ENERGINET

RESUMÉ OG REPORT

SECURITY OF GAS SUPPLY 2017

SUMMARY

Security of gas supply is high in Denmark. Continuous expansion and improvements of the infrastructure and operations have minimised the technical risks related to security of supply. As a result, there has never been an incident in the Danish gas transmission system that led to interruption of consumers.

Historically, Denmark has been and still is a net exporter of gas seen over the entire year. Much of the gas produced in the North Sea can be supplied to either the Netherlands or Denmark. Only the players' commercial considerations determine where the gas flows.

Gas supplies from the North Sea to the Danish and Swedish gas consumers can be supplemented with gas imports from Germany in the border point Ellund as well as with stored gas. Even though Denmark is a net exporter of gas, gas is imported from Germany during some periods of the year, for example if the players can obtain a price gain. The total storage capacity is approx. 890 million Nm^3, corresponding to about one third of the annual Danish gas consumption.

The connection of biogas plants and upgraded biogas to the gas grid continues to rise. Twenty-one biogas plants are connected, one of which is connected directly to the transmission grid. At the end of 2017, upgraded biogas accounted for approx. 5 per cent of total Danish gas consumption.

Assessment of security of gas supply in Denmark
Energinet finds that the Danish gas transmission system is resistant to technical incidents – even at times of high gas demand. The sources of supply from the North Sea and Germany and from the gas storage facilities are also considered to be ample. Energinet upholds the security of gas supply by purchasing, among other things, storage capacity for use in an emergency situation.

"No security of supply incidents in gas year 2016-2017"

GAS SECURITY OF SUPPLY REPORT 2017

Security of supply in the Danish gas system is assessed on the basis of the Danish Executive Order on maintaining security of natural gas supply (Bekendtgørelse om varetagelse af naturgasforsyningssikkerheden). The report is an annual report from Energinet to the Danish Energy Agency and the players in the gas sector. The report accounts for the development in security of gas supply and future security of gas supply initiatives.

However, Denmark is facing a period of a couple of years where gas supplies from the primary source, the North Sea, will be significantly reduced. The reason for this is that the Tyra platform will be reconstructed in the period 2019-2022. Danish and Swedish gas consumers will continue to be supplied with gas throughout the period, but the supply depends on optimum utilisation of the import and storage capacity. The system will therefore be more vulnerable and less flexible. This may be critical for the supply, for example in the event of exceptionally high demand or in case of technical incidents in the infrastructure.

To prevent a crisis situation, Energinet carries out analyses of the supply situation and the status of the gas storage facilities at regular intervals. The conclusion is that it is important for the market players to act expediently during the renovation of Tyra so as to reduce the risk of interruption of the gas consumers.

The present analysis is based on a renovation period running from December 2019 to March 2022. In a communication to the gas market (REMIT) of 24 November 2017, Maersk announced that the Tyra complex will be closed down as from 1 November 2019, and that the gas flow from Tyra will be resumed on 1 July 2022. The change is not expected to alter the general conclusions of the analysis, which will be updated at the beginning of the new year.

Energinet will cooperate closely with the stakeholders to ensure the best possible utilisation of the capacity available during the reconstruction period.

Energinet assesses that security of gas supply will be very high again after the reconstruction of Tyra. It is expected that the production of gas from the North Sea after the reconstruction will be higher than before the shutdown. In addition, there is access to considerable import capacity from Germany.

Current events

Reduction of storage volume

In 2017, the Danish gas storage company, Gas Storage Denmark, reduced the total storage volume capacity in the Danish storage facilities. The volume capacity was reduced in both storage facilities by approx. 120 million Nm^3 in total.

The volume capacity at the Lille Torup gas storage facility has been reduced because one of the caverns is filled with water after maintenance. The water-filled cavern is a consequence of the Danish Environmental Board of Appeal having reversed a previous approval to discharge the water into the Limfjord. The volume capacity in the Stenlille gas storage facility has been reduced on the basis of a withdrawal test.

CUBIC METRE LIMIT

For gas year 2017-2018, the limit for protected customers is 3.2 million Nm^3/year. In practice, this means that industrial enterprises and gas-fired CHP plants will be protected if they have an annual gas consumption of less than 3.2 million Nm^3/year.

New Gas Security of Supply Regulation

The European countries' gas infrastructure is interconnected, and most countries are dependent on imported gas. Denmark is the only country in the EU which is still a net exporter of gas.

The Gas Security of Supply Regulation stipulates, among other things, to which customers gas supplies must be maintained in the event of a supply crisis and how a crisis situation must be handled. The regulation has just been revised. The revised regulation entered into force on 1 November 2017. A number of elements in the regulation will be implemented on an ongoing basis over the coming 18-month period.

The revised regulation sets the stage for increased solidarity among the countries and mutual help in the event of supply crises. Work is in progress to clarify the impact of the regulation on security of gas supply in Denmark.

Analyses of European gas supply
This year, the European Network of Transmission System Operators for Gas, ENTSOG, has for the first time performed simulations of supply and infrastructure disruptions in Europe. The simulation is one of the new initiatives in the revised regulation. The competent authorities must take the results of the simulations into account when preparing risk assessments, preventive action plans and emergency response plans. The simulations are performed every fourth year.

The results from the SoS simulation show that all countries will be able to maintain supplies to gas consumers in a cold winter with exceptionally high demand. However, according to ENTSOG's assessment, Denmark and Sweden, as the only countries, cannot maintain supplies to gas consumers during a single day and a two-week period of exceptionally high demand without taking additional measures. The simulation runs over a four-year period and is based on reduced supplies from the North Sea, but does not include extra firm capacity in Ellund from 2019 and decreasing gas consumption during the reconstruction of Tyra. ENTSOG's simulation thus shows a more negative forecast than Energinet's own analyses.

Furthermore, each year ENTSOG publishes an assessment of the European supply situation for the coming winter. For winter 2017-2018, ENTSOG assesses that none of the European countries will be threatened by supply failure. Individual countries – not including Denmark and Sweden may, however, experience problems with maintaining supplies to gas consumers or delivering flexibility in the system during periods of exceptionally high demand.

A changing gas sector
In connection with the initial public offering (IPO) of DONG Energy (now Ørsted), Energinet took over the company's distribution grid and established the distribution company Dansk Gas Distribution A/S (DGD). Subsequently, it has been proposed that all distribution grids in Denmark should be gathered in a state-owned company. A political voting agreement was made in May 2017 according to which negotiations were to be initiated with HMN GasNet P/S and NGF Nature Energy Distribution A/S. These negotiations have been initiated, but have not yet been completed.

In 2017, DONG Energy and A.P. Moller – Maersk, both of which have been involved in developing the Danish upstream system, divested oil and gas activities to Swiss INEOS and French TOTAL S.A., respectively. According to the Danish Ministry of Energy, Utilities and Climate, TOTAL will take over all of Maersk's obligations – including the full reconstruction of Tyra.

"It will still be possible to supply gas to Danish and Swedish consumers during the reconstruction of Tyra, with the primary source of supply during the renovation period being Germany"

Future events
Reconstruction of Tyra
In April 2016, Maersk announced that the Tyra platform is sinking and that a solution is to be found which either involved permanent or temporary shutdown. DUC (Danish Underground Consortium) and the Danish state concluded an agreement on 22 March 2017 enabling a reconstruction of the Tyra facilities in the North Sea. Maersk has subsequently announced that Danish gas production will be reduced considerably in the period 2019-2022 during which the reconstruction will place.

It will still be possible to supply gas to Danish and Swedish consumers during the reconstruction of Tyra, with the primary source of supply during the renovation period being Germany.

The Danish gas system will be significantly less flexible and more vulnerable during the reconstruction. This means that optimum use must be made of the import and storage capacity to reduce the risk of crisis situations.

Joint balancing zone for Denmark and Sweden
In 2017, Energinet and Swedegas completed a cost-benefit analysis of a joint balancing zone for Denmark and Sweden. Based on the analysis, the companies decided in the spring 2017 to

Metering and regulating station in Egtved. 42 metering and regulating stations are connected to the Danish gas transmission grid. The stations are used for regulating the pressure downwards, for metering the gas and adding odorant to it before it is conducted into the gas distribution grid. Odorisation consists in the addition of a trace element which ensures that any leaks are detected by their smell.

continue the project. The project will be completed towards spring 2019.

The project is in line with the thoughts in the EU on regional development and interconnection of markets across national borders.

The project will support security of supply in Denmark and Sweden, as it is a precondition that line pack in the Swedish gas system will be increased. There will thus be more gas available in the system for supplying Danish and Swedish gas customers.

Baltic Pipe
In the course of 2017, Energinet and Gaz-System have come a long way in the joint Baltic Pipe project, which will connect the Danish and Polish gas markets directly with the Norwegian gas fields.

"Another 10-15 biogas plants are expected to be connected to the gas grid in the course of 2017 and 2018"

The project has a positive effect for Danish gas customers. Increased gas volumes in the Danish gas system are expected to provide more stable gas tariffs and, in addition, the access to an additional source of supply will strengthen security of supply.

In autumn 2017, companies in the gas market have made binding bids and secured capacity in the Baltic Pipe. It is therefore clear that the demand is sufficiently large to continue working on the technical and economic business case for an investment decision. The new infrastructure is expected to be in operation from October 2022 if a final investment decision to commence construction is made. The final investment decision is expected in 2018.

Green transition
Another 10-15 biogas plants are expected to be connected to the gas grid in the course of 2017 and 2018. If the projects are fully realised, upgraded biogas is expected to account for approx. 10 per cent of Danish gas consumption already by the end of 2018.

The injection of upgraded biogas into the gas grid creates new challenges. Examples of such challenges include handling of higher oxygen content in the gas transported across borders and developing the gas grid to be able to handle an increased injection of upgraded biogas.

THE MARKET ENSURES SECURITY OF SUPPLY DURING THE RECONSTRUCTION OF TYRA

Plans are to reconstruct the Tyra platform in the North Sea, probably in the period 2019-2022. Even though the platform accounts for around 90 per cent of the Danish North Sea gas production, gas supplies to Danish and Swedish gas consumers will be maintained during the temporary shut-down. During this period, gas will be supplied from Germany and from the Danish gas storage facilities.

When Maersk Oil on behalf of DUC (Danish Underground Consortium) concluded a new North Sea agreement with the Danish government on 22 April 2017, Energinet's TSO Gas, which is located in Ballerup, became very busy.

– The agreement meant that Maersk (read: now TOTAL) had an incentive for doing a full reconstruction of the platform complex. We're now looking at an expected 2-3-year period essentially without gas from the North Sea. And as we have the main responsibility for Danish security of gas supply, a temporary stop of 90 per cent of the Danish gas production is not just another day at the office, says Claus Møller Petersen, who is project manager on Energinet's Tyra project.

The way things are at the moment, Danish gas consumers are supplied with natural gas from the North Sea and Germany, but when the Tyra field shuts down for reconstruction, 90 per cent of the gas from the North Sea will be removed from the equation. But this scenario does not keep Claus Møller Petersen awake at night:

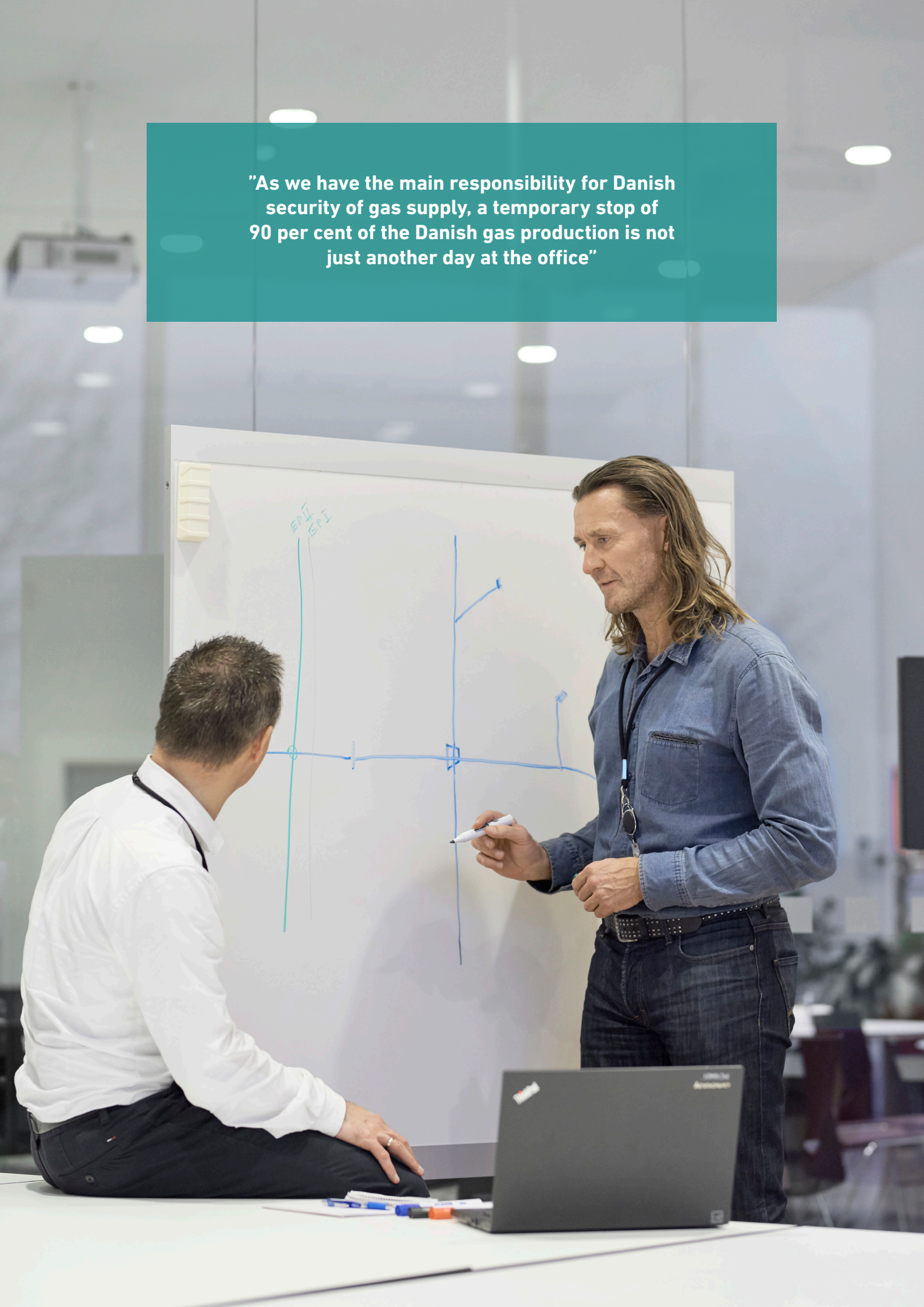
– There will still be sufficient capacity in the gas system to supply the Danish and Swedish gas markets. The primary source of supply during the reconstruction period will be gas from Germany combined with supplies from the Danish gas storage facilities in Stenlille and Lille Torup.

The Danish gas system was originally designed to have one primary source of supply. Today, Denmark has two: the North Sea and Germany. If a large part of the production in the North Sea is discontinued, the gas system will return to a situation with one primary source of supply – Germany.

Preparing for a worst-case scenario when Denmark goes from two to one primary source of supply during the reconstruction period, the gas system loses flexibility. But it will take an

WHY IS THE TYRA PLATFORM BEING RECONSTRUCTED?

Since 1987, the Tyra platform has been the most important source of supply for Danish and Swedish gas consumers. The Tyra complex has sunk approx. 5 metres since its establishment, and that is the reason for the shutdown. There is a growing risk that a 100-year wave could have serious consequences for the platform complex. Tyra therefore needs reconstruction if we are to continue to extract gas in the Danish part of the North Sea. The Tyra complex is owned by DUC, which stands for Danish Underground Consortium.



”As we have the main responsibility for Danish security of gas supply, a temporary stop of 90 per cent of the Danish gas production is not just another day at the office”

extraordinarily cold and long winter – alternatively a technical incident – before the Danish gas supply runs into difficulties.

– As responsible for Danish security of gas supply, we must be prepared for a worst-case scenario. That's why we're looking into different options to ensure gas to consumers in the event of a serious incident, says Claus Møller Petersen.

The possible measures which Energinet will take in order to ensure a continued high level of security of gas supply during the reconstruction of Tyra are being analysed in the project and will be assessed carefully prior to the final decision. But initial steps have already been taken by Energinet, for instance, to move forward the planned maintenance of the compressor station in Egtved.

Market players have a key role
The players in the Danish gas market play a key role when it comes to ensuring a high level of security of gas supply during the reconstruction period. Energinet has therefore invited all shippers to participate in a user group.

"To maintain a high level of security of gas supply, it's necessary that the market players utilise the capacity in the gas storage facilities by filling them up during the summer months, so there's gas available for the winter periods"

In cooperation with Energinet, they will come up with possible measures which can make it attractive for the shippers to use the Danish gas system and ensure the supply of gas up to, during and after the reconstruction of the Tyra platform.

– To maintain a high level of security of gas supply, it's necessary that the market players make sure to utilise the capacity in the gas storage facilities by filling them up during the summer months, so there's gas available for the winter periods, as well as ensuring optimum utilisation of the connection from Germany, says Christian Rutherford from Energinet.

Faith in the market
Christian Rutherford brought no proposals for measures with him to the first user group meeting on 30 March 2017. Instead, the attending shippers were divided into three groups in which they were asked to discuss and make suggestions for tools that could be used to ensure the best possible utilisation of the capacity available during the maintenance period.

After the meeting, the market players' ideas were linked with ideas from Energinet. These measures were

WHERE WILL THE GAS COME FROM DURING THE RECONSTRUCTION OF TYRA?

The gas system was originally designed to have one primary source of supply: the North Sea. Since then, the pipelines to Germany have been expanded, so that currently there are two large supply routes. The gas system will revert to a situation with one primary source of supply. Supplies from Germany supplemented with upgraded biogas and gas from the gas storage facilities.

Together with colleagues at Energinet, project manager Claus Møller Petersen and group manager Christian Rutherford from Energinet's Gas TSO are preparing for the closing-down of the Tyra platform in 2019-2022. They are working on analysing various types of measures available to Energinet during the reconstruction period.

presented at a new user group meeting on 4 October 2017, at which 15 out of Energinet's total customer group of 20+ shippers were represented. At this meeting, Energinet presented the list of possible measures and improvements, and these were debated.

– The market players found it hard to imagine that something would go wrong. They have believe that the market will function if they get the right price signals, and if the flow is moving in the right direction. But they accepted the challenge and came up with a number of ideas and initiatives that we can make use of on depending on the situation, says Christian Rutherford.

Together, we ensure the best possible gas capacity utilisation

In the first quarter of 2018, Energinet will do a final round of consultations with the market before subsequently reporting the relevant measures to the Danish Energy Regulatory Authority as the tools which are to ensure gas supplies during the maintenance period.

"The players in the Danish gas market play a key role when it comes to ensuring a high level of security of gas supply during the reconstruction period"

So even though gas supplies from the North Sea close down temporarily in the period 2019-2022, and if security of supply were to be challenged, the market players and Energinet will jointly ensure the best possible utilisation of the gas capacity.

Concurrently, Energinet will prevent an increased crisis level by continuously analysing the supply situation and drawing on the new methodological tools.

BIOGAS STRENGTHENS SECURITY OF SUPPLY

Biogas makes the gas greener while contributing to security of supply. Five per cent of the gas in the Danish gas system comes from biogas and, in 2020, this figure will have increased to at least 10 per cent.

Denmark's biggest biogas plant is located in a field at Bevtoft in Southern Jutland. Each year, the plant converts 540,000 tonnes of liquid manure, straw and other residual products into approx. 21 million cubic metres of upgraded biomethane. This corresponds to the energy consumption of 15,000 households or 570 city buses.

"Sønderjysk Biogas's plant at Bevtoft is not only the largest biogas plant in Denmark, it is also the only plant that sends gas made from straw, liquid manure and waste into the transmission grid," says Jeppe Bjerg, senior analyst in Energinet's TSO Gas.

Since 7 July 2016, the biogas plant has been connected to Denmark's main gas transmission grid, from which biomethane can be sent into the regional gas distribution grids, stored or exported directly to Germany or Sweden. Popularly speaking, the biogas is sent directly on to the gas highways.

Security of supply and green gas
In order to send biogas that has a pressure of 3.5 bar, into the transmission grid, the pressure must be increased to approx. 70 bar. This pressure increase takes place at Energinet's compressor and meter station at Bevtoft, which was established for this purpose in 2016.

Energinet is responsible for security of supply and is working to integrate renewable energy in the Danish energy system. And the example from Bevtoft kills two birds with one stone, according to Jeppe Bjerg:

"The volumes of biomethane which the plant sends into the distribution grid and the transmission grid respectively, contribute, together with the other biogas plants, somewhat to ensuring to the security of gas supply in Denmark. The biogas plant supplies 15,000 households with energy each year and, at the same time, Denmark's CO_2 emissions are reduced by 51,000 tonnes."

Better fertiliser and lower CO_2 emissions
The biogas plant captures the greenhouse gases in the liquid manure and leaves behind a fertiliser filled with nutrients. In doing so, the plant creates a better fertiliser for crops and reduces the agricultural sector's climate impact.

The agricultural sector is one of three non-ETS sectors. The other two are vehicles and households, which, according to the EU's climate targets for 2030, must reduce their CO_2 emissions by 39 per cent relative to 2005.

"The production of biogas reduces farmers' CO_2 emissions, and it supplants the use of fossil fuels in the heating and transport sectors and in industry", says Jeppe Bjerg.

"Energinet is responsible for security of supply and is working to integrate renewable energy in the Danish energy system"

BIOGAS PLANTS CONNECTED TO THE GAS SYSTEM

Twentyone upgrading plants have been connected to the gas grid since 2011. The plants have a total capacity of 100 million Nm^3/year. The supply of biogas to the gas system is increasing steadily, accounting for 5 per cent of the gas consumption in 2017. Energinet is currently aware of around 10 projects involving biogas upgrading that may be realised within the next couple of years. It is expected that the majority of the upgrading plants will continue to be connected to the distribution grids.

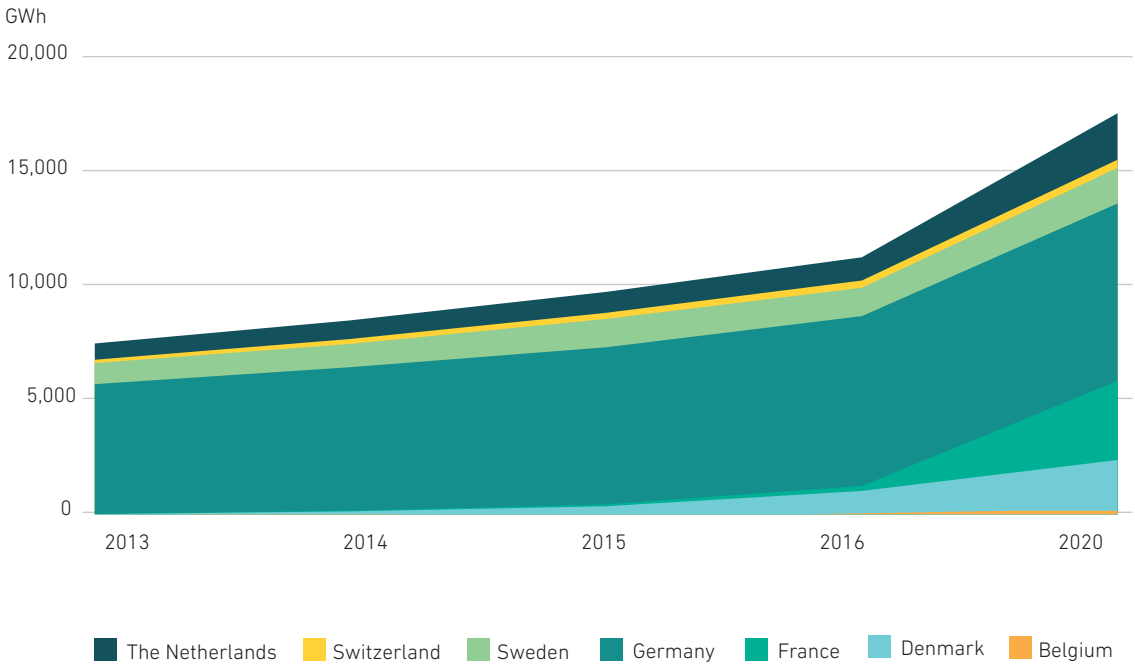
"The way things are at the moment, there are quite a few challenges involved in transporting large volumes of biomethane in the transmission grid, but we are working to solve these"

Different levels of oxygen specifications results in gas beeing denied access to Germany

But sending biogas into the transmission grid is not without its challenges. Christian Meiniche Andersen, head of department in Energinet's TSO Gas, explains that there was a problem on the Danish-German gas border in summer 2016:

"In Germany, some consumers don't want to receive gas with a "high" content of oxygen, but in Denmark, we add oxygen in the upgrading process to remove sulphur from the biogas. At the moment, we therefore only send pure natural gas to Germany from the North Sea. Instead, biomethane is consumed by Danish and Swedish consumers."

FIFTY PER CENT MORE BIOMETHANE IN THE COUNTRIES OF THE GREEN GAS INITIATIVE'S GAS GRID IN JUST THREE YEARS



In 2016, 11 TWh of upgraded biogas was injected into the gas systems in Denmark, Sweden, Germany, France, the Netherlands, Switzerland and Belgium. This is an increase of 50 per cent over the past three years. The growth is expected to continue towards 2020.

Together with Energinet-colleagues, Head of Department Christian Meiniche Andersen and Senior Analyst Jeppe Bjerg in Energinet's Gas TSO are working on preparing and developing the Danish gas system for the green transition. The increase in upgraded biogas injected into the gas grid creates new opportunities in Denmark as well as across borders and presents new challenges for Energinet.

In the long term, it may become physically feasible to send biomethane to Germany, but this requires either that a solution is found for the 'particularly sensitive consumers' in Germany or that oxygen is removed from the gas transported to Germany.

Gas highways do not like odorant

By nature, natural gas is almost odourless, but an odorant is added for safety reasons. The odorant has a very pungent and distinctive smell which ensures that a potential gas leakage can be quickly detected by people nearby.

"We add odorant to the biomethane at our meter and regulator (M/R) stations before it's fed into the distribution grid. However, the odorant-containing gas cannot be sent back into the transmission grid. "We can therefore not reverse the flow of gas from the distribution grid to the transmission grid," says Christian Meiniche Andersen.

"30 years into the future, we imagine that green gas is used for transportation, in industry and in quickly regulating electricity-generating facilities"

The way things are at the moment, there are quite a few challenges involved in transporting large volumes of biomethane in the transmission grid, but we are working to solve these – partly by looking at possible technical solutions for handling oxygen and odorant, and partly by working on harmonising gas quality requirements across the border points.

Biogas in 2050

The Danish Energy Agency's energy scenarios and gas infrastructure analysis all predict that methanised biogas will play a role in Denmark's green energy mix in 2050. The completely CO_2-neutral gas grid of the future represents great value and a potential resource for security of supply:

"30 years into the future, we imagine that green gas is used for transport, in industry and in quickly regulating electricity-generating facilities. The Danish natural gas grid and its gas storage facilities will also constitute an appropriate infrastructure in 2050," says Jeppe Bjerg.

And there are indications that the gas future is green. A new report from the Green Gas Initiative (GGI) shows 50 per cent growth over the last three years in the volume of biomethane in the gas grids in Denmark, Sweden, Germany, France, the Netherlands, Switzerland and Belgium.

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