to be established. Energinet.dk has therefore decided to launch an analysis of the future supply of Copenhagen and how this can best be coordinated with the reinvestment in the 132 kV cable grid, which is expected to take place over the next 5-20 years.

The investigation is expected to be completed by the end of 2016, and the initial establishment activities can then be commenced in 2017-2018. By replacing obsolete cables, the objective is to give Copenhagen a robust and future-proof transmission grid which secures electricity supply in Copenhagen.

Data centre – Apple

On 23 February, Apple announced its decision to place a large new data centre by the Tjele high-voltage substation. The decision put Denmark, and the Danish transmission grid, on the world map. The characteristics of Danish energy supply – a high share of renewable energy combined with a high level of security of supply – and favourable operating conditions apparently contributed to Apple's choice of Denmark as location for a data centre. Apple and Energinet.dk have entered into a maturation contract under which various connection options and technical solutions are being analysed. The connection is expected to involve at least one new 150 kV substation which must be able to handle Denmark's future, largest electricity consumer.

If an opportunity arises in the future for Denmark to attract additional data centres, Energinet.dk and the Danish transmission grid can accommodate such a wish with several suitable location options, a continued high level of security of supply and a continued green transition. A future scenario with more large electricity consumers provides a new and exciting dimension to the development of the future transmission grid.

Generators and consumers are connected on the basis of a number of technical regulations which are to ensure that the connection requirements are determined on a technically uniform, open and non-discriminatory basis. Together with the market regulations, the technical regulations, including the system operation regulations, constitute the non-discriminatory rules to be complied with by the market participants and specify the system-related properties with which a plant must comply in order to be connected to the public grid and the impacts from the grid that a plant must be able to withstand in order to continue to be able to deliver stable operations.

Metering supply and offtake of electricity

Energinet.dk is responsible for metering the supply and offtake of electricity in the electricity transmission grid, which means being responsible for verifying and maintaining settlement meters linked to generation facilities connected to the transmission grid above 100 kV and to the international connections.

It is a necessary prerequisite for well-functioning electricity markets that the market participants trust the accuracy of the metering of the supply and offtake of electricity.The metering must have a high quality level, and the requirement for accuracy must be within a defined framework. In order to be able to comply with these requirements at all times, frameworks and deadlines have been laid down for updating and verification of the equipment. Energinet.dk has initiated a process in which a large share of the meters on international connections and the meters in the regional transmission grid which Energinet.dk took over in 2012 are to be verified or replaced.

Security of electricity supply

As TSO, Energinet.dk has the overall responsibility for security of electricity supply in Denmark. It is therefore Energinet.dk's core duty to ensure both a high and cost-effective level of security of electricity supply – also during the planned transition of the energy supply to renewable energy. Historically, Denmark has had a very high level of security of electricity supply for many years, with power available to consumers 99.99% of the time. This is among the highest levels in Europe. Energinet.dk has the goal of ensuring that security of supply in the Danish electricity system also remains among the best in Europe in the future.

Energinet.dk owns and operates the transmission grid and assesses through long-term grid planning where and how investment should be made in the general infrastructure, such as the transmission grid, international connections and plant providing properties required to maintain power system stability. The overall real-time operation of the Danish electricity system is planned and controlled from Energinet.dk's national control centre.

Grid operators are regulated enterprises which own and operate the distribution grids. The grid operators are thus responsible for expanding and operating the local grid infrastructure and thereby ensuring final delivery to consumers.

From 2015 onwards, Energinet.dk will prepare a separate annual report on security of electricity supply in Denmark.

Objective for Danish security of electricity supply
Energinet.dk has the objective of Danish security of electricity supply being at the top end of the European spectrum. As regards Energinet.dk's area of responsibility, this objective has been defined to mean that, on average, the Danish electricity consumer may only experience a loss of energy corresponding to a maximum of 20 minutes' electricity supply disruption per year, either as a result of faults in the transmission grid (maximum fifteen minutes) or as a result of insufficient power (maximum five minutes).

Historical experience
Any failing electricity supply to Danish electricity consumers will generally be due to either faults in the distribution grids, faults in the transmission grid or simply inadequate electricity generation capacity. Historically, electricity supply to Danish consumers has never been disrupted as a result of lack of electricity generation capacity. In the cases where there have been outages, this has always been due to faults in the grids. For the past many years, the number of outage minutes in Denmark in an average year has been at a very low level. As concerns the transmission grid (the 100-400 kV grids), the

average outage per consumer, seen in isolation, has totalled around fifteen minutes per year for the past ten years. Major outages in the transmission grid are very rare, and historically, major incidents have occurred for short periods of time only in a few years.

Security of supply is about probability
In practice, it is not possible to have 100% security of electricity supply, as this would require infinite backup of both generation and infrastructure facilities and would thus be infinitely expensive. Security of electricity supply is thus not something you either have or do not have. You have a certain level of security of supply.

Energinet.dk has a general probability-based approach to security of electricity supply, as is apparent from its definition of security of electricity supply as: "The probability that electricity is available to consumers on demand". This definition contains key guidelines for how security of electricity supply should be analysed and planned. It is not the number and size of power stations, wind turbines and power lines that determine the level of security of electricity supply in themselves. It is rather a product of the complex temporal and geographic interaction between electricity system elements, the electricity market and the consumer.

For example, generation adequacy – which is part of security of supply – has typically been assessed using domestic capacity balances, where the number of MW from thermal production plants, and later the wind, solar and international connection components, are summed and compared against maximum electricity consumption. This approach was simple and useful when the vast majority of generation was dispatchable (e.g. power stations) and there was limited interconnection with neighbouring countries. With far more non-dispatchable electricity generation, more international connections and the possibility of a higher level of demand-response electricity consumption, there is a need for both a more probability-based and a more international approach to the assessment of generation adequacy. Cost-effective security of electricity supply therefore ideally involves being able to assign probabilities to all key elements of security of electricity supply – today and in the future, nationally and internationally – and then use the resources where they return the most security of supply for the money.

Security in the coming years
In order to assess the security of electricity supply situation for the coming years, it is important to include the long-term analyses of how the electricity transmission grid will develop in the future, and not least how the

Table 6: Capacities in Denmark in 2015 at power stations with dispatchable power generation

EAST DENMARK	MW electric power	Comment
Amager Power Station	320	Wood pellets/coal/oil
Asnæs Power Station	140	Coal/oil
Avedøre Power Station	795	Gas/oil/coal/wood pellets
H. C. Ørsted Power Station	100	Natural gas
Østkraft (Bornholm)	90	Oil/coal
Kyndby and Masnedø Power Station	735	Ancillary plant
Local CHP plants, industry and local power stations	645	Primarily natural gas
East Denmark, total	**2,825**	
WEST DENMARK	**MW electric power**	**Comment**
Fyn Power Station	415	Coal/oil/straw
Nordjylland Power Station	380	Coal/oil
Skærbæk Power Station	390	Natural gas
Studstrup Power Station	375	Coal/oil
Esbjerg Power Station	370	Coal/oil
Herning Power Station	90	Biomass/natural gas
Local CHP, industry and local power stations	1,845	Primarily natural gas
West Denmark, total	**3,865**	

Danish electricity-generating facilities will develop (see the chapter on the green transition).

Concurrently with more and more wind turbines being installed in both Denmark and its neighbouring countries, the thermal electricity-generating facilities will be used less and less. Denmark currently has thermal electricity generation capacity totalling around 6,700 MW compared with wind turbine capacity of around 5,000 MW, see Tables 6 and 7. This should be seen in the light of the average Danish electricity consumption corresponding to a production capacity of 3,500-4,000 MW. As a result of the continued wind turbine expansion, a certain reduction in the Danish thermal power stations' electricity generation capacity can be expected in the long term, corresponding to the capacity of the electricity market.

An increased amount of wood pellets, wood chips and straw will be used in connection with the conversion of large CHP plants to renewable energy up to 2020. Increased use of biomass in the energy supply is an important and relatively cheap tool to increase the use of renewable energy in the Danish energy system. Biomass can relatively easily replace coal in the large CHP plants. The share of renewable energy in Denmark will be approx. 35% in 2020, and more than half will be produced from biomass.

Generation adequacy is primarily delivered at present by the flexible thermal production units in Denmark and by other European countries through the international connections. The latter means that future changes in generation adequacy in Denmark are also dependent on the markets and changes in neighbouring countries.

Energinet.dk's analyses show that there is a difference in security of supply in East and West Denmark, respectively. In 2018, it is estimated that generation adequacy in East Denmark can be maintained at the same level as today, corresponding to an average of 15 outage minutes per consumer per year. However, this assumes the purchase of 200 MW of strategic reserves for the 2016-2018 period. Without the 200 MW of strategic reserves, the level will be approx. ten minutes per year. As concerns West Denmark, no generation adequacy problems arise in 2018, 2020 or 2025.

In 2020, the level of security of supply in East Denmark is not critical either, given the expected developments in neighbouring countries and the domestic capacity. A significant underlying assumption for this expectation is the establishment of an international connection associated with Kriegers Flak offshore wind farm. If more power stations than expected are decommissioned in East Denmark or the Kriegers Flak international connection is

Table 7: Capacities and expected electricity generation in Denmark in 2015 on non-dispatchable electricity-generating facilities

OFFSHORE WIND POWER	Capacity, MW	Annual generation based on expected annual full-load hours in 2015 (GWh)
Horns Rev 1 and 2	369	1,534
Rødsand 1 and 2	373	1,411
Anholt	400	1,698
Near-shore wind turbines	130	389
ONSHORE WIND POWER		
East Denmark	612	1,220
West Denmark	3,013	6,976
WIND POWER, TOTAL	**4,896**	**13,228**
PHOTOVOLTAIC CELLS, TOTAL	**608**	**608**

delayed, new initiatives may be required to maintain the generation adequacy level in East Denmark.

In the short term, Energinet.dk will purchase 200 MW of strategic reserves in East Denmark for the 2016-2018 period to ensure the desired level of generation adequacy. The procurement of the 200 MW has been put to tender and must subsequently be approved by the EU. These strategic reserves are expected to ensure that the level is maintained around five minutes per year in East Denmark, rather than increasing to ten minutes per year. After 2018, it is essential that the Kriegers Flak connection is established and contributes to security of supply in East Denmark.

Security in the long term

In the medium term, Energinet.dk has begun working with market participants in the industry to investigate ways in which generation adequacy can be ensured. This is a part of the Market Model 2.0 project. The conclusions of the work point to the market generally having to procure the necessary capacity, but that the possibility of using strategic reserves must be put into use in order to solve any capacity shortage problems in East Denmark after 2025. The solution will, when the need arises, be compared with other alternatives available at that time.

The large difference between East and West Denmark in terms of security of supply also shows there is economic value in being able to share a larger quantity of power between east and west. This could potentially make it financially relevant to establish a new connection between East and West Denmark. Energinet.dk will therefore undertake a socio economic evaluation of such a connection.

Electricity system operation

Maintaining the technical quality of and balance in the interconnected electricity supply system and ensuring sufficient generation capacity at the moment of delivery are important elements in Energinet.dk's responsibility for security of supply.

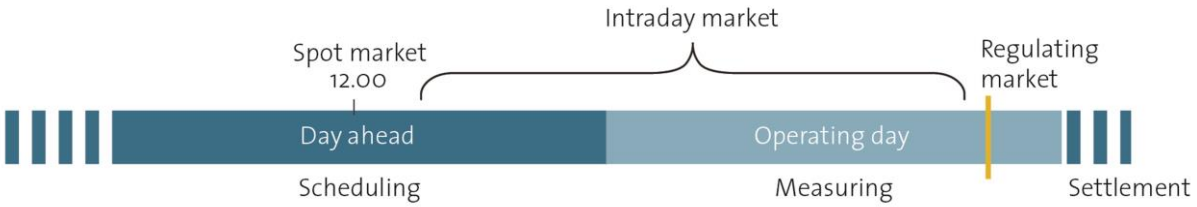
One of the purposes of the everyday operation of the electricity system is to ensure that electricity generation and electricity consumption balance at all times. Through active and ongoing updating of forecasts and operational planning towards the individual delivery hour, it is possible to minimise imbalances before they occur in the delivery moment itself. Not only is such proactive operation a cost-efficient way to balance the electricity system, but it also provides Energinet.dk's control centre with an in-depth and ongoing insight into which resources are present in the electricity system at any given time. Together with a wide range of written procedures, this ongoing insight and control helps to reinforce system security by making it possible to prevent system critical situations to a greater extent – and deal with them more promptly if they do arise.

Technical regulation
One of the cornerstones in ensuring a high level of security of supply is to have a standardised framework for the connection and operation of plants which are to be connected to the transmission grid. The regulation takes place by means of the technical regulations, which are national rules derived from common European policies, Nordic and international standards and national rules. Energinet.dk prepares the regulations in cooperation with stakeholders in the industry, and the regulations are subsequently registered with the Danish Energy Regulatory Authority. Over the coming years, the rules will be harmonised through EU regulations on network codes and guidelines.

Operating agreements with other countries
In proportion to the size of the electricity market, Denmark has many international connections. These help maintain security of supply and allow energy to be most efficiently utilised at the regional level. To support these important international connections, it is essential they are operated in a trustworthy and coordinated manner. The flow in each connection is determined by the European market coupling prior to the day of operation, and is only changed if there is a mutual agreement (trade) between the TSOs involved. Such guidelines are applicable in both normal and critical situations.

Greater harmonisation of the rules across borders cannot be based on cooperation between TSOs alone. An important element in ensuring a high level of security of supply is a clear contractual basis describing how plant operation and services across national borders should be

Figure 10: Balancing the electricity system



managed. In other words, there must be an operating agreement when the electricity system crosses the national border.
A current example of such a mutual agreement is the cooperation between Energinet.dk and the German TSO TenneT on utilising the Danish-German interconnection, as described in the section on integration of wind power in the chapter on the market development for electricity and gas.

In general, Energinet.dk has entered into operating agreements in the Nordic countries through the Nordic system operation agreement and bilaterally with the two north German TSOs, 50Hertz Transmission GmbH and TenneT. In addition, Energinet.dk participates in TSC (Transmission System Operator Security Cooperation), which is a cooperation between TSOs in the countries south of Denmark.

These operating agreements are being regularly refined to match the technological development, expansion of the electricity grid and changes in regulations, and in response to experience from operating incidents which create the need for operating agreements to be revised.

Balancing
Balancing the electricity system is achieved by the market trading towards expected balance up to the delivery hour; see Figure 10. This takes place on the Nordic power exchange for trading in hourly energies in the electricity spot market (day-ahead market) and the Elbas market (intraday market).

Day-ahead trading – trading prior to the day of operation
No later than at 10.00, the TSOs must publish the capacity on the connections between the price areas for the following 24-hour period. This takes place on the websites of the power exchanges. Subsequently, the BRPs have until 12.00 to report their demand and supply to the local power exchange, which is Nord Pool Spot in the Nordic region and EPEX Spot in Germany. All reports are then collected in the European market coupling, which calculates the total result for the day-ahead trading. This contains prices for all areas, exchanges between all areas as well as trading notifications for all market participants in the entire price-coupled area. The result is published at 12.42.

Intraday trading – trading during the day of operation
Up until the hour before the delivery hour, the BRP can use updated forecasts to trade in balance on the intraday market. The intraday market opens at 14.00 on the day before the day of operation and closes one hour before the delivery hour.

Nord Pool Spot's Elbas market facilitates intraday trading on the interconnections between the price areas in the Nordic region as well as on the interconnection between Zealand and Germany (Kontek), and also offers intraday trading within the two Danish price areas DK1 and DK2, respectively. On the border between Jutland and Germany, the intraday trading takes place via a capacity platform which is open from 17.15 on the day before the day of operation and until 1 hour and 15 minutes before the delivery hour.

During the last hour before the delivery hour, Energinet.dk takes over responsibility for balancing. In the Nordic countries, this functions by the TSOs – on behalf and at the expense of the BRPs that cannot maintain their balance – constantly striving to minimise the imbalance all the way up to the moment of delivery.

Forecasts

When Energinet.dk has to assess the imbalance between consumption and generation for the coming hour, it makes use of a range of plans and forecasts. The BRPs for production are obliged continuously to submit plans for their production portfolio as a whole. This production is summed up with forecasts for wind and solar energy generation, which are compared with a forecast for total consumption, resulting in an expected imbalance. The expected imbalance is eliminated by the Nordic TSOs jointly purchasing upward or downward regulation in the Nordic regulating power market, where all BRPs can report dispatchable generation and consumption. The Nordic TSOs coordinate with each other, on the basis of the price, to decide which offers are to be activated in each country. The residual imbalance is then dealt with at the moment of delivery through the application of the automatic reserves.

Regulations on technical quality – operating instructions

Operating instructions represent the operational implementation of the general regulations which are to ensure uniform basis for international agreements and requirements. Operating instructions are divided into three categories:

- System operating instructions which must ensure that operating criteria – both national and international – are complied with, and that operational reliability in the electricity system is maintained as far as possible.
- Grid operating instructions which primarily ensure that electricity system components are protected, so they are as widely available to the electricity system as possible.
- Market operating instructions which ensure that the market operation is optimised to the benefit of both domestic and foreign market participants and security of supply.

Operating instructions are updated in response to any changes to the system (e.g. new regulations, new electricity connections, and new operating criteria), changes to the grid (new plants) or changes to the market package. All operating instructions are also revised at least once every two years as part of the asset management process at Energinet.dk.

Gas facilities

Energinet.dk is responsible for expanding, converting and maintaining the natural gas transmission grid, the natural gas storage facilities and LNG facilities connected to the transmission grid.

With a view to assessing the need for conversion and expansion of the gas transmission grid in the long term, it is important to include the long-term analyses of how the role that gas plays in the energy system may change and what this may entail for the gas transmission grid (see the chapter on the green transition).

Development of the gas system

Maintaining an efficient gas transmission grid with storage options is the prerequisite, among other things, for being able to bring the natural gas produced in the North Sea onshore and passing on natural gas or RE gases for final distribution.

Natural gas production and facility needs

Natural gas supplies from the North Sea have declined in recent years, but production is expected to increase marginally again in 2017 and some years ahead. Gas is extracted from new fields, while supplies from existing fields are dwindling. Combined with supplies from the North Sea, the ongoing expansion in Germany, which is expected to be completed at year-end 2015, will secure the future natural gas supply to Denmark and Sweden as sufficient import capacity will be established to cover the expected demand.

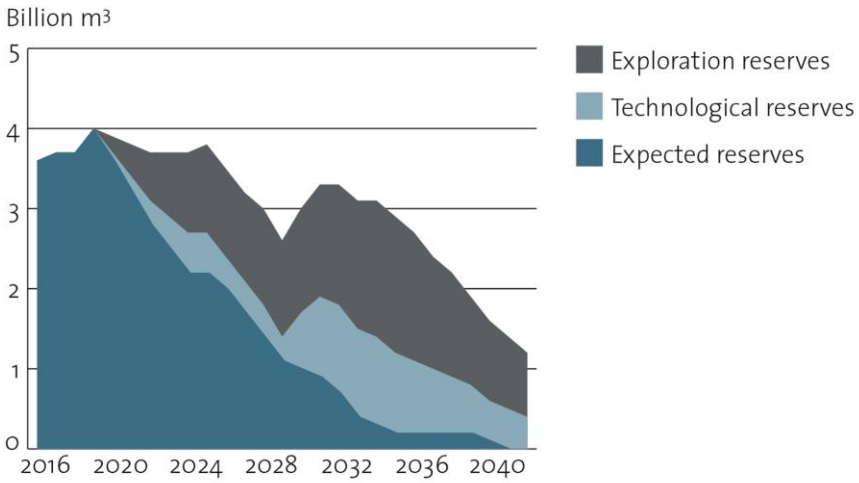
The Danish Energy Agency estimates that gas supplies from the North Sea will decline between 2019 and 2042; see Figure 11. Based on the current knowledge of reserves, supplies are likely to be exhausted in 2045-2050.

In 2015, Energinet.dk made a projection of gas consumption in Denmark and Sweden up to 2025. The supply picture assumes that the second stage of the expansion in Germany will be completed in 2015. It is further assumed that the Danish Hejre gas field will commence production in 2017.

In this way, the Danish and Swedish markets will be supplied from the North Sea and Germany, at least until 2025. After 2020, the North Sea production is expected to have declined to such a degree that the connection to Germany becomes the largest source of supply, and it may be relevant in the long term, eg for supply-related reasons, for example to establish a connection to Norway or make major investments in storage facilities if it is not possible to establish other gas production in Denmark.

In 2016, Energinet.dk will complete an EU-funded preliminary study which examines the possibilities of establishing a connection between Poland and Denmark (Baltic

Figure 11: Expected natural gas supplies from the North Sea



Pipe) in the context of a connection between the Norwegian and Danish offshore system; see Figure 13.

Bio natural gas
The biogas expansion began in earnest in 2015. The Danish Energy Agency assesses that biogas production will increase from just under 7 PJ in 2015 to 14 PJ in 2020. The uncertainty range is estimated to be 11-18 PJ in 2020. This is due, in particular, to the approval of state aid for the subsidy for upgrading proposed in the Danish Energy Agreement, which was finally settled in February 2014. The production from decided new plants and plant expansions alone is expected to reach approx. 10 PJ already in 2017, with two plants alone accounting for 0.9 PJ each.

Upgrading of and injection into the natural gas grid is expected to be the primary sales opportunity for biogas, while direct supply of biogas for electricity generation is expected to stagnate towards 2020. The competitive situation and the market conditions mean that the majority of investors prefer upgrading. The biogas volume used directly for process energy, transport etc. is expected to be limited due to the lower subsidies for these applications.

Total production of bio natural gas (upgraded biogas) is expected to reach more than 200 million Nm^3 in 2020, equivalent to 7.8 PJ. This corresponds to approx. 10% of the expected Danish gas consumption in 2020. The framework is now in place for supplying and trading bio natural gas via the gas system.

Conversion and expansion plans

From supplying natural gas from a few central sources, the system is to be converted into supplying consumers with renewable energy in the form of green gases (biogas, synthesis gas etc.) from many local production sources.

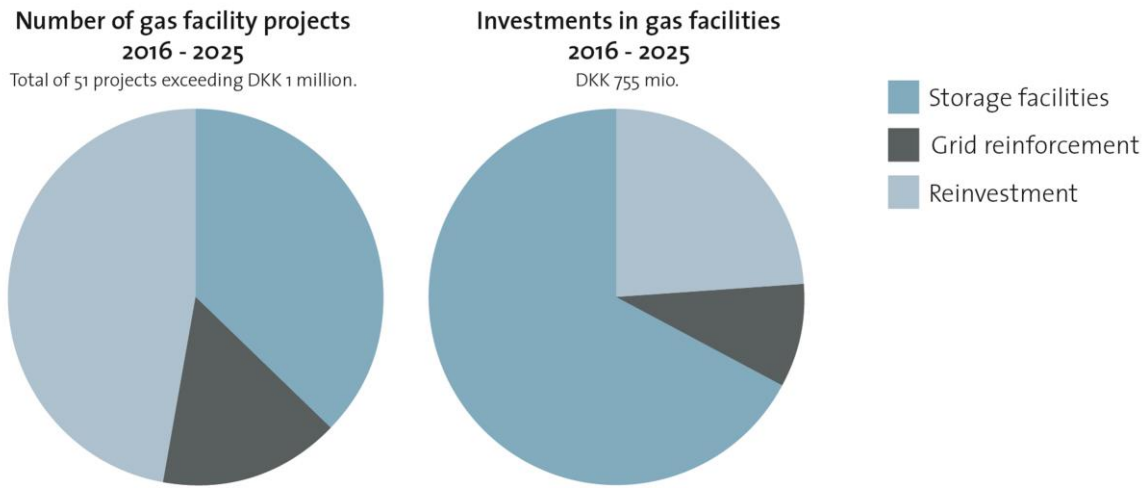
The total number of projects with investment costs are shown in Figure 12.

Connection of biogas facilities
Energinet.dk is responsible for connecting facilities for upgrading biogas to natural gas quality (upgrading facilities) to the transmission grid.

Currently, a number of biogas facilities are being constructed, which are to upgrade the gas to a quality which can be distributed in the transmission system and the distribution grid. Two transmission grid-related projects are being established at the moment.

In the Kliplev project, the upgrading facility will be connected to the DONG Energy Gas distribution grid, and

Figure 12: Number of conversion and expansion projects and investment costs for gas facilities up to 2025



the purpose of the project is to establish a connection from ENVO's biogas connection equipment in Aabenraa to the transmission system at Terkelsbøl. A compressor station is established at ENVO Biogas Aabenraa A/S's facility, consisting of three compressor units each with a capacity of 4,700 Nm^3/h, a metering station and a filtration system for the removal of odorant. The purpose of the entire facility is to pressurise and transport gas which cannot be sold by DONG Energy Gas Distribution in the distribution system from two biogas facilities situated in Tønder and Aabenraa, respectively. The enterprise ENVO is responsible for the establishment of both biogas facilities via its two subsidiaries ENVO Biogas Tønder A/S and ENVO Biogas Aabenraa A/S.

The Sønderjysk Biogas Bevtoft project concerns connection equipment from biogas and upgrading facilities. The upgrading facility is connected directly to the gas transmission grid approx. one kilometre east of the plant. The plant is owned by Sønderjysk Biogas Bevtoft and E.ON. The connection equipment consists of a metering station and a gas pipeline to the transmission pipeline.

Rerouting of pipelines

The new railway between Copenhagen and Ringsted has required five reroutings of the transmission pipeline, as well as rearrangement at the Vallensbæk meter and regulator station. When Energinet.dk performs rerouting of pipelines, this will always be done in a way that maintains gas supply and ensures security of supply. This is ensured by establishing a temporary bypass before the pipeline is rerouted.

Enghave Brygge is an urban development area in Sydhavnen, Copenhagen's southern port areas, where CHP City & Port Development, on behalf of several development businesses, has requested that Energinet.dk carry out rerouting prior to the construction of the residential area Enghave Brygge. Energinet.dk owns two 132 kV circuits and a gas pipeline, which are to be moved. CHP City & Port Development wants the pipeline rerouting to be performed at the end of 2015 or the beginning of 2016 for the sake of the other activities.

The Danish Parliament has decided to implement a new train timetable which is to enable travelling from Copenhagen to Odense in one hour and from Odense to Aarhus and Esbjerg in one hour. This means that a new railway line must be established between Odense and Middelfart in a transport corridor situated 75 metres north and south of the motorway between Odense and Middelfart. Depending on the exact location, the new train timetable may result in a need to move the gas transmission pipeline on this section.

Figure 13: Existing gas transmission grid and possible future pipelines

Major maintenance activities

A number of maintenance operations need to be performed in the transmission system, as described below.

Pipeline inspections are carried out every year to check the condition of the pipes. In 2016, intelligent pipeline inspections (pigging) must be carried out on three pipe sections as well as a data logger inspection being performed on two pipe sections.

Pipe sections for pigging in 2016:

- Egtved-Lille Torup, approx. 127 km
- Nybro-Egtved (southern pipeline), approx. 57 km
- Torslunde-Stenlille, approx. 43 km.

The reinvestment programme for gas wells is continued at the Lille Torup gas storage facility. There are a total of seven caverns, one of which was renovated in 2013, a second is currently being renovated and a decision has been made to start renovating a third. The life of the wells is extended to after 2050.

LNG

Energinet.dk has decided not to own, operate or invest in facilities for liquefied natural gas (LNG), but will assist market participants with input to project maturation.

The interest in LNG is driven primarily by the possibilities of selling LNG for sea transport. But synergies with other markets are often required in order to realise a sustainable business model in Denmark under the current market and framework conditions. An earlier review in Denmark pointed to a total Danish potential for LNG for sea transport corresponding to around 500-600 million Nm^3 of natural gas.

A number of ports, shipping companies and transport operators have investigated the possibilities of establishing LNG facilities in Denmark. LNG facilities were established in Hirtshals and Hou in March 2015. In Hirtshals, the facility is a bunkering facility for the LNG ferry Hirtshals-Kristiansand, which is expected to receive supplies from Norway, while the facility in Hou is a bunkering facility for the LNG ferry Hou-Samsø, which is expected to receive supplies from Rotterdam by lorry.

As concerns the transmission grid, the connection of LNG production facilities will increase the offtake from the transmission grid by an expected flat load all year round. The increase in offtake is so small, however, that it has no impact on transmission grid capacity or on security of supply, regardless of where in the grid an LNG-generating facility is connected. However, the choice of connection point may affect the economy in the distribution grids.

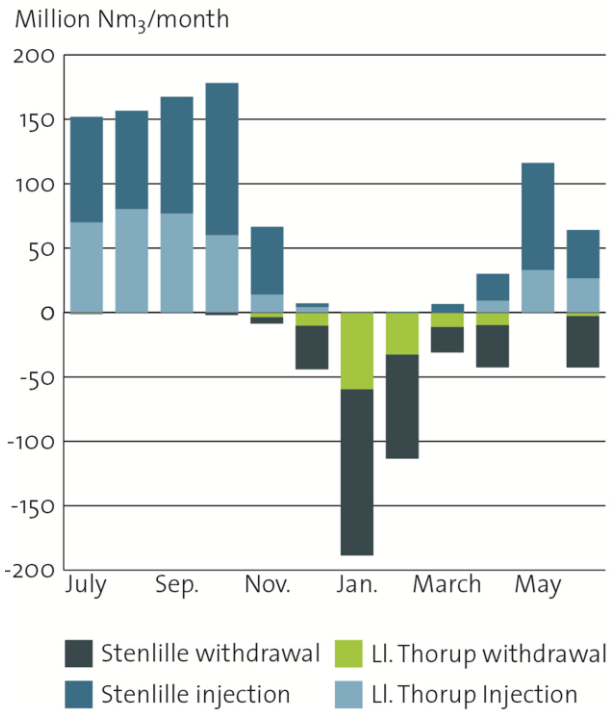
Small-scale LNG liquefaction
A number of inquiries to Energinet.dk have concerned small-scale liquefaction plants connected to the gas grid. Energinet.dk has primarily contributed technical and market-related knowledge to support project maturation. Small-scale plants produce LNG or LBG for lorries, buses, ships or industrial purposes.

Bio natural gas for transport
Biogas for transport is seeing growth in our neighbouring countries. In Denmark, the framework conditions have so far not created sufficient incentive to increase the use of gas and, by extension, biogas in the transport sector. Market participants have now established the first ten gas-filling stations which are to introduce the technology and provide experience in a Danish context. This will pave the way for biogas to be used for transport; particularly for heavy transport.

Efficient gas-fuelled buses and lorries have come onto the market in recent years. Gas-fuelled passenger vehicles and light lorries are being mass-produced, and many standard petrol and diesel models are available in a gas version. Currently, there are nine gas filling stations in Denmark, and new stations are on the way in Copenhagen and Skive, among other places.

Indications from the initial experience with gas-fuelled fleets are very positive, and several owners and operators want to expand their fleets, for example in Copenhagen and Skive. For local authorities and bus operators, bio natural gas purchased via the certificate model is one of the cheapest realisable measures to reduce CO_2 emissions. Energinet.dk's certification system is a prerequisite for the approval of bio natural gas under one of the three voluntary schemes. The certification system ensures that

Figure 14: Injection into and withdrawals from the Danish gas storage facilities in 2014



the bio natural gas is not counted twice, and the system lives up to the voluntary schemes' requirement for traceability and mass balance. The three voluntary schemes are ISCC, RED-Cert and NTA8080.

Since April 2015, bio natural gas can replace petrol and diesel and comply with EU requirements in transport. The Danish mixing requirement ensures that all fuel for the Danish transport sector is mixed with 5.75% RE fuel. This requirement increases to 10% in 2020.

Storage capacity

For a number of years, the market price for storage capacity has been below the long-term average cost of establishing and operating a natural gas storage facility. There are still no signals in the forward markets to indicate a reversal of this situation. The market thus offers no incentive to make more long-term investments in storage capacity.

In the northwestern European market, the incipient reduction of storage capacity is continuing as a result of the market situation. Much like the development in respect of thermal power stations, the least efficient storage facilities and storage facilities facing major reinvestments will be closed. There is nothing to suggest that this gradual capacity adaptation has had any impact on the market yet.

On 31 December 2014, Energinet.dk took over the Stenlille gas storage facility, which from then on has been operated together with Lille Torup as a joint storage facility. The use of the two gas storage facilities in 2014 is shown in Table 14. The merger of the two storage facilities does not affect the volume capacity of approx. 1 billion Nm^3, but the joint operation offers operational synergies which mean even higher availability of withdrawal and injection capacity in the market.

Tariff development

Energinet.dk's finances, including construction activities, are based on a break-even principle. This means that income and costs must balance. As regards the transport segment, efforts are currently going into completing a European network code concerning harmonisation of tariff structures across the European countries, which is expected to enter into force on 1 October 2017.

This work may give rise to changes in the Danish tariff model in the transport segment. The work on implementing these changes is expected to commence in autumn 2015 and to be registered with the Danish Energy Regulatory Authority by 1 October 2016 at the latest.

Security of gas supply

Energinet.dk is responsible for security of supply of natural gas in Denmark and for ensuring the availability of the necessary transport capacity, including capacity reserved for security of supply for transit.

In 2016, security of supply for the Danish gas market will be better than ever, as there are two major sources of supply (the North Sea and Germany) as well as the possibility of receiving supplies from two gas storage facilities; this means full compliance with the EU regulation. After 2020, the North Sea production is expected to have declined to such a degree that Germany becomes the largest source of supply, and if compliance with the EU regulation is to be ensured in the long term, it may be necessary, for example, to establish a connection to Norway or make major investments in storage facilities if no other gas is produced in Denmark, including shale gas.

The North Sea production can be sold either to the Netherlands through Nogat[5] or to Denmark and Sweden as well as to Germany. It is expected that supplies to the Netherlands will decrease and that most of the North Sea production will be supplied in Nybro, but this depends on the competition. Therefore, there is also a high degree of uncertainty as to when Germany becomes the largest source of supply.

The Danish crisis management rules are the result of the EU regulation on security of natural gas supply, which entered into force in 2012 and which was adopted on the basis of the first Russian crisis in 2008/2009. The European Commission is working on revising the regulation, and the revised version is expected to be adopted in 2016.

This work concerns, among other, the following conditions:

- Increased regional cooperation and solidarity in emergency situations
- Very large differences in the number of protected customers
- Specification of the N-1 criterion as indicator of the level of security of supply
- Differences in implementation and verification of compliance with the supply standard
- More uniform preventive action plans and emergency plans
- Possibly, increased powers for the European Commission in crisis situations
- Possibly, protection from crisis situations lasting longer than 30 days.

[5] NOGAT (Northern Offshore Gas Transport) is a pipeline between the Dutch natural gas extraction facilities in the North Sea and Den Helder in the Netherlands. Danish natural gas extraction in the North Sea is connected to NOGAT through the Tyra F3 pipeline (see Figure 13).

Table 8: Security of gas supply model

Balancing tools						Emergency tools	
No supply disruption				Supply disruption			
Normal state of operation		Early Warning		Alert		Emergency	
1	Buffer	8	Increased imbalance charge	9	Commercially interruptible costumers	11	Emergency storage and emergency withdrawal
2	Split of withdrawal and injection between the gas storage facilities			10	Reduced capacity towards Sweden	12	Filling requirements
3	System operator storage, including withdrawal capacity					13	Interruption of all or part of the non-protected costumers
4	Interruptible capacity at exit and entry border points						
5	Reduced capacity						
6	Balancing gas						
7	Syd Arne upstream pipeline						

The solidarity principle is the crucial element in the regulation, and it is expected that great benefits can be achieved when the individual country no longer assesses security of supply in isolation, but from a regional perspective. A thorough review of the countries' preventive action plans and emergency plans has showed that the desired coordination between countries has not taken place, which means that, for example in connection with supply crises at EU level, there has been uncertainty about the principles for the distribution of available volumes and capacities. The European Commission does not have the necessary authority to carry out a prioritisation, and this issue is therefore an important topic in connection with the revision of the regulation.

Energinet.dk has gained extensive experience with the Danish security of supply model, which has been in force since 2004 and was aligned with EU requirements in 2012. The most important change was implemented in 2014, when it was decided that non-protected customers should not automatically be interrupted upon the declaration of an emergency situation (Emergency).

In 2015, a pro-rata model for interruption of non-protected customers was also introduced, which means that, in the event of an interruption, it is possible to carry out a partial reduction of the consumption for non-protected customers in Denmark and Sweden.

In the Danish security of supply model created on the basis of the regulation, the market plays a much larger role than previously. Overall, the intention is to avoid an Emergency, which is the most serious security of supply situation in the market. The model contains a number of specific tools that Energinet.dk as TSO may use to increase the likelihood of the market being able to continue to supply customers if the gas supply comes under pressure in a crisis situation.

Generally, the market itself is responsible for maintaining security of supply in the Danish gas system for as long as possible. If necessary, Energinet.dk takes over the obligation to supply the market when the system is declared in a state of emergency, but not before that.

Table 8 above lists the tools at Energinet.dk's disposal for handling the various crisis levels.
All the system balance tools (1-7) can be used during normal operation and also at the three crisis levels.

From the Early Warning level, i.e. also in Alerts and Emergencies, it will be possible to increase payments during imbalances (8). The Syd Arne tool can be used at all crisis levels, but only if there is reduced capacity in the Tyra-Nybro pipeline.

At Alert level and, if the situation escalates, Emergency level, activation of the commercially interruptible consumers in Denmark and Sweden (Hyper3) may become possible.

According to the security of supply model, the tools in Emergency will also be emergency storage and emergency withdrawal as well as filling requirements in the storage facilities. Ultimately, full or partial (pro rata) interruption of non-protected customers must take place, if necessary. These tools are to support Energinet.dk's ability to maintain supplies to protected customers.

Gas system operation

Energinet.dk is responsible for the physical balance in the gas transmission system in Denmark. This is primarily ensured via balancing rules that give market participants an incentive to balance their own quantities.

Gas consumption varies over the year, and in addition to supplies from the North Sea and Germany, the market participants also use the Danish gas storage facilities to satisfy their needs. Gas is injected into the gas storage facility mainly in the summer and is withdrawn in the winter. To the extent there is a need for additional balancing, Energinet.dk uses available linepack, supplies from storage and purchase/sale of gas.

Transmission of North Sea production
The majority of the natural gas transported via Energinet.dk's transmission grid comes from the North Sea fields. Most of the gas from the Danish fields is sent to Denmark via the Tyra and Syd Arne pipelines, where it is sold in exit zone Denmark or exported to Sweden and occasionally Germany. Gas is also exported to the Netherlands via the NOGAT pipeline.

Consumption and degree days in Denmark
Gas consumption in Denmark has been decreasing since 2010 when looking at consumption adjusted for degree days; see Figure 15 and Figure 16. The year 2010 was a cold year with 9% more degree days than in a normal year, and consumption at the central power stations was extra large as a result of the low water level in the Nordic hydroelectric power reservoirs.

In 2014, consumption in Denmark was approx. 2.4 billion Nm^3. There were 23% fewer degree days in 2014 than in a normal year, which means that 2014 was relatively warm.

Operational cooperation
Energinet.dk has established operational cooperation with all adjacent systems, storage facilities, the German TSO, the Swedish TSO, upstream submarine pipelines and distribution companies. Operational cooperation agreements have been concluded with all adjacent systems, describing the framework for the operational work.

Coordination of maintenance work with the Swedish and German TSOs takes place at operations meetings. These are not announced on Energinet.dk's website, but on the relevant TSOs' own websites.

In addition, there is ongoing contact between the operational coordination units in the relevant enterprises and between the control centres to ensure optimum operational cooperation across the systems.

Figure 15: Natural gas consumption and exports/imports

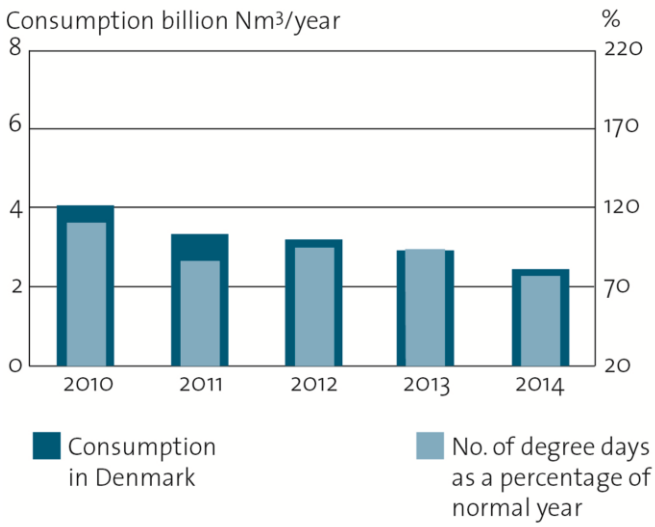
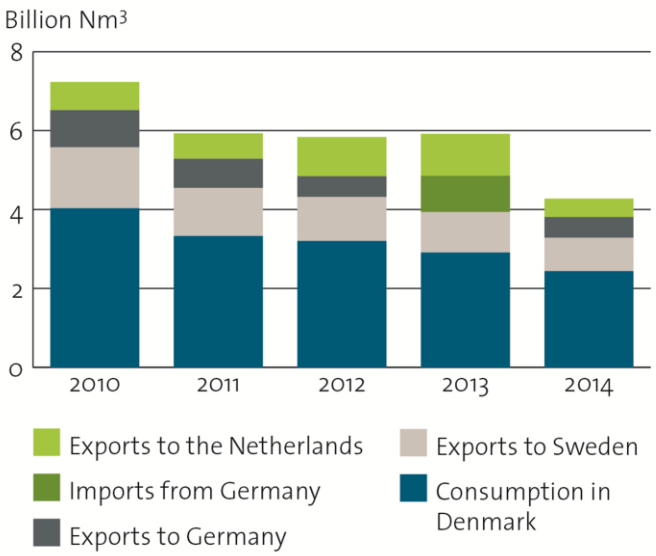


Figure 16: Danish natural gas consumption adjusted for degree days



EU network code

The development of common rules continues in the EU. Legislation on capacity and balancing has been adopted. Most recently, the European Commission approved rules on interoperability, which will thus be a statutory requirement as of 1 May 2016.

The interoperability rules describe the minimum requirement for cooperation between TSOs in the EU. Energinet.dk already complies with the rules in the existing interfaces with neighbouring TSOs. As concerns data exchange, Energinet.dk has launched the measures necessary to get these things to fall into place on time.

Gas quality

Energinet.dk is responsible for ensuring that the gas in the transmission system meets the given quality and composition requirements at all times. The gas flowing in Energinet.dk's transmission system comes either from the Danish part of the North Sea via the Nybro treatment plant, from the German market via Ellund or from the gas storage facilities at Stenlille and Lille Torup.

In the period from 1 June 2014 to 1 June 2015, gas quality varied as follows:

- The Wobbe index[6] for natural gas varied from 14.45 kWh/Nm^3 to 15.49 kWh/Nm^3, averaging at 15.21 kWh/Nm^3
- The relative density varied from 0.566 to 0.690
- The upper calorific value varied between 10.87 kWh/Nm^3 and 12.86 kWh/Nm^3, averaging at 12.14 kWh/Nm^3.

In the coming winter, Energinet.dk expects gas quality to vary as follows:

- The Wobbe index of the Danish North Sea gas is expected to vary from 14.7 kWh/Nm^3 to 15.5 kWh/Nm^3
- Gas imported from Germany is expected to have a lower Wobbe index than that of Danish North Sea gas
- Energinet.dk estimates that the average Wobbe index of gas from Germany will be 14.7 kWh/Nm^3, varying from 13.9 kWh/Nm^3 to 15.5 kWh/Nm^3
- Bio natural gas injected into the gas system is expected to have a lower Wobbe index than that of Danish North Sea gas.

[6] The Wobbe index is an expression of the heating effect of gas and its combustion characteristics.

What does the future hold?
The Danish North Sea gas is characterised by a very uniform composition and gas quality due to the fact that Danish gas has a relatively high content of methane, propane and butane, which are not extracted from the natural gas in Denmark. Danish natural gas has always had a high heating effect and reliable combustion (high Wobbe value) compared with gas in adjacent systems. Despite the injection of natural gas from Germany, the natural gas supplied to Danish gas customers will continue to have a high heating effect. This will also apply in the long term, whether or not future supplies will come from Norway, Germany, the Netherlands or Russia, as LNG or as a mixture of this via the injection from Germany.

Upgraded biogas has similar combustion characteristics to natural gas and normally consists of a mixture of methane and CO_2. Upgraded biogas typically has a gas quality located at the lower end of the variation range permitted in the gas regulation. In the new gas regulation, the Danish Safety Technology Authority lays down requirements for the quality of upgraded biogas that is to be fed into the gas system. The intention is to ensure that the upgraded biogas can be used safely by consumers on an equal footing with natural gas.

In future, new types of RE gases will be introduced into the Danish gas system. These include hydrogen produced by electrolysis or methane produced from hydrogen and CO_2 from, for example, biogas in a methanation process. In the coming years, Energinet.dk will prepare for the new RE gases by examining the extent to which the gas system is ready for them.

Local RE gas grids may play a role in the future, where RE gas (biogas, synthesis gas and hydrogen) and the main gas grid are integrated to a greater extent. In most cases, local RE gas grids require technical and market maturation as well as further analyses within the area.

Further information

http://energinet.dk/EN/Sider/default.aspx

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