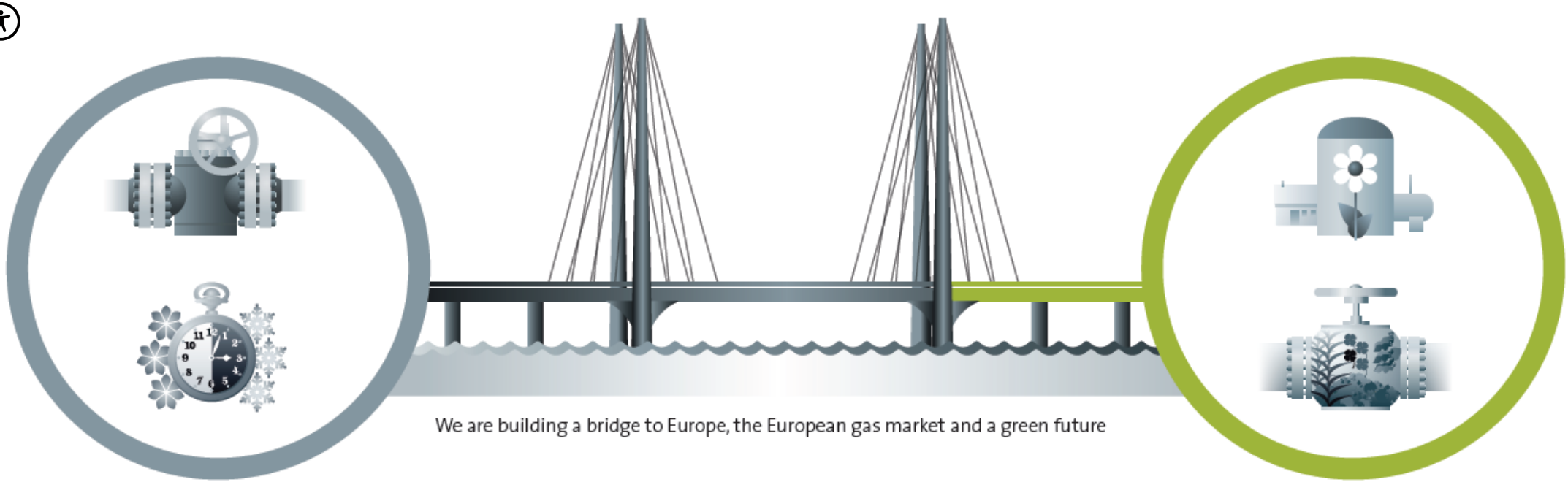

We are building a bridge to Europe, the European gas market and a green future

2014
GAS IN DENMARK

ENERGINET.DK

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Gas in Denmark 2014

Content

Gas in Denmark 2014

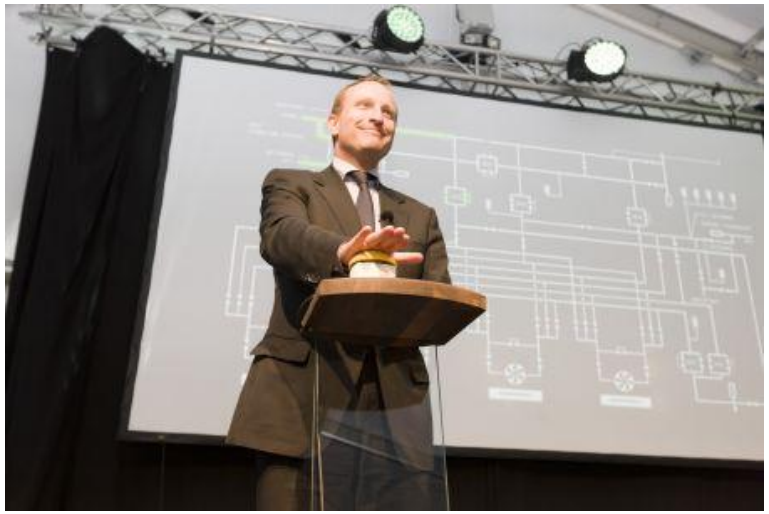
We are building a bridge – not only to Europe and the European gas market, but also to a greener future.

'This is a great day for Denmark and Danish energy policy. We are building a bridge to the future, we are building a bridge to Europe, but we are also building a bridge to the green energy transition.

In the long run, it is not possible to switch to green energy with excellent security of supply without having international connections – and this goes for power connections as well as gas connections. So this is something that will benefit us all.

Denmark has ambitious objectives for its green energy transition, but for this to work, we need an effective and flexible alternative, and gas is perfect for this. And in the long term, gas will also be green.'

So said the Danish Minister for Climate, Energy and Building Martin Lidegaard in an interview with the Danish broadcaster DR on the inauguration day of the compressor station at Egtved and the new gas pipeline to Germany. Read more in 'Gas in Denmark 2014' to find out how gas can build a bridge to the future energy system.



'Ladies and gentlemen. It gives me great pleasure to declare the compressor station and the new gas connection to Germany open.' Danish Minister for Climate, Energy and Building Martin Lidegaard inaugurates the compressor station at Egtved and the new gas pipeline to Germany by pushing the yellow button on 30 September 2013. Photo: Bent Sørensen, Medvind.

Facts

- 'Gas in Denmark' is Energinet.dk's report to the Danish Energy Agency and is published every year.
- The 'Gas in Denmark 2014' report meets the following requirements:
  - Annual security of supply report; see Section 3 of the Executive order on maintaining security of natural gas supply
  - Coherent, holistic planning of the transmission network; see Section 7 of the Executive order on implementing natural gas supply networks.

1. What happened in 2013?

In spring 2013, the situation became near-critical as Energinet.dk issued two Early Warnings only weeks apart due to a critical gas supply situation.

'We were getting a bit anxious because we could see that supplies to the Danish gas market were slipping to a critical level,' says Jeppe Danø, Marketing Director of Energinet.dk's gas division, and continues:

'For the first time in the 40-year history of gas in Denmark, we were only days away from having to interrupt the gas supply to the largest Danish gas customers.'

The crisis was caused by a rare overlap of a number of unfortunate circumstances.

Jeppe Danø, Market Director, Gasdivision. Photo: Steven Hofman.

First warning

In March, gas supplies were more or less normal; only supplies from the Danish part of the North Sea were a little lower than expected. On the other hand, the spring temperatures were extraordinary low, and more gas than expected was therefore being used, leading to declining stocks.

'Normally, the temperature rises in March, and consumers therefore use less gas. But this year, the exact opposite happened. Temperatures fell, and the Danish Meteorological Institute's forecasts continued to show cold weather. So if we did nothing, the gas stocks would be depleted by April,' explains Jeppe Danø.

This prompted Energinet.dk to issue Early Warning to the market players on 18 March asking them to rectify the situation and restore balance to the market.

The market caught the signals, supplies from the North Sea rose again and after ten days, on 27 March, the situation was called off.

Second warning

In April, there was trouble again. On 27 April, Mærsk Oil & Gas, which operates the Tyra platform in the North Sea responsible for 90% of the total Danish gas production, announced that they expected to suspend production for six days due to repairs. Then, on 28 April, Stenlille, one of the two gas storage facilities in Denmark, announced that the withdrawal capacity would be reduced the next three-four days. The technical issues were solved, but complications arose which in fact interrupted North Sea supplies for ten days – the longest interruption in North Sea gas supplies to date.

This was serious. After the critical situation in March, the gas stocks were depleted, prompting Energinet.dk to issue yet another Early Warning on 29 April.

Energinet.dk's gas division held its breath as it watched the gas stock chart slide to the level that Energinet.dk is obliged to keep in reserve for protected consumers such as private

customers, hospitals and small enterprises. In the beginning of May, the situation was so critical that Energinet.dk considered revising the warning level to 'Alert'.

'Luckily, we had positive indications that repairs on the Tyra platform progressed as planned and were able to call off the Early Warning after having seen a stable supply level throughout the Ascension Day holidays,' says Jeppe Danø.

Educational process

The marketing director emphasises that the incident has been an educational process for Energinet.dk.

'Of course, it was also the first time we had to use Early Warning, so we have definitely learned a lot about how we can make better use of some of our 'levers', among other things with regard to accurate and adequate communication to the market, not least the affected industrial enterprises.'

In connection with the Early Warning incidents, Energinet.dk was critised by Danish gas customers, which would have had their supply interrupted in an emergency situation.

Not all non-protected enterprises felt that they had been adequately informed of the incidents in spring. Energinet.dk understands the frustration. In light of the Early Warning incidents, Energinet.dk has launched a new annual event, Industry Forum, for all enterprises with a large gas consumption. This is in recognition of the fact that although Energinet.dk has no direct contact with the enterprises, a forum for information and debate is still needed. The gas-consuming enterprises have embraced the Industry Forum.

New gas pipeline secures imports

Energinet.dk also has other initiatives in the pipeline to counter the problems that arose in the wake of the Early Warning incidents.

'Of course, it is entirely untenable that companies hear about an aggravated delivery situation via their oil supplier as some have,' says Jeppe Danø and explains that this is because Energinet.dk does not have direct contact with the end-users, but only their suppliers.

'That is why we only notify the suppliers, or shippers as we call them. But industrial customers and other affected parties do not have access to a direct information channel, and we are therefore looking into how we can improve the process for them. Because it is, of course, important that the non-protected users are kept up-to-date on the development well in advance.

With an hourly gas capacity totalling 700,000 cubic metres, the new gas pipeline between Ellund and Egtved will also ensure that Denmark can import a much larger volume of gas than previously. This could play a vital role if the gas stocks were to drop to a critical level again.'

Facts

- Early Warning is the lowest warning level in Energinet.dk's emergency supply preparedness. The next steps are 'Alert' and 'Emergency'.
- The three steps make up the European gas market scale and were introduced on 1 October 2012 with the EU regulation concerning measures to safeguard security of gas supply.
- With the change in the emergency-supply model, which was implemented on 1 October 2012, the Danish gas consumers were divided into protected and non-protected consumers.
- It is the gas consumers' consumption which determines whether they are protected or non-protected, meaning that there can be no guarantee that, for example, large enterprises with an annual gas consumption above a certain cubic metre limit can have their gas needs covered.
- At the 'Emergency' crisis level, the gas supply to non-protected consumers is interrupted at 72 hours' notice whereas protected consumers are protected for 60 days.

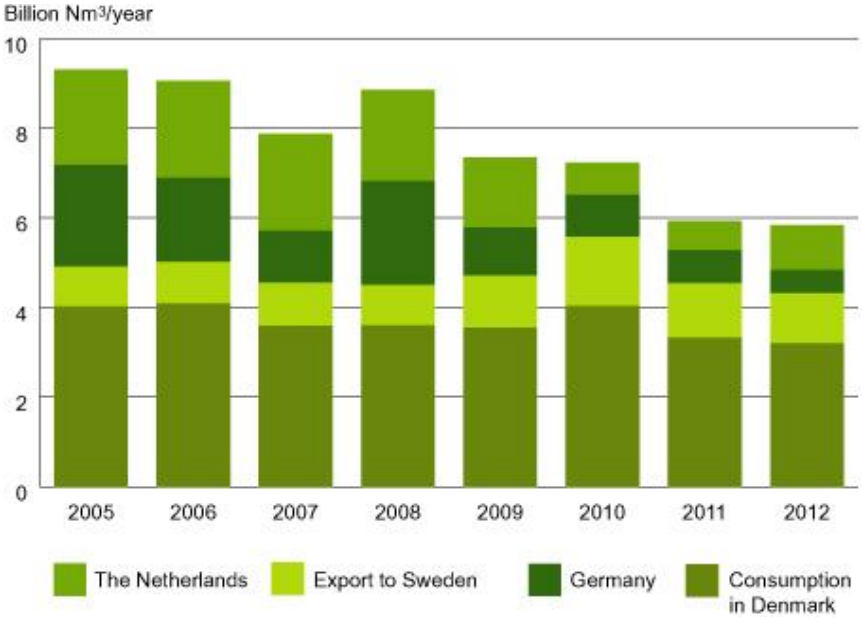
1.1 Gas supply situation in 2012-2013

Approximately 16% of natural-gas production in 2012 was exported to the Netherlands, whereas 18% was exported to Sweden and 13% to Germany.

The majority of natural gas transported via Energinet.dk's transmission network comes physically from the North Sea fields. Denmark continues to be a net exporter of gas.

Most of the gas from the Danish fields is sent to Denmark via the Tyra and Syd Arne pipelines, where it is sold in the Danish exit zone or exported to Germany or Sweden. Gas is also exported to the Netherlands via the NOGAT pipeline.

Production volumes shown in the figure below are net production (excluding own consumption) led onshore to Denmark or the Netherlands.



Annual net production (excluding own consumption) led onshore in Denmark or the Netherlands. Net exports to Germany and Sweden. Source: Danish Energy Agency and Energinet.dk.

Utilisation of entry and exit capacities

The table shows capacities at the transmission-system entry and exit points and storage-withdrawal capacity compared to the actual peak-day volumes during the past three winters.

Million Nm^3/Day		Capacity	Max. Flow 2010/2011	Max. Flow 2011/2012	Max. Flow 2012/2013
Nybro	Entry	32[2]	23	19	14,1
Lille Torup storage facility	Withdrawal	8[3]	7	7	6
Stenlille gas storage facility	Withdrawal	12	10	11	9,3
Exit zone Denmark	Exit	26	22	22	19,5
Ellund	Entry / Exit	4,7 / 8,3	4,7 / 8,5	4,0 / 7,6	5,2 / 2,2
Dragør Exit	Exit	9[1]	8	7	7,7

Capacities at the transmission-system entry and exit points compared to actual peak-day volumes.

Please note:

- Note 1: The Swedish system is not designed to receive these volumes at the assumed minimum pressure at Dragør of 45 bar. The firm capacity is stated at 6 million Nm^3/day.
- Note 2: Total capacity of the receiving terminals at Nybro. The potential supplies are today smaller as the Tyra-Nybro pipeline is subject to a capacity constraint of about 26 million Nm^3/day, and large volumes cannot be supplied from the Syd Arne pipeline.
- Note 3: Guaranteed capacity.

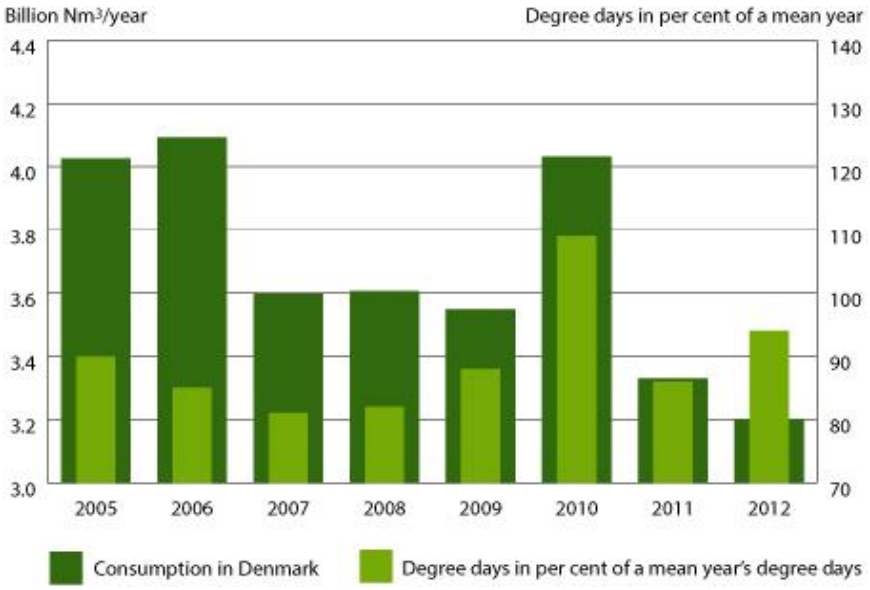
Facts

- The maximum daily supply from the North Sea during the last winter was 14.1 million Nm³/day. This occurred during the first Early Warning. For the period July 2012 to July 2013, this delivery, however, was surpassed on 27 September 2012 when it was 14.4 million Nm³/day.
- In the period July 2012 to July 2013, gas was physically imported from Germany for a total of 236 days and physically exported to Germany for 116 days.

1.1.1 *Gas consumption 2012-2013*

Gas consumption in Denmark is declining. 2012 was a warm year, further reducing consumption.

Gas consumption in Denmark has seen a slightly falling trend since 2006, when disregarding annual fluctuations in temperatures (normal years). This can be seen in the figure below, which shows natural gas consumption for the period 2006-2012.



Natural gas consumption in the period 2005-2012.

Prior to 2007, the average was approximately 4 billion Nm³. The fall from 2006 to 2007 is mainly due to a fall in the natural gas-based power generation. This fall continues as biomass replaces natural gas as fuel at local CHP plants.

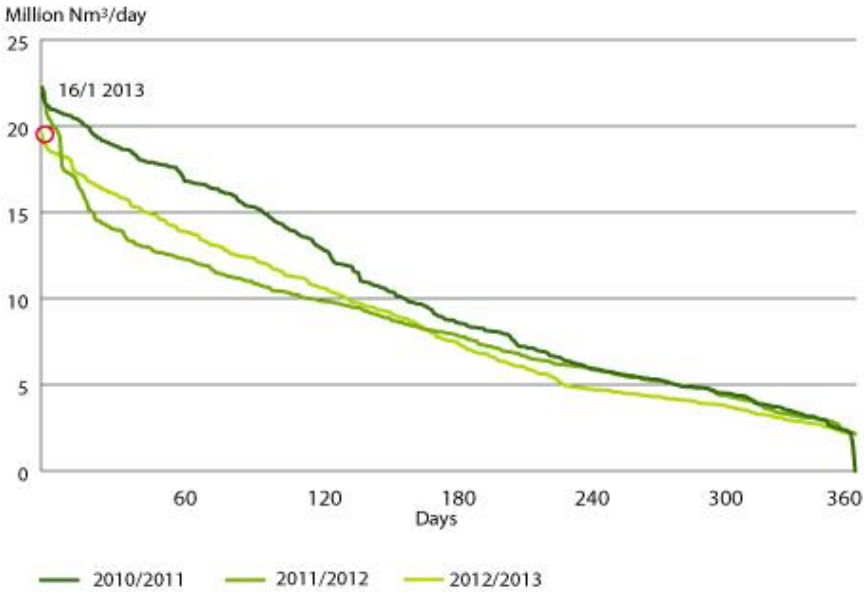
As can be seen in the figure, the year 2010 was an exception. This is due to the fact that 2010 was a cold year with 9% more degree days than in a normal year, and that consumption at the central power stations was high.

In 2012, consumption in Denmark was approximately 3.2 billion Nm³. There were 6% fewer degree days in 2011 than in a normal year.

Maximum daily consumption

The temperature has a major impact on the maximum daily consumption and hence on the load on the transport systems. The figure below compares duration curves for daily consumption for the period 2010-2013. In a duration curve, the daily consumption for the 365 days of the year is sorted according to size.

Last winter, the maximum daily consumption was 19.5 million Nm³. This was on 16 January 2013 when the daily mean temperature was -5.6°C. In a normal year, a minimum daily mean temperature of -8°C is assumed. In comparison, Energinet.dk assumes a maximum daily consumption of approximately 23 million Nm³/day at a daily mean temperature of -13°C.



Duration curves for daily consumption compared for the period 2009-2012.

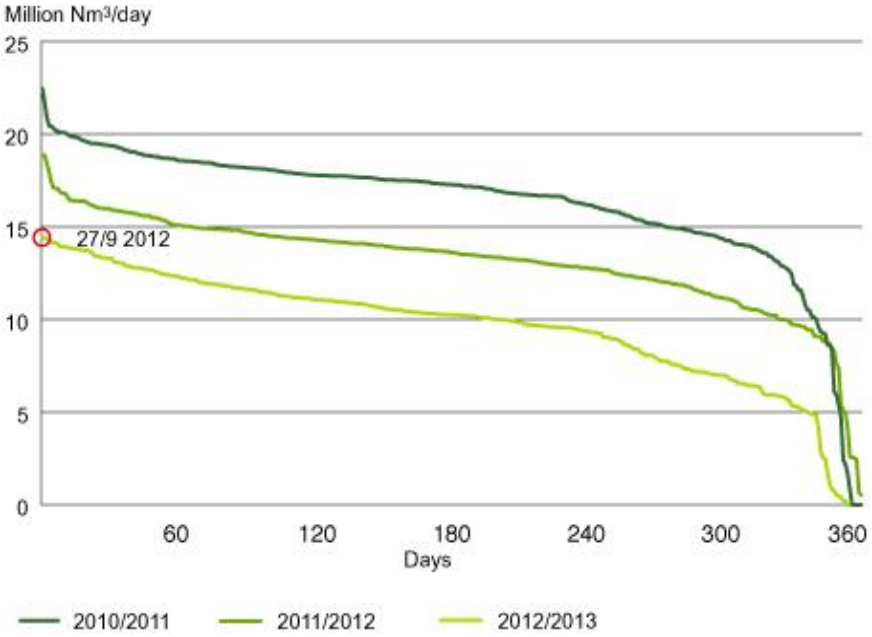
Facts

- Degree days are a measure of how cold it has been. A day's degree days are the difference between the average temperature during the day and 17 degrees Celsius. If the average temperature during the day is four degrees, for example, there are 13 degree days in the day in question. At an average temperature of 17 degrees or more, there are zero degree days, and at minus 5 degrees, for example, there are 22 degree days. The Danish Technological Institute calculates the degree days.
- The Danish Energy Agency believes that the financial crisis is the cause of the decline in gas consumption.
- Read more in the Danish Energy Agency's Energy Outlook.

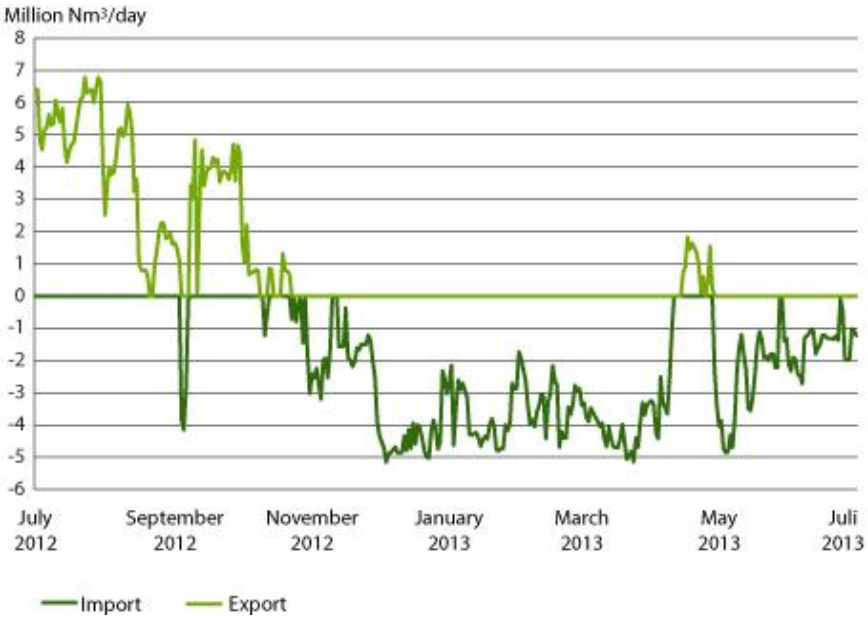
1.1.2 Gas supplies 2012-2013

The majority of all gas supplied to Denmark comes from the North Sea. Denmark continues to be a net exporter of gas, but sometimes the flow is reversed such that we import gas.

In the period from July 2012 to July 2013, the maximum supply at Nybro was 14.4 million Nm³/day. It took place on 27 September 2012. The duration curves for the annual supplies are shown in this figure.



Duration curves for daily consumption compared for the period 2010-2013.



Imports and exports at the Danish-German border point in the period July 2012-July 2013.

Ellund entry

On 1 October 2013, additional physical imports from Germany as compared to previous years were made possible.

The figure below shows the imports and exports at the Ellund border point in the period July 2012-July 2013.

Facts

- Until 1 October 2013, the transmission system was physically capable of importing up to 200,000 Nm³/hour. Since then it has been possible to import 310,000 Nm³/hour corresponding to 7.4 million Nm³/day from Germany.
- In comparison, the system can export 344,000 Nm³/hour corresponding to 8.3 million Nm³/day across the German border.

1.1.3 Gas storage utilisation 2012-2013

Gas consumption varies greatly and much more than supplies from the North Sea. This is managed by using the two Danish gas-storage facilities.

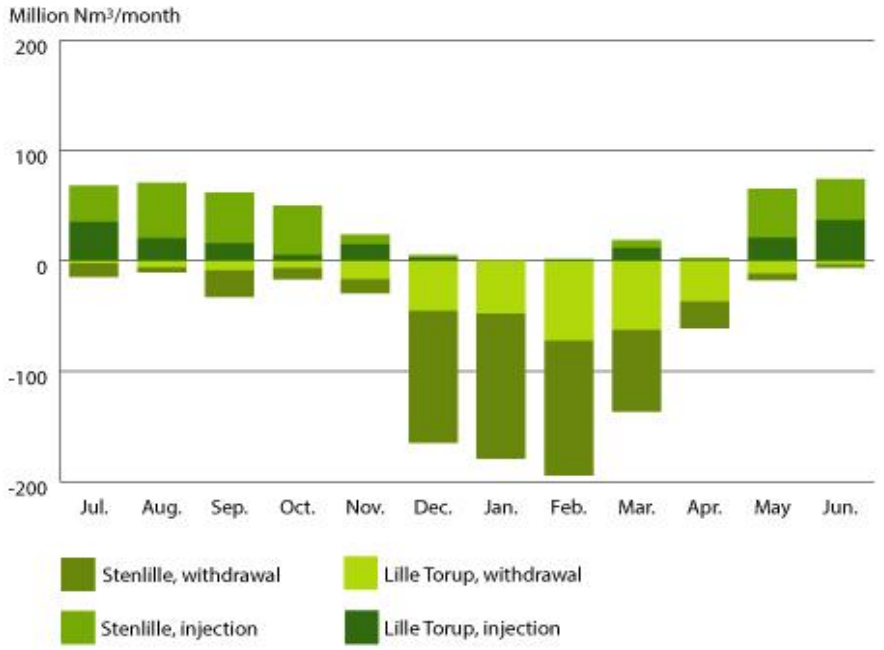
Gas consumption varies with the seasons and during the day. These variations are far greater than the fluctuations in supplies from the North Sea. The market players use the two Danish underground storage facilities at Lille Torup and Stenlille to store gas between seasons and to supply the necessary daily capacity.

During the summer, when gas consumption is low, surplus gas is injected into the gas storage facilities. During the winter when supplies from the North Sea can no longer cover Danish consumption or exports to Sweden and Germany, gas is withdrawn from the storage facilities again.

In case of interruptions of supplies from the North Sea or Germany, the two gas storage facilities serve as emergency-supply storage facilities.

Withdrawals and injections

The figure illustrates the monthly distribution of withdrawals from and injections into the storage facilities for the period July 2012-June 2013.



Monthly distribution of withdrawals from and injections into the storage facilities for the period July 2012-June 2013.

1.1.4 Gas transmission incidents 2013

The Danish emergency-supply concept was put to the test in spring with two Early Warning incidents in the gas system within two months.

Energinet.dk has previously informed the market players that the supply situation could be relatively strained in 2012-2014 until the expansions in the transmission system on both the Danish and the German side of the border are completed in October 2014. This became true in spring 2013 as Energinet.dk declared an Early Warning twice within two months.

Both early warning incidents were solved without the use of the physical or commercial tools available in the security of supply model. However, mechanisms from Rules for Gas Transport were used that had never been used before, but which ensured a higher flow of gas from Germany to Denmark.

The first Early Warning from 18 to 27 March 2013

The first Early Warning situation occurred due to the extremely low temperatures in March 2013 combined with the low gas filling in the storage facilities and a highly critical weather forecast.

The second Early Warning from 29 April to 13 May 2013

The second Early Warning incident was due to an interruption in and reduction of several supply sources at the same time compared with the low storage filling.

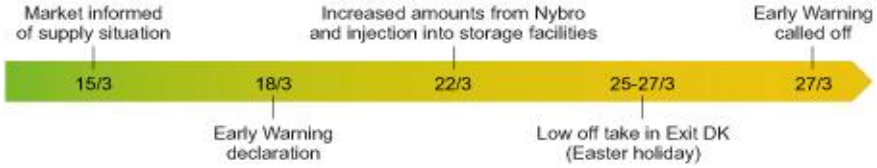
Facts

- Energinet.dk is responsible for ensuring the supply of gas to the Danish market in emergency-supply situations. These situations may arise in case of serious failures in gas supplies to Denmark. If this happens, Energinet.dk assumes responsibility for supplying gas to all Danish consumers.
- Read more about how Energinet.dk handles emergency-supply situations here.

1.1.4.1 The first Early Warning

Cold weather and low gas filling caused Energinet.dk to declare an Early Warning for the period 18-27 March 2013.

Energinet.dk assessed that the Early Warning criteria had been met and, on 18 March 2013, Energinet.dk declared Early Warning. Energinet.dk was hoping that the signal to the market would make the market players extra aware of the need to use the existing opportunities for supplying gas to the Danish market.

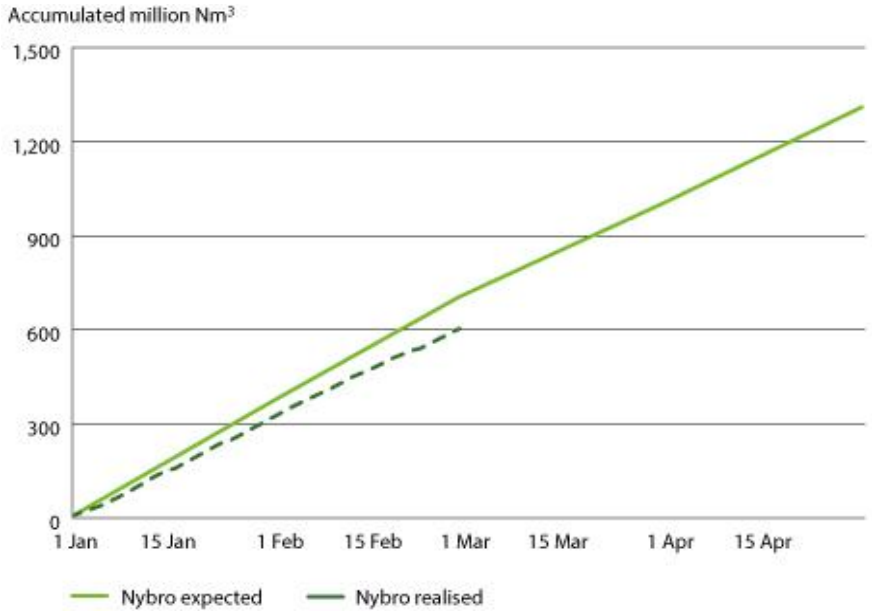


Progress of the entire first Early Warning incident 18-27 March 2013.

Expectations of lower supplies as early as January 2013

On 28 January 2013, Energinet.dk issued a brief description of the supply situation to the players. The supply situation did not give rise to immediate concern, but Energinet.dk's description outlined the actual picture for January 2013 and Energinet.dk's expectations for spring 2013.

It appeared from the description that supplies from Nybro were 15% lower than expected, and that the surplus stock was 7% lower than expected.

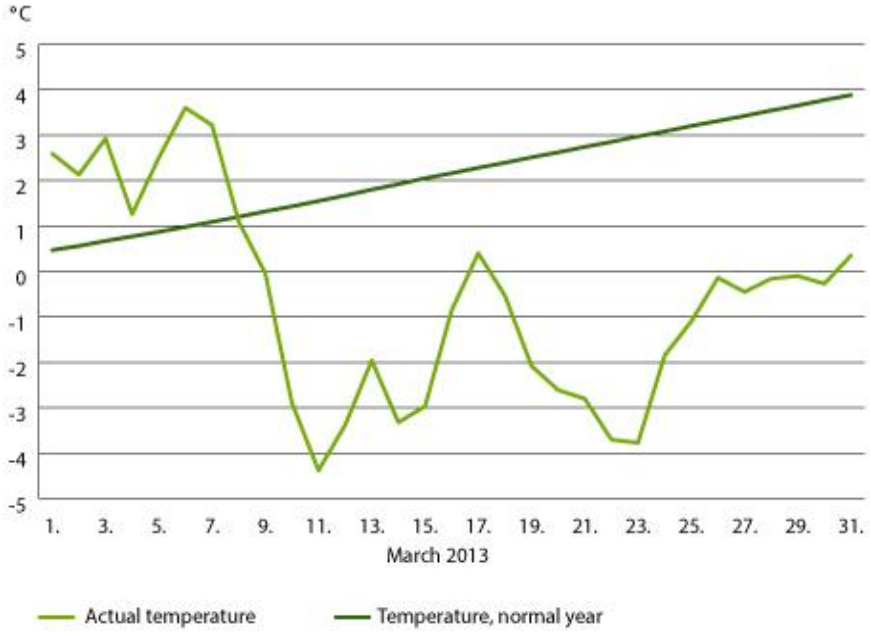


Supplies from Nybro January-March 2013.

Unusually cold weather in March

In early March 2013, Energinet.dk could see that gas supplies at Nybro were still below expectations and that withdrawals from the storage facilities were accordingly higher. This was not critical as such, but now expectations for consumption in March and April 2013 became a factor.

Temperatures usually rise significantly in March while withdrawals from the storage facilities decrease. However, the exact opposite happened. Temperatures fell, and the Danish Meteorological Institute's monthly forecasts continued to show cold weather.

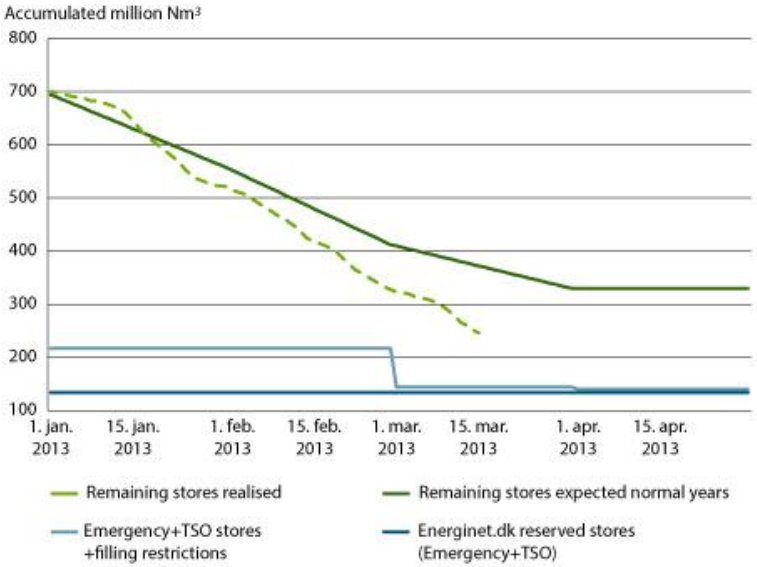


The temperatures in March 2013 compared with the temperatures in a normal year.

Early Warning on 15 March 2013

On 15 March 2013, Energinet.dk knew that if the supply situation continued, storage customers would have spent their storage gas as early at the beginning of April 2013. This meant that the only gas left in the storage facilities would be the gas reserved for long-term emergency supply situations.

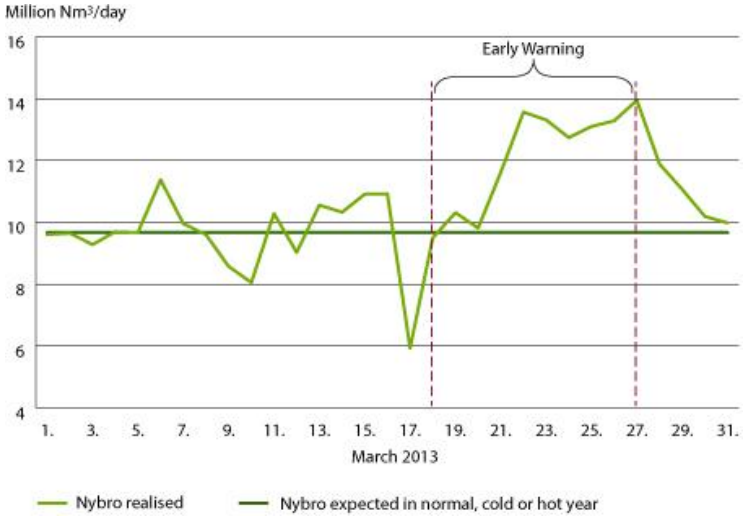
The question was whether there would be sufficient gas to supply the Danish and Swedish consumers. Energinet.dk therefore issued Early Warning to the market players concerning a possibly critical supply situation. However, this did not give rise to a changed supply situation.



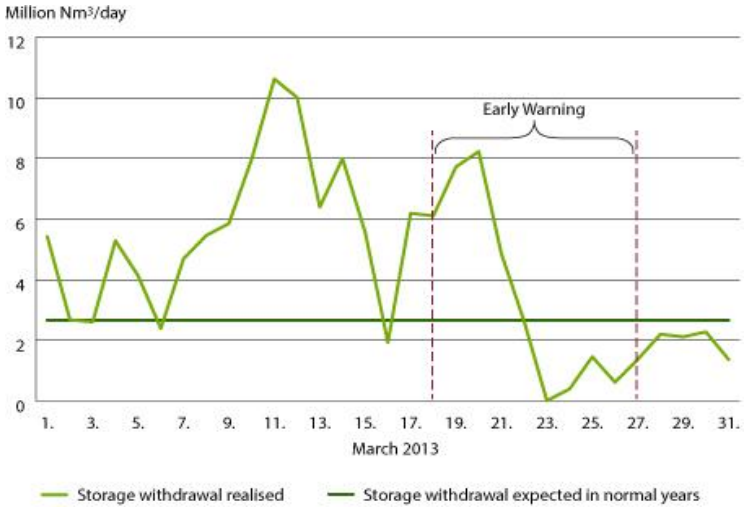
Surplus stock as at 15 March 2013.

More gas from Nybro

Three days into the Early Warning incident, the supply situation changed significantly. The Nybro supplies increased considerably, and storage facility withdrawals fell accordingly.



Supplies at Nybro during the first Early Warning.



Storage facility withdrawals during the first Early Warning.

Situation normalising

On 27 March 2013, Energinet.dk assessed that the risk of emptying the storage facilities and of a shortage of gas had been reduced considerably. The surplus stock was no longer critical for the season. Energinet.dk therefore called off the Early Warning situation, even though the weather forecast for the rest of April 2013 still showed relatively cold weather.

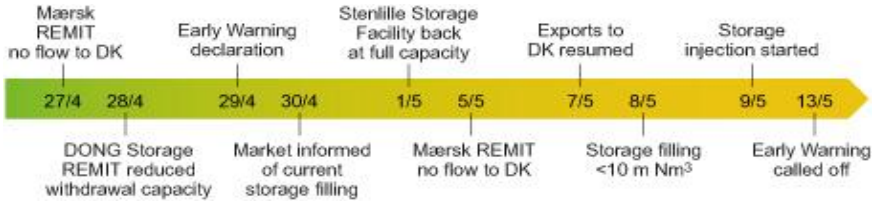
Facts

- Early Warning is the lowest warning level in Energinet.dk's emergency supply preparedness. Energinet.dk declares an Early Warning when there is concrete, serious and reliable information that an incident may occur which is likely to result in significant deterioration of the supply situation and is likely to lead to the alert or the emergency level being triggered. The Early Warning level may be activated by an early-warning mechanism. Read more in the Emergency plan.
- Energinet.dk's emergency storage gas is purchased based on expectations of variations in consumption to cover both short-term emergency-supply situations at extreme temperatures and long-term emergency-supply situations in a normal year.

1.1.4.2 The second Early Warning

Low storage filling and interruption and reduction of supply sources led Energinet.dk to declare an Early Warning for the period 29 April-13 May 2013.

For the second time in a short period of time, Energinet.dk declared an Early Warning in the gas system and once again sent a signal to the market players to take action to avoid gas shortage.



Progress of the first Early Warning incident on 29 April to 13 May 2013.

Energinet.dk called off the first Early Warning incident on 27 March 2013 as stocks were no longer critical for the season. In the period up to mid-April, the stocks, however, continued to fall due to sustained withdrawals from the storage facilities and exports to Germany.

No gas supplies from the North Sea

The situation became critical when, on Saturday 27 April 2013, Mærsk issued a REMIT message that production at Tyra East would be suspended for six days.

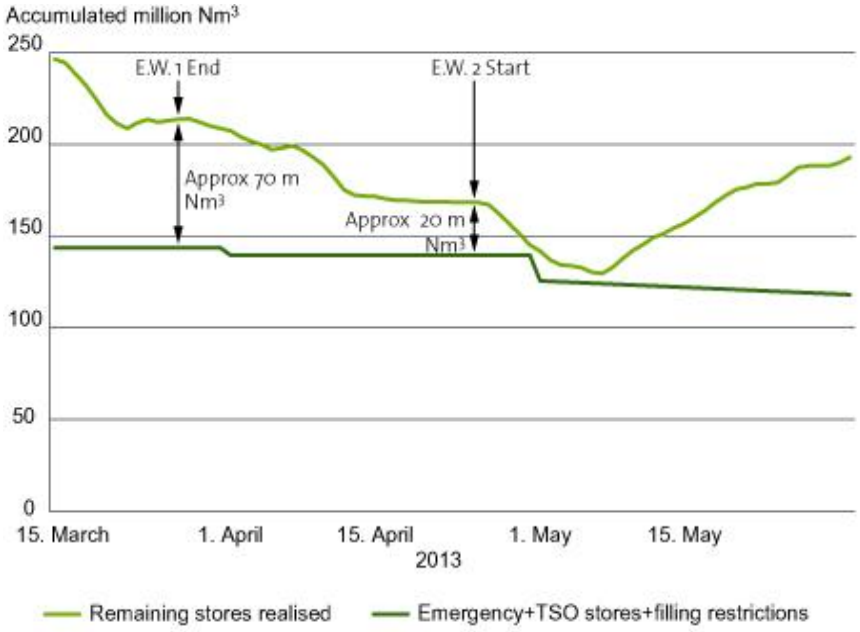
Furthermore, on Sunday 28 April 2013, DONG Storage sent a REMIT message that the withdrawal capacity at Stenlille gas storage facility would be reduced for four days.

The gas system was thus under pressure from both outage and capacity reduction affecting two important supply sources.

No guarantee for stable supplies to the market

The two messages and the storage filling being low for the season were two such factors as to lead Energinet.dk to assess that there was no guarantee for stable supplies to the market at the beginning of May 2013. On 29 April 2013, Energinet.dk therefore sent a REMIT message about a change in the crisis level to Early Warning.

On 30 April 2013, Energinet.dk informed the shippers about how much gas was left in the storage facilities and that Energinet.dk had decided not to increase the incentive payment for imbalances.



Storage situation at the beginning of the second Early Warning.

Slow improvement

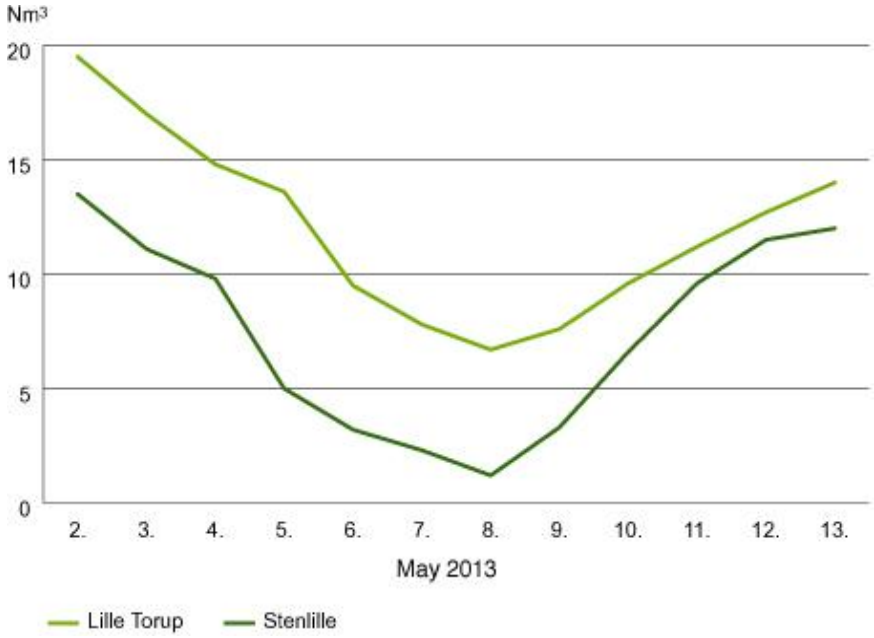
On 1 May 2013, the supply situation slowly began to change as full withdrawal capacity was restored at Stenlille gas storage facility. However, there was still a lot of uncertainty about supplies from the North Sea.

In the period 3-8 May 2013, Mærsk issued new messages to the gas market. Mærsk started to supply gas to Denmark shortly before midnight on 8 May 2013, and supplies were not fully restored until 9 May 2013.

Gas storage facilities almost empty

On 8 May 2013, customers' filling of the two gas-storage facilities combined was as low as 10 million Nm³, which can only cover a few days' consumption.

On some days during the Early Warning situation, upwards of 4 million Nm³/day was withdrawn from the storage facilities. This means that the commercial storage customers were very close to having spent all their stored gas, after which the storage facilities would only contain Energinet.dk's emergency-storage volumes.



Storage customers' gas stocks at the beginning of May 2013 (Nm³).

Maintaining the crisis level

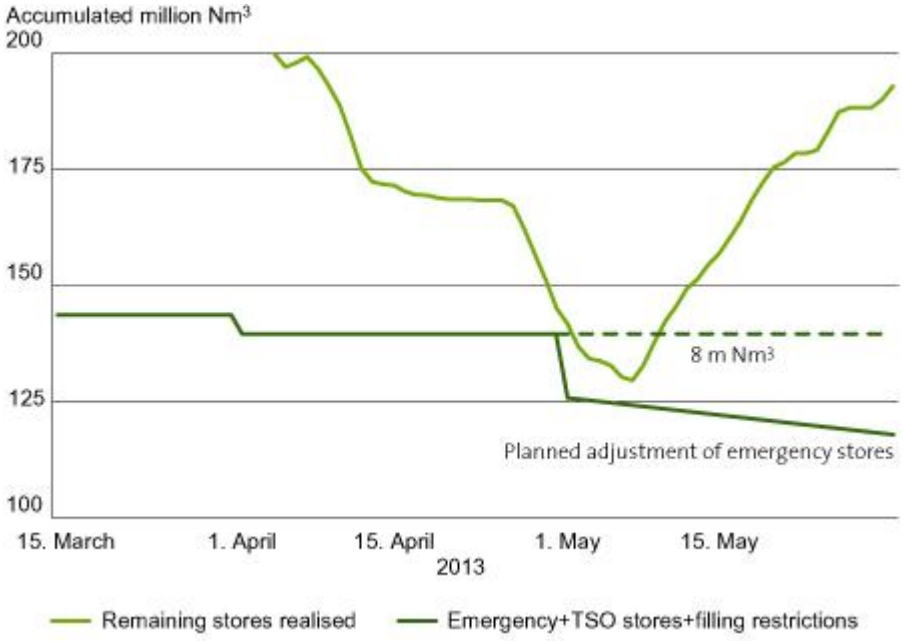
In the period 9-12 May 2013, supplies to Denmark were stable again, and gas was injected into the storage facilities.

Energinet.dk decided to maintain the Early Warning crisis level throughout the Ascension Day holidays until a sufficient volume of gas had been injected into the storage facilities by

the storage customers. On 13 May 2013, customers had more than 25 million Nm³ in the storage facilities, and Energinet.dk decided to call off the Early Warning crisis level.

Declaration of emergency avoided due to emergency gas
Energinet.dk's planned reduction of the stored emergency gas was the main reason why the Emergency crisis level could be avoided. If Energinet.dk had not planned a reduction of the emergency-storage volume on 1 May, the stocks would have fallen 8 million Nm³ below the emergency-storage requirement.

It should be emphasised that the adjustment of the emergency-storage volume was planned and therefore took place independently of the ongoing operating situation.



Storage situation at the end of the second Early Warning.

Facts

- A REMIT message is a message to the market about conditions that may affect the price of gas on the wholesale market. The REMIT regulation means that market players may only react to such information when the entire market has received the same information.
- Incentive payment for imbalances means that Energinet.dk may purchase or sell surplus gas at an incentive-based price.

1.2 Gas market 2013

Trading patterns changed in 2013. At the same time, the sum of shippers increased – but without impacting the number of active customers in the market.

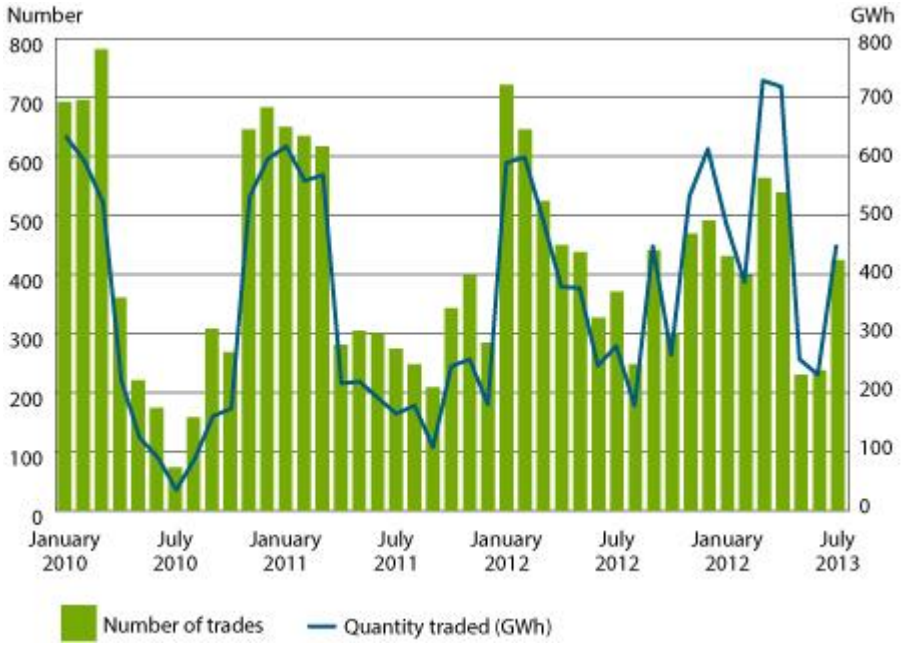
The number of shippers registered with Energinet.dk continues to increase. Energinet.dk now has more than 30 registered customers. However, only a little more than half of the registered customers are active in the market.

It is expected that several of the newly registered customers will become active within the next year. It is therefore possible that a kind of milestone can be reached within a foreseeable future where there will be more than 20 active shippers in the Danish gas market.

Trade on the gas exchange continues to grow

2012 saw an increase in both trades and volumes on Gaspoint Nordic (formerly Nord Pool Gas), such that the traded volume corresponded to approximately 17% of gas consumption in Denmark, up 7 percentage points on the previous years.

At the present time, it seems that the record will be beaten once again in 2013. Sales of gas up to and including mid-August 2013 were thus at a level corresponding to more than 21% of the total Danish gas consumption during the same period. Until mid-August, a total of approximately 5 billion kWh was traded in 2013 compared to approximately 6.3 billion kWh in 2012 as a whole.



Number of trades and volumes traded on Gaspoint Nordic per month since January 2010.

Day-ahead trade still accounts for the great majority of the total trade on Gaspoint Nordic.

Surprising fall in the use of the Gas Transfer Facility

Every year since its introduction in 2004, the Gas Transfer Facility (GTF) has set a new record for the gas volume traded and transferred at the point. 2012 was thus the first time that the volume traded at GTF exceeded the volume consumed in Denmark.

In the first half of 2013, however, there was a significant shift in the customers' use of GTF. It can be seen that the volume traded at the GTF in the first six months of the year only corresponds to around 66% of consumption in Denmark. It is the first time since the GTF was introduced that the traded volume has decreased.

In other words, there has been a relatively large shift in shippers' trading behaviour in a short period of time. The decline may be due both to shippers trading with each other at other points and to the fact that there are shippers that trade their gas earlier in the value chain, thereby bypassing the GTF. A possible third explanation is that more shippers obtain their gas via Gaspoint Nordic instead of via the GTF.

Facts

- Gas Transfer Facility (GTF)
  - GTF was the first virtual point in the gas system.
  - The point was introduced in late 2004.
  - In 2006, less than 10% of total Danish consumption was traded on the GTF. In 2012, the figure was more than 100% of the total Danish consumption.
  - In 2013, there was a fall in volumes traded for the first time since the point's introduction.
  - The point works such that two shippers have a bilateral agreement on supply at the GTF. The supply itself takes place via nominations of volumes from one shipper to another.

- Gaspoint Nordic
  - Gaspoint Nordic is the Danish gas exchange.
  - Gaspoint Nordic was introduced in March 2008 under the name Nord Pool Gas.
  - In summer 2013, the gas exhange changed its name from Nord Pool Gas to Gaspoint Nordic.
  - Gaspoint Nordic is wholly owned by Energinet.dk, but is operated as an independent enterprise.
  - In 2009, less than 3% of total Danish consumption was traded on Gaspoint Nordic.
  - In 2013, it is expected that more than 20% of total Danish consumption will be traded on Gaspoint Nordic.
  - Trading takes place via a 'continuous trade', whereby the total volume traded on a given day consists of a large number of smaller trades between anonymous shippers.

1.2.1 Challenges for the gas market in 2013

The commercial market was crucial in securing the supply of gas during the two Early Warning incidents in spring. The incidents showed that the Ellund-Egtved expansion is vital.

When Energinet.dk declared an Early Warning for the first time in mid-March 2013, it was a signal to the players that the gas storage facilities risked being emptied if the cold weather continued and gas supplies from other sources were not increased. There was a need for receiving more gas from the Nybro and Ellund entry points than was the case up to the declaration.

A common feature of both entry points was that the degree of utilisation was lower than expected. This was surprising because the spot price of gas in Denmark was approximately EUR 5 higher per MWh than on the exchanges in Germany and the Netherlands in the week leading up to the declaration. In other words, it was worthwhile for shippers to bring gas to Denmark.

Record prices – increased gas volume

On 18 March 2013, Energinet.dk declared an Early Warning. Both up to and during the Early Warning situation, Energinet.dk encouraged shippers to fully use the capacity at Ellund and to sell unused capacity to other shippers. This increased the flow at Ellund to some extent, but there was also capacity that was not used in the Early Warning period.

Both up to and particularly after the declaration, the spot price of gas rose, and Gaspoint Nordic (then Nord Pool Gas) saw record gas prices in Denmark several days running. The market situation culminated on 22 March 2013 when the gas price in Denmark rose to almost EUR 80 per MWh, which was more than double the price in Germany and the Netherlands. On the same day, there was a significantly higher flow from the North Sea, which continued in the following days.

The North Sea fields are connected to both the Danish and the Dutch market, and together the two markets take 100% of production. During the first Early Warning incident, the increased flow did not reflect increased production, but the fact that a smaller part of the

gas than normal went to the Netherlands. However, this did not happen until there were marked price differences between the Netherlands and Denmark.

The increased gas volume and the higher temperatures meant that Energinet.dk was able to call off the early-warning level on 27 March 2013.

Early warning 2

After the first early-warning incident, storage filling was still low, and the market continued to withdraw gas, but not to a critical degree. The lack of storage filling did, however, make the market vulnerable, and, during the weekend 27-28 April 2013, the North Sea plant was hit by a sudden need for corrective maintenance, which meant that the production initially had to be shut down for a week.

In light of these events, Energinet.dk declared Early Warning on 29 April 2013 for the second time.

Unlike the first event, there was no access to gas from the North Sea during the second Early Warning situation. In that way, the Ellund point was more critical than during the first Early Warning incident as a sufficiently high flow together with the remaining storage volume could ensure enough gas to maintain the balance, until the North Sea was up and running again.

To ensure that as much gas as possible was supplied from Germany to Denmark, Energinet.dk bought back capacity from the shippers that did not want to use it. The capacity was sold on to other shippers willing to send more gas up north. Another market mechanism was to sell a half-daily product based on the capacity that was not utilised on the day in question. Both market mechanisms ensured larger volumes to the Danish market.

Facts

- Both Early Warning periods were solved without the use of the physical or commercial tools available in the security-of-supply model.
- However, some mechanisms from Rules for Gas Transport were used which had never been used before, but which ensured a higher flow of gas from Germany to Denmark.

1.2.2 Gas market development 2013

With the opening of the PRISMA capacity platform, Energinet.dk and 23 other European TSOs took a giant step in the development of the single gas market.

1 April 2013 became a landmark date for the gas market development in Denmark and Europe as a large number of countries began to sell their capacity across border points via the PRISMA capacity platform. Several countries are expected to follow.

The PRISMA platform is 24 TSOs' answer to the question of where and how the harmonisation of the European gas market should take place. The 24 TSOs are domiciled in seven countries, and Energinet.dk has been involved in the project from the outset, thereby meeting most of the requirements in the first network code for capacity allocation (CAM NC). Furthermore, it happened almost two years ahead of the implementation requirement.

Apart from Denmark, Germany, the Netherlands, Belgium, France, Italy and Austria have joined the project at the present time. The 24 TSOs have a total of 78 points on the platform, where over 45,000 auctions are expected to be completed in 2013 alone. Nearly 300 shippers have registered with approximately 800 users in total.

Pia Hammerum, Head of Market Development and Jeppe Danø, Market Director in the Gasdivision. Photo: Steven Hofman.

Energinet.dk on PRISMA

The great majority of the shippers in Denmark have already registered. Energinet.dk has two points on PRIMA – Ellund and Dragør. Here, shippers have been able to purchase capacity via daily auctions since the beginning of April 2013. The first monthly auction was also held in April 2013 – for capacity in May 2013, and, in May 2013, the first annual auctions for the gas year 2013/2014 took place.

Before PRISMA was launched, Energinet.dk sold daily capacity on a first come, first served basis and saw several periods when numerous shippers struggled to get to capacity from Germany to Denmark first. This was also the case during the first Early Warning period at the end of March 2013.

With the launch of PRISMA, capacity is allocated according to an auction mechanism where capacity will be distributed according to the willingness to pay – and not according to who can type faster. On most days, there have been no excess demand for capacity, but there have been days when capacity was sold at more than the basic price.

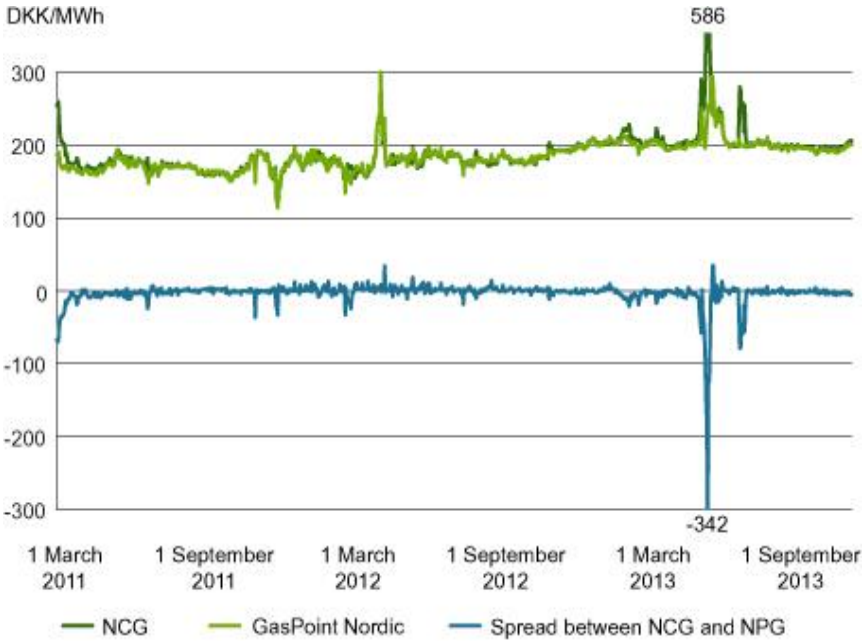
Thorough review of prices

Over the next few years, the Danish Energy Regulatory Authority will conduct a thorough review of the product composition, ie prices and advance distribution of yearly, quarterly, monthly and daily products.

The price relationships between the capacity product types have been relatively constant since 2007 whereas the market's use of short and flexible capacity products has grown.

Development in prices on Gaspoint Nordic

On most days, gas prices in Denmark are equal to gas prices in Germany/the Netherlands plus a small extra payment due to the transport costs at the border point. This means that gas prices in Denmark rise and fall in the same way as they do south of the border. The price difference is typically less than DKK 4/MWh.



The price development on Gaspoint Nordic compared with the price development on Netconnect Germany (NCG).

The trend is clearly visible in the graph where the upper part shows the spot price of gas on Gaspoint Nordic and on the most liquid German gas exchange (Netconnect Germany, NCG).

The bottom part of the graph shows the price difference, also called the spread, between the Danish and the German daily price of gas.

It also shows that there are times when the prices differ. The fluctuations indicate when the capacity between Germany and Denmark was fully utilised, ie the times of congestion at the border point.

In other words, the pricing on Gaspoint Nordic followed the same pattern in 2013 as in previous years. It also appears from the prices that Energinet.dk declared Early Warning in March and April 2013.

Balance system to change in 2014

Energinet.dk's next big challenge is the work to establish common network codes in the commercial market. The rules are close to being accepted by the member states, and implementation must be completed in a short time frame. Energinet.dk expects that most of the rules will be implemented in Rules for Gas Transport in October 2014.

The rules on balancing will entail the biggest changes in the balance system since the market liberalisation. For the shippers, the network code will result in less flexibility as to the allowed imbalance and more surveillance of the player's own balances and the system's balances. On the other hand, the customers will also receive data on their position more frequently, and the price of an imbalance will be lower.

However, the first step was taken as early as October 2013 when the distribution companies began to disclose data for the largest customers' consumption twice during the gas day. This reduced some of the uncertainty felt by the shippers.

Facts

- Energinet.dk has had a fixed product range since 2004: Year, month, week and day. This product range was changed on 1 October 2012 to become: Year, quarter, month and day.
- The change was necessary in order to match the European product range. In future, multi-year products and within-day products will also be introduced.
- With PRISMA, there were also changes to when and how the products are offered and sold in a large number of European countries. Seven countries have now come a long way in implementing the first network code for capacity allocation, the so-called CAM NC.
- Network codes are network rules for the provision and management of effective and transparent access to the transmission network across national borders.

2. What is happening in 2013-2014?

Security of supply and the European gas market strengthened with a new gas pipeline between Egtved and Ellund.

'Today, we are not only building a bridge to the European gas market, but also to a greener future,' said the Danish Minister for Climate, Energy and Building Martin Lidegaard in his speech at the inauguration of a new compressor station at Egtved and an expanded gas pipeline to Ellund just south of the Danish/German border.

The purpose of the 94 km long gas pipeline is to help ensure stable supplies to 400,000 Danish gas customers as the North Sea production declines.

Denmark now has a 'motorway' to the extensive gas network in Europe and can receive larger volumes of gas not just from Germany, but also from Norway, Russia and a number of other countries.

'This means improved security of supply for us, but it will also benefit competition and ensure the best prices for consumers as the gas will be obtained from the source which is cheapest at any given time,' says Nina Vendelboe, Project Manager of the new gas pipeline.

Project leader, Nina Vendelboe in front of the compressor station in Egtved, Foto: Medvind/Bent Sørensen.

Prevents supply crises

The European heads of government will expand the single market to also include gas and aims for gas to be traded freely across EU borders by 2014. However, the market coupling of the national markets also helps the countries to better support each other in emergency supply situations.

This is important, not least in light of the two early-warning incidents in spring when the Danish gas supply was threatened by failing supplies from the North Sea, low stocks and cold weather. During this crisis, Germany sent gas through the existing pipeline at full capacity. But with an interruptible capacity of 200,000 cubic metres per hour it was not sufficient to ensure both Denmark and Sweden's supply.

'The gas motorway can now transport a total of 700,000 cubic metres per hour, which is a great deal more than previously,' says Nina Vendelboe.

The transmission network capacity towards the south is now so large that it can cover the entire future need for imported gas once the Germans finish the pipeline on their side of the border.

Quality on time

The new compressor station at Egtved, which is a hub in the Danish gas transmission network, is the first onshore compressor station in Denmark and is made up of four compressor units.

Aarsleff Streicher Bunte has designed and built the compressor station, whereas the Dutch contractor Visser & Smit Hanab and sub-contractors have constructed the gas pipeline.

And although the construction project is of a considerable size, the process has been very efficient with 6,000 underground gas pipes laid in less than a year. Each pipe section is 17 metres long with a diameter of 76 cm and weighs approximately four tonnes. The pipes were welded together on site and laid in a trench or drilled under major roads, railways or large watercourses. All in all, around 1 million working hours have been invested in the project without a single serious accident.

Ellund-Egtved pipeline, Photo: Medvind/Bent Sørensen.

The project manager is very happy with the result of the efforts.

'We got exactly the high quality we asked for, on time and on budget. Such good craftsmanship will last for many, many years,' she says.

Important element in the green transition

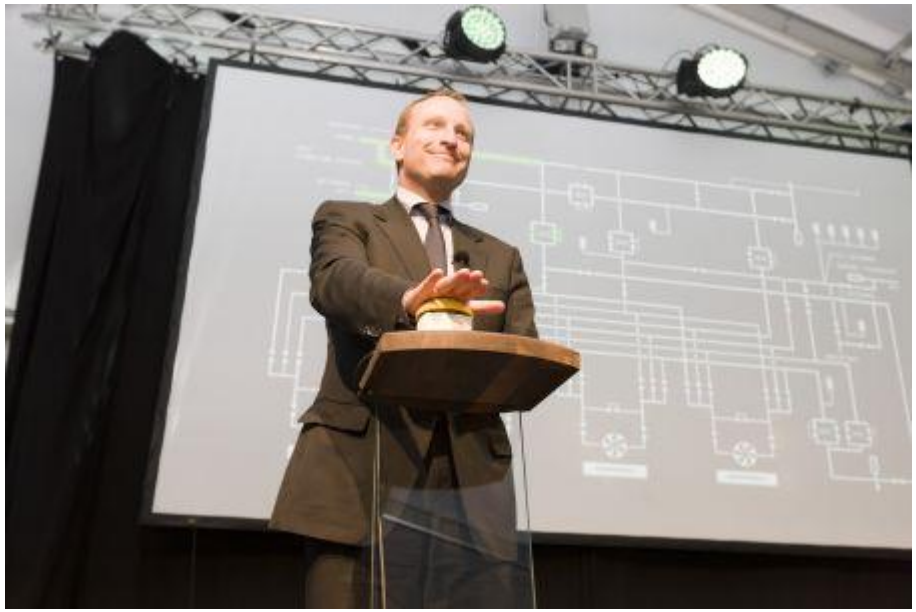
And it is important that the compressor and pipeline can continue operating for many years to come as gas will also be playing a key role in the future transition to green energy. Green energy is predominantly weather-dependent, so a more stable supplement is needed for non-windy conditions.

'We need to remember that the pipeline and the compressor station can also take biogas, which we are working hard to incorporate into the Danish transmission network,' explains Nina Vendelboe.

The compressor station raises the pressure in the gas system to a level which ensures that the gas can be transported in several directions, including to the east – across the country and to Sweden. The Egtved location was chosen over a location closer to the German border to achieve a degree of flexibility that will allow gas to be received and pumped in different directions. That makes it possible to control the pressure in all Energinet.dk's gas pipelines from all over the country instead of being limited to the pipeline from Germany.

The project cost DKK 1.7 billion. The European Energy Programme for Recovery has contributed EUR 100 million, or approximately half, while Energinet.dk has paid the rest.

The new gas pipeline and compressor station at Egtved were inaugurated on Monday 30 September with the push of a button, speeches and entertainment. More than 240 guests attended, including the Danish Minister for Climate, Energy and Building Martin Lidegaard, the EU's Director General for Energy Philip Lowe, but also neighbours, landowners and business partners.



Minister for Climate, Energy and Building, Martin Lidegaard inaugurates compressor station in Egtved as well as the new gas pipeline to Germany by pushing the yellow button. Photos: Medvind/Bent Sørensen.

Facts

- The new gas motorway can transport 700,000 Nm³ per hour.
- The pipeline system was constructed using approximately 6,000 gas-pipe sections.
- Each pipe section is 17 metres long with a diameter of 76 cm and weighs approximately three tonnes.
- The pipe sections were welded together on site and laid in a trench.
- Under major roads, railways and watercourses, the pipeline was rammed or drilled in place.
- The Ellund-Egtved project with the compressor station and the gas pipeline was completed using around 1 million working hours and without any serious accidents.

2.1 Increased capacity towards Germany

First step towards extended connection to the German gas system taken with the expansion towards Germany, but the supply situation is still strained.

The first step towards an improved supply situation was taken when the red ribbon at the new compressor station at Egtved was cut on 30 September 2013. The winter 2013-2014 will thus be the first winter when the new gas pipeline in Southern Jutland and the new compressor station can supply more natural gas to Danish and Swedish consumers. The expansion cannot, however, be fully utilised until after 2015 when the expansion of the North German system is commissioned.

New pipelines from Ellund to Egtved

After the inauguration of the new compressor station, the North Sea production is increasingly supplemented by gas from Germany, making it necessary to maintain a sufficiently high pressure in the Danish part of the gas system. The compressor station is located in the centre of the transmission system, and, in future, Energinet.dk can distribute gas and pressure more flexibly towards the north, south, east and west from Egtved.

With the need for increasing volumes of gas supplied from Germany to Denmark, the existing pipeline from Ellund to Egtved was insufficient, which is why Energinet.dk decided to build a new 94 km pipeline parallel to the existing pipeline.

Improved security of supply

The expansion of the natural gas network increases the gas transmission network capacity, enabling Denmark to import natural gas when the production of natural gas in the Danish part of the North Sea starts to decline.

The expansion also helps to increase the security of supply as it ensures that multiple sources and suppliers can supply gas to Denmark. In addition, competition in the gas market is strengthened to the benefit of Danish consumers.

Improved market integration

As the physical capacity between Denmark and Germany is increased, the Danish gas market is also closer integrated with the north-western European gas market. Among other things, this means that the prices will be closer aligned to the north-western European prices.

Facts

- Security of supply in the Danish gas system is traditionally very high. One of the reasons for this is that the system is generally robust and very flexible, and contingencies are in place to handle major incidents such as serious breakdowns in the technical systems.
- The Ellund-Egtved expansion is designed to receive 700,000 Nm³/hour from Germany. For a start, there is an interruptible capacity of 310,000 Nm³/hour from Germany, which is expected to be increased to about 450,000 Nm³ firm capacity on 1 October 2015.

2.2 Winter Outlook 2013-2014

Energinet.dk's calculations of the emergency-supply requirement for the coming winter are based on a temperature of -13°C.

Energinet.dk calculates both offtake in Denmark (exit zone) and in transit and the supplies from the North Sea, from Germany and from storage facilities based on a winter's day with a temperature of -13°C. The calculations for the winter 2013-14 are shown in this figure:

- **Total transport:** Total net transport has been estimated at 30.6 million Nm³/day.
- **Exit Denmark:** Consumption in Denmark is 22.7 million Nm³/day. For the exit zone, the offtake corresponds to Energinet.dk's expectations at a daily mean temperature of -13°C.
- **Ellund:** Ellund has net imports of 2.4 million Nm³/day corresponding to 100,000 Nm³/hour.
- **Dragør:** Dragør has net exports of 7.9 million Nm³/day, corresponding to 329,000 Nm³/hour.
- **Storage facilities:** Total withdrawal of gas from the storage facilities is estimated at 17.5 million Nm³/day, with 9.5 million Nm³/day coming from Stenlille and 8.0 million Nm³/day from Lille Torup. The distribution of withdrawals is optimised to achieve the highest possible network pressure.
- **Nybro:** Supplies at Nybro are estimated at 10.7 million Nm³/day.

Facts

- Winter is the time when consumption is at its highest. EU legislation therefore requires all TSOs to prepare a forecast for supply in the coming winter. This is called the winter outlook.
- ENTSOG (European Network of Transmission System Operators for Gas) publishes an overall annual winter outlook based on the reports from each TSO, including reports from Energinet.dk.

2.3 Capacity orders 2013-2014

With the common capacity platform PRISMA, capacity is now sold in the same way and at the same time as in many other European countries.

In order to transport gas in the system, shippers must order system capacity. Capacity orders therefore show how much gas shippers expect to need to transport hour by hour through the Danish gas system in the coming year.

A large number of TSOs, including Energinet.dk, have joined the PRISMA capacity platform, which was used for the first time on 1 April 2013. Via PRISMA, capacity at Ellund and Dragør will therefore only be offered via auctions, which run at completely fixed times at all the participating TSOs.

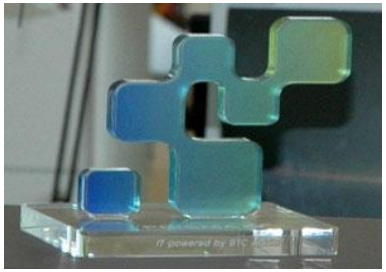


Photo: Steven Hofman.

In this way, annual and quarterly capacity is offered via auction prior to the start of the gas year, whereas the monthly auctions are held in the month before the current month. The daily capacity is put to auction the day before the gas day on which the capacity is to be used.

Ellund entry roughly on a par with last year

At the Ellund entry point, where firm capacity has been available since 1 October 2013, almost 1.7 million kWh/h of the available 7.7 million kWh/h was sold, corresponding roughly to the same level as the previous year. The total capacity at Ellund was increased considerably for the coming gas year when the Ellund-Egtved expansion was commissioned.

Part of the volume sold is made up of the first long Open Season contracts, which will come into play in the next 10 years. This year, however, the volume is small (about 0.4 million kWh/h), but the Open Season contracts will gradually make up a larger share of the total contracts in the coming years.

Southbound capacity not sold out

In the opposite direction (Ellund exit), a slightly larger capacity than the year before has been sold (approx. 0.9 million kWh/h). This may indicate that there will still be transit volumes that will go from Denmark to Germany. Historically, however, the level is much lower than previously, and capacity is far from sold out in the southbound direction.

Towards Sweden, most of the firm capacity offered for sale was sold as yearly products, (approx. 2.6 million kWh/h), which was also the case the year before. However, Energinet.dk has set aside 10% of the total firm capacity for later sale as daily products.

Nybro has changed its order calendar

Capacity at Nybro continues to be sold on a first come, first served basis. However, this principle has been changed from last year, meaning that Energinet.dk opens for capacity purchases at the same time as on PRISMA. The purchase window does not close until the day before the start of the gas year in order to take account of the great uncertainty about the North Sea production.

For the gas year 2013, the volume of capacity ordered via annual booking is bigger than for the gas year 2012. Thus, up to 1 October, the capacity ordered amounted to approx. 6 million kWh/h as compared to approx. 4 million kWh/h the previous gas year.

Exit zone and BNG entry unchanged

The booking principle remains the same as before at the exit zone and BNG entry, ie a flexible first come, first served principle whereby yearly products can be purchased month by month. As most contracts run from 1 January, capacity has not yet been ordered very far into the future. The situation for the new gas year is therefore not yet known.

Facts

- PRISMA is a cooperation between seven countries with a total of 24 TSOs on establishing a joint European capacity platform. The capacities are offered on PRISMA in the same way and at the same times for all participating TSOs. More and more countries are expected to join the project, so PRISMA may in future be the platform for all capacity sales across the border points in the whole of Europe.
- Open Season is a two-phase tender procedure allowing market players to submit bids for long-term transport contracts concerning newly established transmission capacity. Energinet.dk undertakes to establish the capacity if demand is sufficiently high.

2.4 Emergency supply options

The Early Warning incidents in spring nearly developed into emergency situations. The gas market caught the signals, and the situations were prevented.

Generally, the market itself is responsible for maintaining the security of supply of the Danish gas system. Energinet.dk will not take over the obligation to supply the market until the system is declared in a state of emergency. This is the situation shown in red in the figure below.

An incident must be very serious before leading to an emergency situation in the gas system. Serious breakdowns in the technical systems, such as the rupture of an offshore pipeline, interruptions in the gas storage facilities, or if the production of natural gas on the Tyra platform is interrupted, could affect the gas system to the extent that Energinet.dk may have to declare an emergency.

The model shows how an emergency situation may develop.

In such cases, Energinet.dk may use its emergency storage facility and begin the procedure of disconnecting non-protected consumers.

In an emergency situation

In the special situation where there is damage to the offshore pipeline from Tyra to Nybro, Energinet.dk has until now had an agreement with selected operators in the North Sea to redirect the flow from the Tyra platform via the Harald platform through the Syd-Arne pipeline. No such agreement has been concluded for 2013/2014 due to maintenance work in the North Sea.

In the hours immediately after Energinet.dk declares Alert, interrupting the commercially interruptible consumers in Denmark and reducing supplies to Sweden may relieve the

pressure on the system. Subsequently, the non-protected consumers may be disconnected, if necessary, by declaring Emergency.

Protected and non-protected consumers

All household customers are protected consumers. To offer gas consumers the best possible protection, the Danish Energy Agency has also decided to classify small and medium-sized enterprises, district heating systems, schools and hospitals as protected consumers.

Which consumers are protected is determined by the 'cubic metre limit' determined and published each year by the Danish Energy Agency on the basis of a recommendation from Energinet.dk. In 2013/2014, the limit is 4.7 million Nm^3. In practice, this means that all industrial enterprises with an annual gas consumption of less than 4.7 million Nm^3 and most gas-fired CHP plants will be protected. In comparison, the figure was 2 million Nm^3 last year.

Each year, Energinet.dk is responsible for identifying, based on the Danish Energy Agency's executive order, which customers will be non-protected in the coming year.

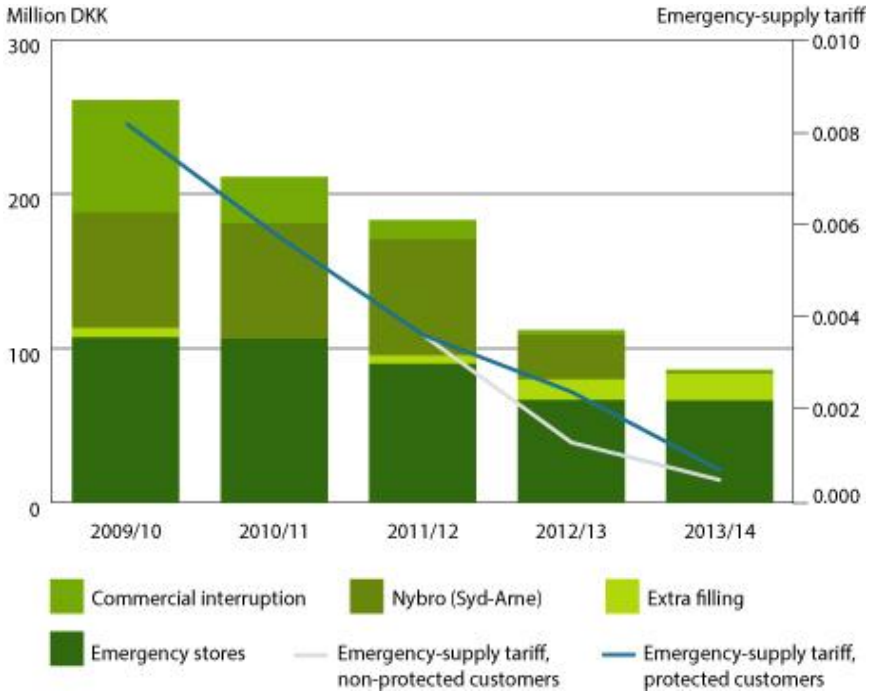
Energinet.dk does not currently expect any change in the cubic metre limit for the gas year 2014/2015.

Change in the concept of commercial interruptibility

In 2013, Energinet.dk adjusted the concept of commercial interruptibility based on the two Early Warning incidents.

Energinet.dk holds an annual auction of commercial interruptibility, where Energinet.dk purchases the right to interrupt large consumers' gas supply in cases where the supply situation is under pressure, thereby reducing the demand in the gas system.

The adjustment of the concept relates to a change in the K1 value, in the pricing and the registration fee. The K1 value is the maximum daily offtake (one or several days), which is based on consumption for the past two years in all months of the year, ie a K1 value for each month.



Costs of purchasing emergency supply services and tariffs for protected and non-protected customers.

2.5 Distribution and dimensioning

Each year, Energinet.dk and the gas distribution companies compare their forecasts for M/R station capacity.

In 2008, Energinet.dk performed a number of in-depth analyses of the correlation between temperature and gas consumption for each M/R station in the transmission system. The purpose was to uncover any system congestion. These analyses are deemed to also cover Gas in Denmark 2014.

When evaluating consumption, especially at very low daily mean temperatures, the simultaneity of various types of consumption must be taken into account to ensure that the capacity requirements for the M/R stations stay realistic.

The assessment of offtake at very low temperatures is hampered by the fact that no relevant metered data are available for daily mean temperatures lower than approximately -7°C. Furthermore, ring connections render the assessment of the individual M/R stations difficult.

Facts

- The distribution companies have expectations for M/R station capacity. These are compared to Energinet.dk's expected and measured gas offtake for the previous year.
- Potential changes in capacity requirements are identified during the annual review.

2.5.1 Capacity of the distribution companies

The development in gas consumption and the consequences of changes in the gas quality are continuously analysed by Energinet.dk. These data are for the winter 2013-2014.

Naturgas Fyn Distribution

The M/R stations supplying Naturgas Fyn Distribution A/S are assessed to have sufficient capacity to cover the supply requirement for the 2013-2014 winter.

Naturgas Fyn's expected capacity requirement in the Capacity of stations connected to Naturgas Fyn's system table has been calculated for the distribution company based on historical data and a review of customers' capacities. Naturgas Fyn then adjusted the figures taking into account the simultaneity of various types of consumption.

DONG Gas Distribution

Overall, Energinet.dk's M/R stations are assessed to have sufficient capacity to meet DONG Gas Distribution's requirements for the coming winter 2013/2014.

Where the Frøslev and Terkelsbøl stations are concerned, the relationship between the capacity limit, the maximum metered offtake and the peak-hour expectation is, however, of such a nature that a minor capacity increase has been planned for late October 2013.

In 2013, DONG Gas Distribution discussed the connection options for a number of biogas projects and submitted a fixed-price quote for four projects so far.

The optimum point of connection to the distribution network or the transmission grid has been determined for each project. The point of connection is determined based on a financial assessment of the total costs of the connection and the subsequent operating costs.

HMN Naturgas

The M/R stations and distribution systems in HMN Naturgas' licence area are assessed to have sufficient capacity for the winter 2013/2014.

The capacities stated in the table Station Capacities Adjacent to HMN Naturgas indicate the enterprise's forecast for 2013-2014. The development in gas consumption and the consequences of changes in the gas quality are analysed on an ongoing basis.

In 2014, HMN Naturgas expects to receive the first upgraded biogas from biogas plants where biogas production is based on livestock manure and energy crops.

This will only marginally impact the capacities at Energinet.dk's M/R stations. From 2014 to 2015, it is expected that an upgraded-biogas capacity corresponding to 6-8,000 Nm³/hour natural gas will be connected.

HOFOR

Insufficient gas supplies to HOFOR's city-gas system could have serious economic consequences as it would be very difficult to restore the supply.

In 2010, Energinet.dk established a new remote-controlled valve at Torslunde M/R station to help send gas from Stenlille direct into the Lynge pipeline if the main transmission pipeline between Torslunde and Dragør breaks down. In addition, HOFOR decided in 2012 to establish a new city-gas production plant in Mørkhøj, which will be commissioned in 2014.

HOFOR works with Lynettefællesskabet I/S on supplying biogas to the city-gas network. The plant opened on 23 October 2013 and is expected to deliver approximately 1,000 Nm³/hour.

2.5.1.1 Capacity of stations connected to Naturgas Fyn

Station capacities are listed in the table below, which also shows the expected offtakes during the peak day and average peak hour. Please note that the station capacities shown are based on the inlet and outlet pressures stated in the table.

There are a few examples in the table below where measured peak hour exceeds station capacity. This is because the station inlet pressure is calculated conservatively at a temperature of -13° C whereas the inlet pressure during the measured peak hour is higher. Hence station capacity during the measured peak hour is correspondingly higher than indicated in the table.

Utilisation of M/R stations in 2011 and 2012

The maximum capacity utilisation for each M/R station during the 2011/2012 and 2012/2013 winters is shown in the table on the right, which contains the results for both maximum daily volume and maximum flow of gas in one hour. The date and the hour of maximum flow does not necessarily coincide.

		Period: 01-05-2012 - 30-04-2013		Period: 01-05-2011 - 30-04-2012	
		Daily volume	Max hour	Daily volume	Max hour
	M/R-Station	Nm³/day	Nm³/hour	Nm³/day	Nm³/hour
551	Middelfart	99,499	5,075	95,684	4,793
553	Billesbølle	91,265	6,115	109,367	5,530
554	Koelbjerg	444,544	25,940	498,860	28,896
557	Højby	531,663	28,679	649,010	34,911
559	Ullerslev	78,686	4,571	96,997	6,024
560	Nyborg	35,712	2,052	53,549	2,893

The figure shows the registered peak day and peak hour consumption at individual M/R stations between 1 May 2011 and 30 April 2012 and between 1 May 2012 and 30 April 2013.

Capacities at given inlet and outlet pressures	Expected offtake during a peak day (-13° C)	Expected offtake during an average peak hour (-13° C)	Calculated inlet pressure	Agreed set point	M/R-station calculated capacity (-13° C)	Expected capacity requirements of distribution companies	Measured peak hour 01-05-2011 to 04-30-2012
	Nm³/day	Nm³/hour	Barg	Barg	Nm³/hour	Nm³/hour	Nm³/hour
Naturgas Fyn	1,308,737						
551 Middelfart	81,985	4,180	65.2	17.1	9,927	6,000	5,075
553 Billesbølle	103,684	4,744	64.2	17.1	9,787	6,500	6,115
554 Koelbjerg	458,910	21,452	64.0	17.1	40,866	38,000	25,940
557 Højby	507,276	24,070	62.8	17.1	118,650	34,000	28,679
559 Ullerslev	108,838	5,217	62.4	17.1	9,503	7,500	4,571
560 Nyborg	48,043	2,327	62.0	17.1	9,450	4,000	2,052

The figure shows the expected offtake, calculated inlet and outlet pressure and capacities for M/R stations in the transmission system in normal supply situations at a daily mean temperature of -13° C. The distribution companies' expected capacity requirements are also specified.

2.5.1.2 Capacity of stations connected to DONG Gas Distribution

Station capacities are listed in the table on the next page, which also shows the expected offtakes during the peak day and average peak hour. Please note that the station capacities shown are based on the inlet and outlet pressures stated in the table.

There are a few examples in the table on the next page on the right where measured peak hour exceeds station capacity. This is because the station inlet pressure is calculated conservatively at a temperature of -13° C whereas the inlet pressure during the measured peak hour is higher. Hence station capacity during the measured peak hour is correspondingly higher than indicated in the table.

Utilisation of M/R stations in 2011 and 2012

The maximum capacity utilisation for each M/R station during the 2011/2012 and 2012/2013 winters is shown in the table on the right, which contains the results for both maximum daily volume and maximum flow of gas in one hour. The date and the hour of maximum flow does not necessarily coincide.

		Period: 01-05-2012 - 30-04-2013		Period: 01-05-2011 - 30-04-2012	
		Daily volume	Max hour	Daily volume	Max hour
	M/R-Station	Nm³/day	Nm³/hour	Nm³/day	Nm³/hour
663	Køge	561,168	35,804	526,613	27,009
664	Karlslunde	542,280	27,152	538,018	26,228
665	Torslunde	256,084	20,160	283,936	13,832
667	Vallensbæk	488,648	25,160	523,174	25,746
668	Brøndby	1,536,408	71,720	1,808,904	81,284
672	Dragør	186,052	9,832	206,177	9,725
682	Lynge	1,549,264	77,392	1,686,144	78,552
684	Måløv	1,344,160	65,024	1,395,668	63,188
464	Viborg	1,428,992	67,504	1,592,336	76,912
473	Haverslev	303,144	19,272	306,848	17,072
474	Ellidshøj	197,560	9,498	202,306	9,629
476	Aalborg	1,284,592	70,576	1,405,456	76,848
482	Brande	110,627	5,497	102,935	5,359
483	Herning	1,808,912	87,824	2,084,072	101,624
484	Karup	274,890	13,812	294,061	14,503
486	Ll. Torup M/R	59,914	3,406	66,243	3,491

The figure shows the registered peak day and peak hour consumption at individual M/R stations between 1 May 2011 and 30 April 2012 and between 1 May 2012 and 30 April 2013.

Capacities at given inlet and outlet pressures	Expected offtake during a peak day (-13° C)	Expected offtake during an average peak hour (-13° C)	Calculated inlet pressure	Agreed set point	M/R-station calculated capacity (-13° C)	Expected capacity requirements of distribution companies	Measured peak hour 01-05-2011 to 04-30-2012
Regi	Nm³/day	Nm³/hour	Barg	Barg	Nm³/hour	Nm³/hour	Nm³/hour
Hovedstaden	6,737,278						
663 Køge	490,489	22,399	59.8	17.9	39,420	40,000	35,804
664 Karlslunde	589,565	26,118	59.6	17.9	88,918	30,000	27,152
665 Torslunde	252,057	11,210	59.4	17.9	27,546	20,000	20,160
667 Vallensbæk	476,109	20,501	58.7	17.9	28,053	25,000	25,160
668 Brøndby	1,714,683	72,017	58.5	31.0	134,871	90,000	71,720
672 Dragør	204,629	8,898	57.7	16.6	23,039	12,000	9,832
682 Lynge	1,618,612	70,243	56.9	32.7	141,615	90,000	77,392
684 Måløv	1,391,133	58,012	57.3	17.9	106,000	70,000	65,024
Midt - Nord	5,819,986						
464 Viborg	1,498,096	65,423	69.2	35.4	91,894	100,000	67,504
473 Haverslev	278,663	14,410	69.7	35.4	26,073	34,000	19,272
474 Ellidshøj	188,161	8,363	68.2	35.4	10,740	12,000	9,498
476 Aalborg	1,412,074	65,013	67.0	44.3	155,699	90,000	70,576
482 Brande	94,184	5,154	65.2	35.4	10,664	6,000	5,497
483 Herning	1,995,565	88,083	66.0	47.4	154,280	120,000	87,824
484 Karup	289,298	13,283	67.8	35.4	17,001	18,000	13,812
486 Ll. Torup M/R	63,945	2,814	72.2	35.4	8,653	5,000	3,406

The figure shows the expected offtake, calculated inlet and outlet pressure and capacities for M/R stations in the transmission system in normal supply situations at a daily mean temperatu¬re of -13° C. The distribution companies' expected capacity requirements are also specified.

2.5.1.3 Capacity of stations connected to HMN Naturgas

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The figure shows the expected offtake, calculated inlet and outlet pressure and capacities for M/R stations in the transmission system in normal supply situations at a daily mean temperature of -13° C. The distribution companies' expected capacity requirements are also specified.

2.6 Gas quality during the coming winter

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.

The gas quality is measured at the metering stations at Nybro, Egtved, Dragør Border, Ellund, Lille Torup and Stenlille.

Variation in gas quality in 2012-2013

In 2012, the Danish market was supplied with Danish North Sea gas and European gas imported via Ellund.

In the period from 1 August 2012 to 1 August 2013, gas quality varied as follows:

- The Wobbe index for natural gas varied from 14.14 kWh/Nm³ to 15.36 kWh/Nm³, averaging at 5.11 kWh/Nm³.
- The relative density varied from 0.581 to 0.666.
- The upper calorific value varied between 10.83 kWh/Nm³ and 12.51 kWh/Nm³, averaging at 12.02 kWh/Nm³.

Gas quality 2013-2014

Gas quality in the coming winter is expected to be based on a combination of Danish North Sea gas and gas from Germany imported via Ellund.

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/Nm³ to 15.5 kWh/Nm³.
- 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 will be 14.5 kWh/Nm³, varying from 13.9 kWh/Nm³ to 15.5 kWh/Nm³.

What does the future hold?

Danish North Sea gas belongs to the group H of the second gas family and is characterised by a highly uniform composition and gas quality. Danish natural gas has always had a high Wobbe index compared to the gas in adjacent systems. This is due to the fact that Danish gas has a relatively high content of ethane, propane and butane, which are not extracted from the natural gas.

Following full expansion towards Germany, the natural gas will still belong to group H. This applies whether or not future supplies will come from Norway, Germany, the Netherlands or Russia, as LNG or as a mixture of this from Germany.

Bio-natural gas

Upgraded biogas (bio-natural gas) has similar combustion characteristics to natural gas and normally consists of a mixture of methane and CO_2. Bio-natural gas generally has a low calorific value and a Wobbe index which is at the lower end of the range permitted in the Danish Gas Regulation.

At the beginning of 2013, the Danish Safety Technology Authority updated the Gas Regulation with a new section (C12), which specifies the requirements for the gas quality of upgraded biogas that is to be fed into the gas system. This ensures that bio-natural gas can be used safely by consumers on an equal footing with natural gas.

Facts

- The gas must at all times comply with the quality requirements set out in Rules for Gas Transport.
- Gas distributed to Danish consumers must comply with the quality specifications set out in the Danish Safety Technology Authority's Gas Regulation.
- The Danish market is always supplied with gas complying with the requirements set out in Rules for Gas Transport and in the Gas Regulation.

3. Future challenges facing gas

Expansion towards Germany secures gas supply to Denmark until 2020.

Gas consumption and supplies 2014-2050

Natural gas supplies from the North Sea have been declining dramatically in recent years, but production is expected to increase again in 2015 and some years ahead. The gas comes from new fields, while supplies from existing fields are dwindling.

Combined with supplies from the North Sea, the expected expansion in Germany will secure the gas supply to Denmark and Sweden until 2020, as sufficient import capacity will be established to cover the expected demand.

After 2020, the expected demand in Denmark will be covered by supplies from the North Sea, by the increased import capacity and the green gases, which are expected to play a bigger role in the overall supply situation.

Gas supply situation 2014-2015

The supply situation is expected to be tight in the years 2014 and 2015. However, Energinet.dk expects that the existing increased options for physical supplies from Germany combined with supplies from the Danish storage facilities will be adequate to handle the strained supply situations for Denmark and Sweden that are to be expected during the period.

Tariffs

Transport tariffs have fallen during the period Energinet.dk has operated the transmission grid. In the slightly longer term, however, Energinet.dk expects the transport tariffs to rise, as the volume of gas transported will be lower.

Leading up to 2030, transmission system costs are expected to remain relatively constant. As the volumes decrease in the same period, this will result in increasing transport costs per Nm^3.

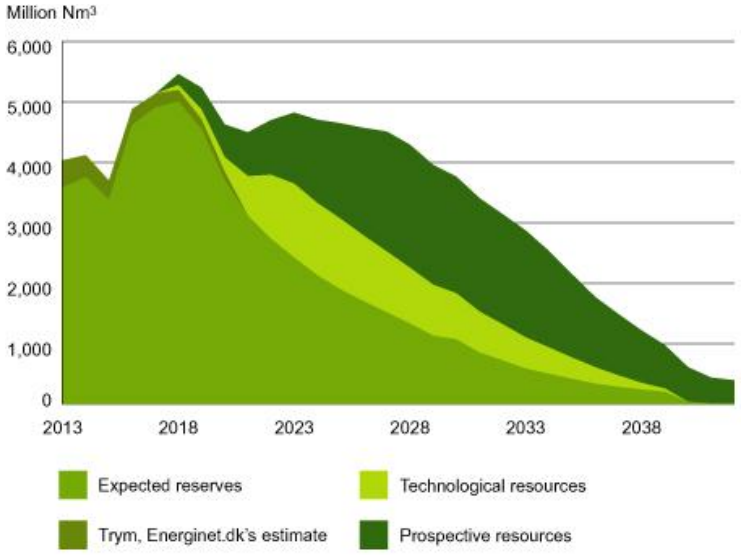
3.1 Gas consumption and supplies 2014-2050

Combined with natural gas supplies from the North Sea, the expansion towards Germany is expected to secure gas supplies to Denmark and Sweden until 2020.

Until 2010, Denmark was supplied gas from the North Sea only. The North Sea production peaked in 2005-2006.

In 2010, the first supplies from Trym, a small Norwegian gas field, were sent through the Danish offshore pipelines. Supplies from Trym are currently being used to supply the Danish, Swedish and Dutch gas markets.

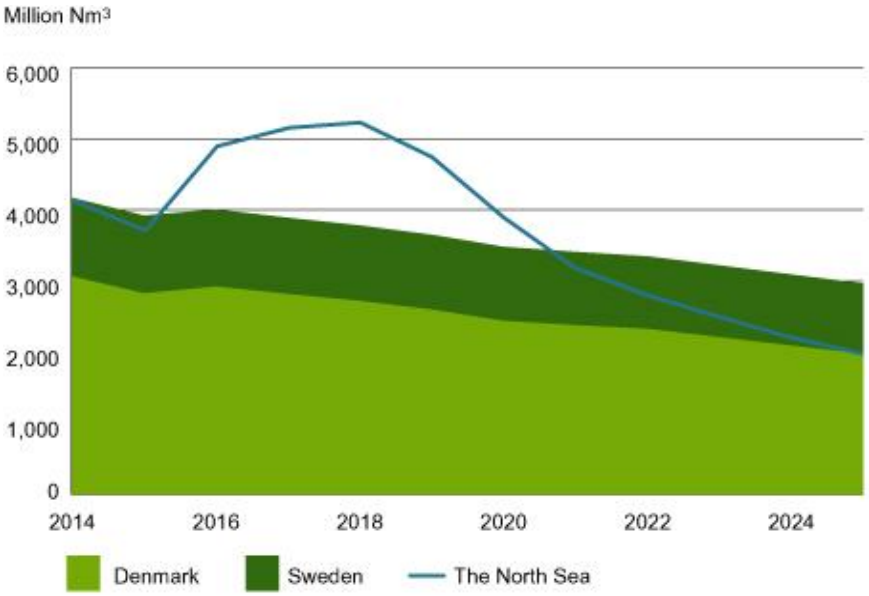
The Danish Energy Agency estimates that gas supplies from the North Sea will decline between 2018 and 2042. Based on the current knowledge of reserves, supplies are likely to be exhausted in 2040.



Gas supplies from the North Sea 2014-2042. Source: Danish Energy Agency and Energinet.dk 2013.

North Sea production and Danish and Swedish gas consumption

In 2014 and 2015, it is expected that there will be insufficient gas from the North Sea to supply the entire Danish and Swedish gas markets. These supplies therefore need to be supplemented with gas from Germany and the storage facilities.



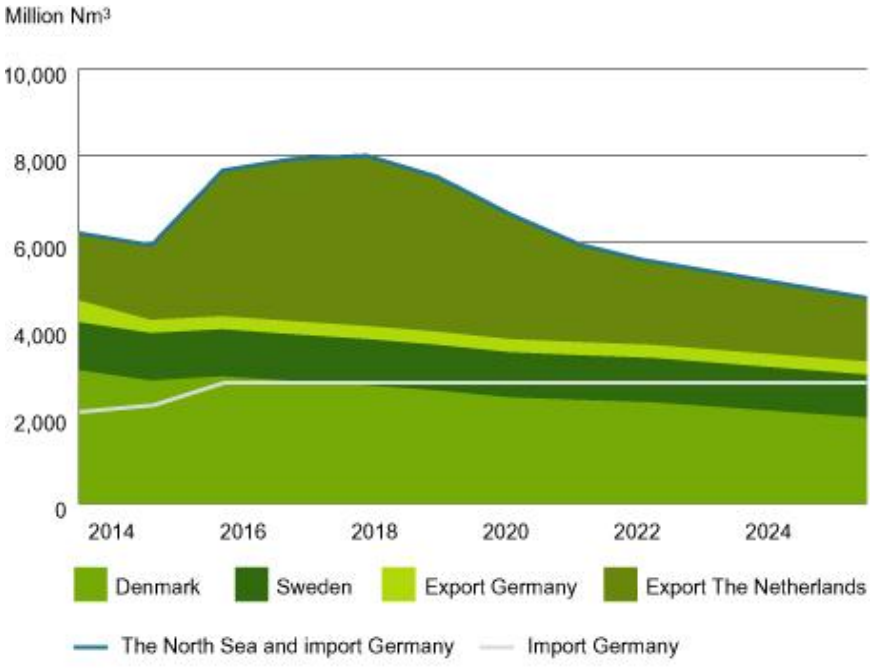
Danish and Swedish natural gas consumption and expected gas supplies from the North Sea 2014-2025. Source: Danish Energy Agency and Energinet.dk 2013.

There is much uncertainty about the extent to which production can be increased leveraging technological resources (new extraction technologies) and prospective resources (new fields). Energinet.dk therefore relies on the expected production profile and an estimate of supplies from the Norwegian Trym field as a conservative basis for estimating the supply situation.

Total supply situation 2014-2025

In 2013, Energinet.dk made a projection of gas consumption in Denmark and Sweden up to 2025. The Danish expansion towards Germany was completed in 2013. The supply picture assumes that the first phase of the expansion in Germany will be completed in 2014. It is further assumed that the Danish Hejre gas field will commence production in 2015.

In its projection, Energinet.dk also assumes that further expansion of the North German system has been completed by the end of 2015. In this way, the Danish and Swedish markets will be supplied from the North Sea and Germany at least until 2025. Energinet.dk's projection of gas consumption is shown in this figure.



Projection of gas production, supplies and consumption 2014-2025. Source: Danish Energy Agency and Energinet.dk 2013.

Facts

- From 1984 to 2010, Denmark was supplied with gas from the North Sea only.
- The supply picture is still strained in 2014-2015.
- The Danish Energy Agency expects the gas reserves in the North Sea to be exhausted before 2050. The existing concessions expire in 2042.

3.1.1 Gas storage capacity

The limited options for acquiring gas for the Danish and Swedish markets over the next few years entail that the key role played by the storage facilities in overall supply will be reinforced.

The Danish gas-storage facilities are an essential and integral part of the Danish gas system – in relation to the market, the capacity, the security of gas supply and the daily operation.

Most of the storage-facility volume of a total of approximately 1 billion Nm^3 is utilised by commercial players. This corresponds to just under one-third of the total Danish annual gas consumption.

Energinet.dk reserves storage capacity for use during long-term emergency supply situations. Energinet.dk also reserves the necessary withdrawal capacity for short-term emergency-supply incidents in extreme situations.

Greater importance of the storage facilities between 2014 and 2015

Until adequate capacity has been established on the German side of the border, the gas market has limited physical alternatives for acquiring gas for Danish and Swedish consumers during the next few years. This will lead to a continued major need for drawing on the existing storage facilities. Energinet.dk expects the storage need of the commercial players to total a minimum of 500 million Nm^3 in 2014.

It is important that shippers and storage customers carefully consider the need for flexibility in the coming years. Energinet.dk continuously gives the market the best possible information about the expected transport and storage needs in order for it to secure supplies to its customers.

Energinet.dk expects that the demand for withdrawal capacity in normal situations may vary between 10 million Nm^3/day and up to the current capacity of 18 million Nm^3/day.

Energinet.dk estimates that the volume required by commercial players in 2015 will still total approximately 500 million Nm^3.

The purchase of gas for emergency supply in 2014/2015 will decrease immediately when security for the supply from Germany has been obtained.

Expansion towards Germany to become operational from 2015

The transmission system in Germany will be expanded in the coming years with a view to increasing supplies to Denmark and Sweden. At the same time, the Danish Hejre field in the North Sea is expected to commence operations.

Energinet.dk expects that the combined sources of supply are sufficient to supply a declining Danish and Swedish market for a number of years in spite of declining production from the North Sea. Other things being equal, reduced pressure on the existing storage facilities is expected in the short term.

Storage need in the medium and long term

A large number of other factors may change the storage need in the medium (2015-2020) and long term (2020-2050).

In the long term, the storage need (in addition to seasonal adjustments) will, among other things, be determined by:

- Energinet.dk's choice of tools to fulfil the security of gas-supply obligations to the Danish market and to cover the security of gas-supply need on the Swedish market.
- The demand for and supply of flexibility from other markets, eg the German market.
- The production of biogas and other RE gases.
- The extent to which the gas system will be used longer term as a re-serve and peak-load source to ensure security of supply in the electricity system.
- The security of gas supplies from the North Sea.

Facts

- The Stenlille and Lille Torup gas-storage facilities, which have a total storage volume of approximately 1 billion Nm³, are operated commercially by DONG Energy and Energinet.dk, respectively.
- In normal situations, the gas-storage facilities have a withdrawal capacity of 17.5 million Nm³/day.
- In emergency situations, the withdrawal capacity of the gas-storage facilities is 25 million Nm³/day.
- The storage facility for seasonal adjustments between 2014 and 2025 is expected to range between 300 and 800 million Nm³.
- The EU security-of-supply regulation requires security of supply to be viewed from a regional perspective. This means that security of gas supply in Sweden must also be included in the assessment.

3.1.2 Consumption trends in Denmark and Sweden

The total Danish and Swedish natural-gas consumption will decline in the years ahead. The largest decline occurs in the CHP sector.

The total natural gas and biogas consumption in Denmark, excluding field consumption in the North Sea, is expected to decline from approximately 3.5 billion Nm³/year (151 PJ) in 2013 to approximately 2.8 billion Nm³/year (118 PJ) in 2022.

Natural-gas consumption in Denmark

Natural-gas consumption, excluding biogas, is expected to decline from approximately 3.3 billion Nm³/year to approximately 2.3 billion Nm³/year in the period, whereas biogas consumption is expected to grow from 0.17 billion Nm³/year to 0.51 billion Nm³/year in 2022.

This estimate is based on Energinet.dk's annual projection of Danish gas consumption for a 10-year period, which is also applied in Energinet.dk's Environmental Report 2013. This year, the calculations cover a projection period from 2013 to 2022.

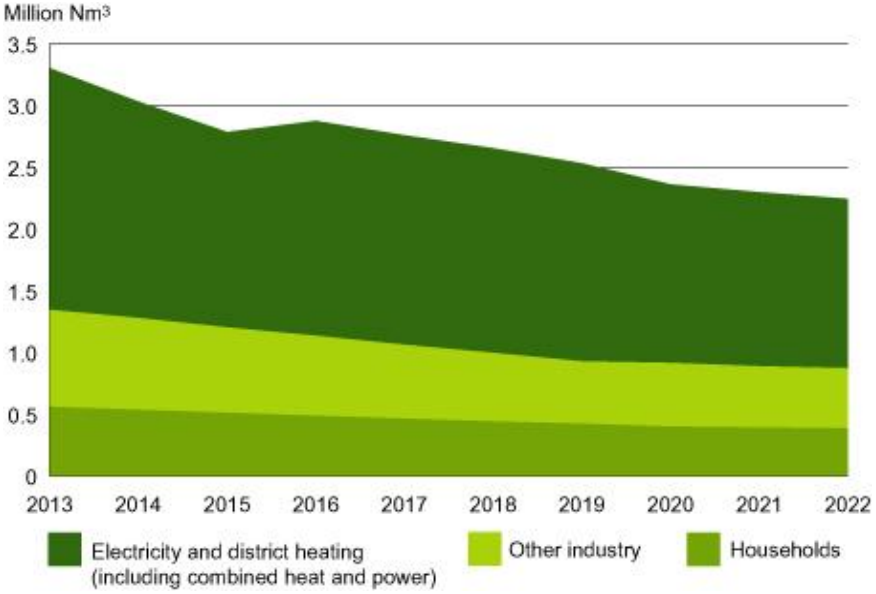
The projection of natural-gas consumption covers the existing consumption segments: Central, local and industrial CHP plants, district heating boilers, other sectors and households. However, the projection does not include future gas consumption for transport.

Biogas consumption in Denmark

Up until 2022, production of RE gases is expected to cover biogas only. In October 2012, the Danish Energy Agency assessed that the production of biogas will grow from approximately 6.6 PJ in 2013 to approximately 20 PJ in 2022. These energy volumes correspond to 0.17 and 0.51 billion Nm³/year of upgraded biogas.

Consumption projection for Denmark

Danish natural-gas consumption for the various consumption segments is shown in this figure.



Energinet.dk's projection of Danish natural-gas consumption by consumption segment.

Consumption in Sweden

Sweden currently receives its supplies of natural gas exclusively from Denmark via Dragør. Denmark is expected to remain Sweden's only large source of supply.

Sweden is seeing continued development in areas such as biogas, gasification gas and LNG in the network, and gas for the transport sector. However, it is difficult to estimate the effect on consumption and any local production.

Consumption increased dramatically in 2009 and 2010 in Sweden, due in part to the new CHP plant in Malmoe becoming operational. Consumption in 2013 is expected to be approximately 1.1 billion Nm³/year.

There is much uncertainty involved in the projection of Swedish natural-gas consumption, but a slight decline is expected. This expectation is based in part on limited announcements from the Swedish Energy Agency and Swedegas. Energinet.dk therefore expects natural gas consumption in Sweden to be approximately 1.1 billion Nm³/year over the next few years, after which a slow decline in consumption is expected.

Facts

- Projections are based on the energy policy agreements concluded in 2008 and 2012 and on a number of assumptions stipulated by the Danish Energy Agency and Energinet.dk's data coordination group.
- Data was presented in connection with Energinet.dk's Environmental Report 2013.
- Fuel prices have been taken from the IEA fuel-price forecast from 2012.
- The evaluation includes measures to accommodate wind power in the form of electric vehicles, heat pumps in areas served by CHP plants and individual heat pumps to replace oil-fired boilers.
- Energinet.dk's SIVAEL model was used. It simulates the CHP sector on an hourly basis, year by year.
- Natural-gas consumption at central, local and industrial CHP plants and peak-load boilers has been calculated using this model.
- The natural-gas consumption figures for other sectors and households have not been calculated. These figures were taken from the latest projection by the Danish Energy Agency (October 2012).

3.2 Gas supply situation 2014-2015

The supply situation is also expected to be tight in 2014 and 2015. Supplies from Germany will make it possible to meet demand on the Danish and Swedish gas markets.

The supply situation is expected to be tight in 2014 and 2015. This is because gas supplies from the Danish part of the North Sea are declining.

Energinet.dk is keeping a close eye on the supply situation and will keep market players regularly informed of the expected development between 2014 and 2015. Energinet.dk will continue doing so until the expansions of the transmission system in Germany have been established in October 2014. Energinet.dk thus provides the market players with a common information base, thereby allowing them to take the necessary precautions to avoid critical supply situations.

Sufficient gas in 2014-2015

Energinet.dk estimates that there is sufficient gas to secure the gas supply for Denmark and Sweden in 2014 and 2015. This is due to the combination of supplies from the North Sea and, furthermore, the fact that Danish gas-storage facilities have been able to obtain physical supplies from Germany since October 2010. The import capacity has been increased following the inauguration of the new compressor station at Egtved and the pipeline looping from Ellund to Egtved on 1 October 2013.

New North Sea and gas consumption forecasts

The Danish Energy Agency annually produces a new forecast for gas production from the Danish part of the North Sea. Energinet.dk prepares a corresponding new forecast for gas consumption in Denmark and Sweden. These analyses provide the basis for the latest projections of the supply situation for 2014-2017.

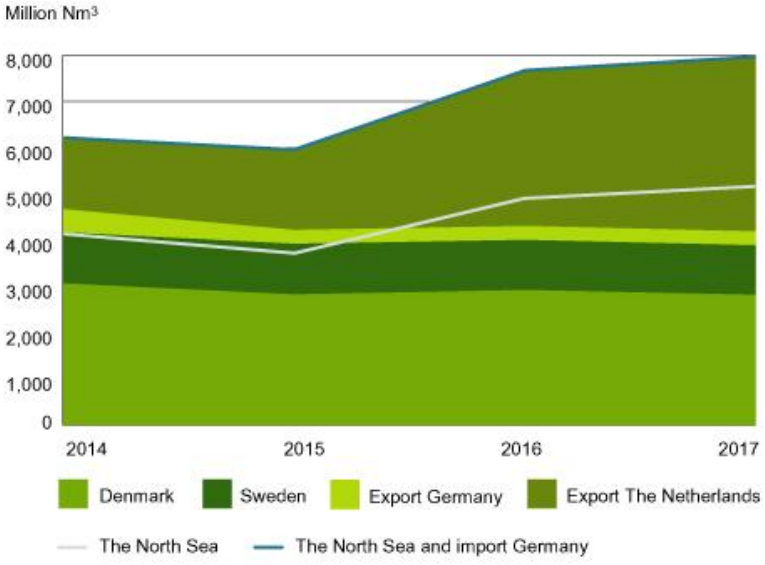
In the short term, it is expected that the interruptible physical supplies from Germany of 310,000 Nm³/hour from November 2013 will help meet any shortfall that may arise in the supply of gas to Denmark and Sweden.

New import facilities in Denmark became operational on 1 October 2013. The expansions in Germany towards Denmark will become operational from October 2014, thus ensuring firm capacity of 310,000 Nm³/hour.

The supply situation has been tight in 2013. This spring's two Early Warning events increased market players' awareness of the need for utilising market-based tools to avoid actual emergency situations. The continued tight supply situation in 2014 and 2015 means that shippers and storage customers need to carefully assess how they can secure adequate supplies during these years.

Expected supply situation 2014-2017

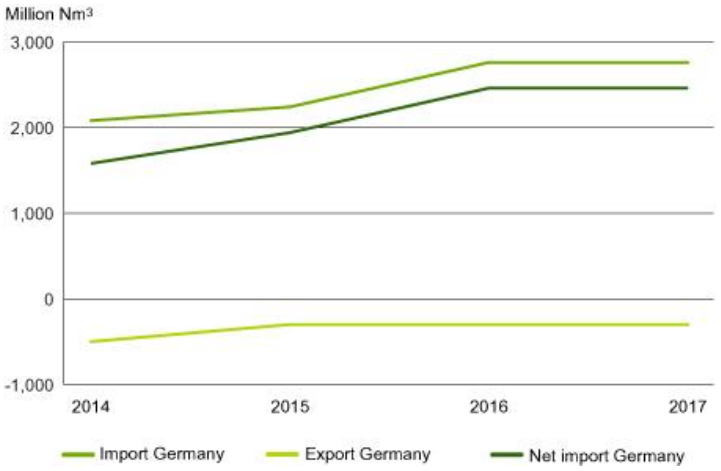
The new Danish Hejre gas field is expected to commence operations in 2015, while a further expansion will become operational in Germany. Opportunities for supplies to Denmark and Sweden will have been created in 2016, as is assumed below.



Expected supply situation 2014-2017.

Millions Nm³	2014	2015	2016	2017
Exports, The Netherlands	1,550	1,740	3,370	3,740
Exports, Germany	500	300	300	300
Sweden	1,110	1,090	1,080	1,070
Denmark	3,060	2,820	2,920	2,810
Imports, Germany	2,080	2,240	2,760	2,760
The North Sea	4,130	3,720	4,910	5,170

As a supplement to supplies from the North Sea, it will be necessary in 2014 and 2015 to import gas from Germany to meet demand on the Danish and Swedish markets, and these imports are expected to increase further in 2016 when the further expansion in Germany has become operational. This is illustrated in the figure below.



Supplies Ellund 2014-2017.

Millions Nm³	2014	2015	2016	2017
Imports, Germany	2,080	2,240	2,760	2,760
Exports, Germany	-500	-300	-300	-300
Net, Germany	1,580	1,940	2,460	2,460

Important supply issues

The following issues are important to consider:

- The volumes of gas supplied from the North Sea are expected to be insufficient to meet demand on the Danish and Swedish gas markets in 2014. Net imports from Germany will be required. The imports are expected to be around 1.6 billion Nm³. Energinet.dk expects that a physical maximum of 310,000 Nm³/hour can be supplied from Germany. The gas will be supplied on an interruptible basis until 1 October 2014, after which supplies will be firm.
- The volumes of gas supplied from the North Sea are also expected to be insufficient to meet demand on the Danish and Swedish gas markets in 2015. Net imports from Germany will be required. The imports are expected to be around 1.9 billion Nm³.
- The Hejre gas field is expected to become operational towards the end of 2015.
- In 2015, the German gas system is expected to have been expanded further so that a minimum of 450,000 Nm³/hour can be supplied from Germany.

Facts

- The supply situation will remain tight between 2014 and 2015.
- It will be necessary to import gas from Germany in 2014 and 2015. Imports of 1.6 billion Nm^3 in 2014 and 1.9 billion Nm^3 in 2015 are expected.
- The interruptible capacity from Germany of 310,000 Nm^3/hour is expected to be made firm as from 1 October 2014.
- Firm capacity from Germany of a minimum of 450,000 Nm^3/hour is expected from October 2015.
- When Energinet.dk declares an emergency (emergency-supply situation), Energinet.dk takes over the responsibility for supplies to protected customers on the Danish market.
- Supplies to non-protected customers can only be ensured by the shippers.

3.3 Infrastructure after 2014

Together with the Danish expansion in 2013, the German stage 1 in 2014 ensures security of gas supply. The North German system is expanded by a stage 2 for completion in 2015.

German expansions towards Denmark after 2014

A further expansion of the system in Northern Germany is expected to become operational in 2015, such that the Danish and Swedish markets can be supplied from the North Sea and Germany for a number of years.

Greater connection with the rest of Europe

The German expansion in 2015 will provide a high level of security of gas supply. If North Sea production decreases dramatically, it may be necessary to find new supply routes.

3.3.1 German expansions towards Denmark after 2014

Capacity in Northern Germany will be expanded, depending on demand.

Energinet.dk has outlined a supply picture for gas consumption and supplies between 2013 and 2050. The analysis assumes that the first stage of the expansion in Germany is completed in 2014. It also assumes that the Danish Hejre gas field commences production in 2015 concurrently with the further expansion in Germany becoming operational. The Danish and Swedish market can thus be supplied from the North Sea and Germany for a number of years.

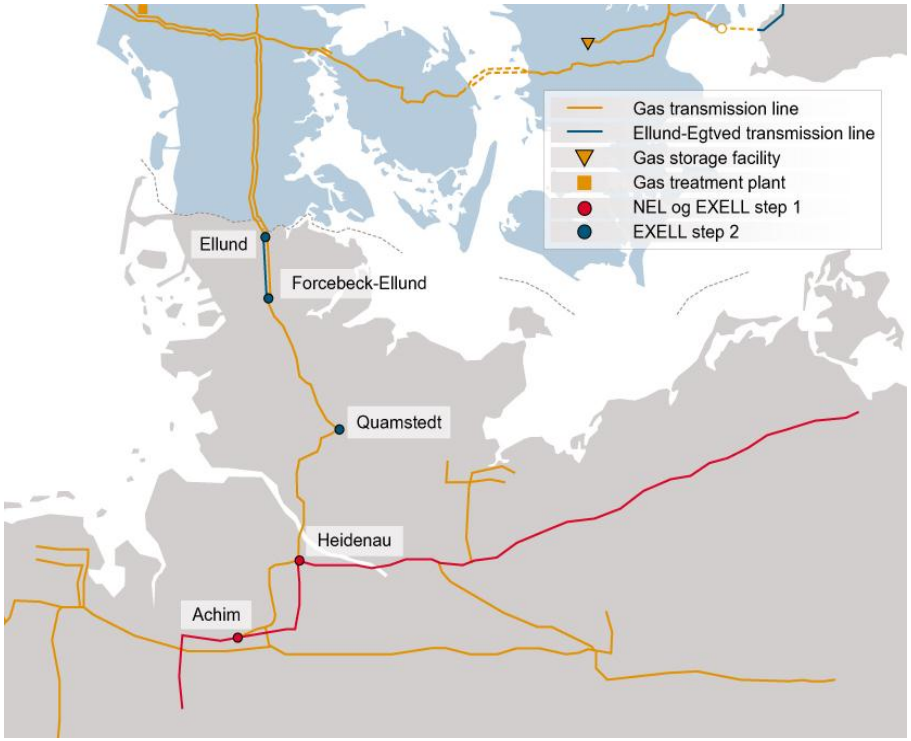
Stage-1 expansion

The German system operator Gasunie Deutschland will have commenced the expansion of the capacity from Germany to Denmark by late 2014.

The previously available interruptible capacity of 200,000 Nm^3/hour at the German Ellund exit has been expanded to 310,000 Nm^3/hour supplied on interruptible conditions as from November 2013.

Stage-2 expansion

Gasunie Deutschland has decided to launch further expansions to increase the capacity and flexibility in the North German system to match the increased demand in Schleswig-Holstein and on the Danish-Swedish market.



Stage-2 expansion of North German natural-gas system.

The stage-2 expansions are expected to become operational at the end of 2015. The final size and distribution of capacity between domestic consumers and the Ellund border point will depend on demand signals, German legislation and the final technical solution. But supplies of minimum 450,000 Nm³/hour to Denmark are expected.

Facts

- The interruptible capacity from Germany has been increased to 310,000 Nm³/hour from November 2013.
- Firm capacity from Germany of 310,000 Nm³/hour and a further approximately 40,000 Nm³/hour of interruptible capacity are expected in October 2014.
- An expansion in Germany that makes it possible to supply a minimum of 450,000 Nm³/hour will have been completed in October 2015.
- The European system operators plan and publish joint 10-year plans for network development.

3.3.2 Greater coherence with Europe

A German expansion in 2015 will contribute to the security of supply. A dramatic decrease in North Sea production may result in a need for supplementary supply routes.

Compared to most of our neighbours, Denmark has been privileged by being self-sufficient in terms of oil and gas.

Transmission lines to neighbouring countries have therefore been designed with a view to exports, as opposed to the European transmission grids, which are primarily designed for transit and imports from the major producers in Algeria, Norway and Russia and for LNG imports.

More gas from Germany in the future

As North Sea production decreases, Denmark will become more dependent on gas imported from Germany. The Danish and Swedish gas markets have access to extensive gas reserves for many years to come via the connection to the European gas network at Ellund. The gas in the North German system consists of a mixture of Norwegian, Dutch, Russian and German gas (including biogas) and liquefied natural gas (LNG).

The Norwegian gas fields have reserves for the next 50 years, whereas Russian reserves are estimated to be many times larger and adequate to maintain existing production for the next 100 years. More gas from Russia will enter the North German system in the years ahead through the recently established Nordstream pipeline through the Baltic Sea. Gas from Nordstream is a prerequisite for the planned expansion of the North German transmission system.

Energinet.dk's investments in import capacity from Germany greatly improve the long-term security of gas supply, but, depending on the development, it may still be necessary to evaluate other alternatives after 2020.

Prospective expansions, including a connection to Norway

In May 2010, the Danish Energy Agency published the report Expansion of the infrastructure for transporting natural gas with a view to future imports to Denmark. The aim of the report was to show how the Danish production facilities and pipelines in the North Sea can be used optimally in conjunction with the onshore infrastructure.

The Danish Minister for Climate, Energy and Building also approved Energinet.dk's expansion towards Germany.

In the report, the Danish Energy Agency mentions that the decision to expand towards Germany does not exclude the possibility of later establishing a connection to the Norwegian gas infrastructure. This could be done either by using the existing Danish offshore infrastructure, or by establishing a direct connection to the shore. The decision depends on whether the necessary market arises at some point in time.

A prospective Norwegian connection may be justified on the basis of:

- **Security of gas supply,** ie securing of alternative pipelines after 2018 when gas supplies from the Danish part of the North Sea start to dwindle and Germany most likely becomes the primary source of supply.
- **Increased competition** for the supply of gas to Denmark and Sweden.
- **Supply of gas** through Denmark to the Northern European market, including the Baltic States.

The Danish Energy Agency's report also mentions the possibility of changing the direction of the flow in the pipeline between Tyra and F3 such that 'wet' gas is imported from the Dutch NOGAT system. This will also require treatment of gas either at Tyra or at Nybro.

Security of gas supply for Northern Europe

Gas imports from Norway are a supplement to the supply of the Danish and Swedish markets. However, the imported capacity can also be passed on to the Northern European market, including the Baltic States.

Through the Baltic Energy Market Interconnection Plan, for example, the European Commission supports initiatives for the diversification of gas supplies to Northern Europe and the Baltic area. The EU is therefore positive towards investigation of both a Norway-Denmark and a Denmark-Poland connection.

The security of gas supply regulation

In the long term, as North Sea production wanes and Germany represents the greatest supply source, fulfilment of the EU regulation on security of gas supply may necessitate the establishment of new infrastructure. Alternatively, storage facilities could be expanded or steps to rapidly disconnect consumers be secured.

A Norwegian connection may help ensure that the North Sea resources are exploited optimally. Energinet.dk therefore continually assesses the options for establishing a connection from Norway to Denmark before 2020.

Denmark's energy resources

Oil and natural gas play a key role in Danish energy supply. The Danish government is pursuing two objectives. As much as possible of the oil that has been discovered should be extracted. Investments should also be made in locating new resources.

Preliminary studies are currently being conducted in North Zealand and Northern Jutland to show whether there is subterranean shale gas in Denmark that can be exploited. However, no decision has yet been made as to whether it would be environmentally acceptable to extract any such shale gas. If there are sufficient volumes of shale gas and if the government grants permission to extract it, this could significantly change the supply situation in Denmark after 2020.

Facts

- There is certainty that a further expansion in Germany will become operational before 2016, and this ensures prospective imports of a minimum of 450,000 Nm^3/hour.
- Supplies from the Dutch system may help ensure natural-gas supplies from the North Sea and exploitation of marginal fields.
- A connection to the Norwegian offshore gas system may secure the supply of gas to the Danish and Swedish gas market after 2020.
- The European Commission supports both a Norway-Denmark and a Denmark-Poland gas connection via the Baltic Energy Market Interconnection Plan (BEMIP).
- Subterranean shale gas in Denmark could significantly change the supply situation.
- The Danish government's vision of fossil-free energy supply in 2050 will change the supply situation after 2020.
- 'Wet' gas is gas that contains many heavy hydrocarbons. The gas must be cleaned of hydrocarbons so that it complies with the specifications for sales gas.

3.4 Transmission tariffs

Transport tariffs have fallen over the past five years. This will change in the long term as transport costs per Nm^3 will rise due to declining volumes.

Energinet.dk's finances are based on a self-financing principle. This means that income and expenses must balance. The main part of the income is collected in the form of tariffs.

All necessary costs incidental to the respective activities are covered by the transmission tariffs paid by the customers. Necessary costs are costs incurred by Energinet.dk for reasons of operating economy in order to maintain efficient operations. This means that the tariffs cover costs incurred in connection with:

- Operation of the gas systems
- Security of gas supply
- Expansion of the transmission grids.

The Danish Energy Regulatory Authority approves the tariffs.

The costs in the transmission system are constant

Transport tariffs have decreased during the period Energinet.dk has operated the transmission grid. Energinet.dk expects that they will continue to do so in the near future.

In the slightly longer term, however, Energinet.dk expects the transport tariffs to rise, as the volume of gas transported will be lower.

Leading up to 2030, transmission system costs are expected to remain relatively constant. If the volumes decrease by 40%, this will result in a 20% increase in transport costs per Nm^3.

Harmonising tariffs in Europe

In addition, the coming years will be characterised by the work on harmonising tariffs at a European level.

3.4.1 Transport tariffs

The gas transport tariff has decreased since 2005. Differentiated capacity tariffs were introduced in October 2013.

On 23 September 2013, Energinet.dk received the Danish Energy Regulatory Authority's approval of a changed method for inclusion of new investments in the transport tariff. In 2013, this concerns, for example, the Ellund-Egtved pipeline.

The change of method consists of two elements: Change of the capacity/volume ratio and introduction of differentiated tariffs. The change entered into effect on 1 October 2013.

Tariffs have declined

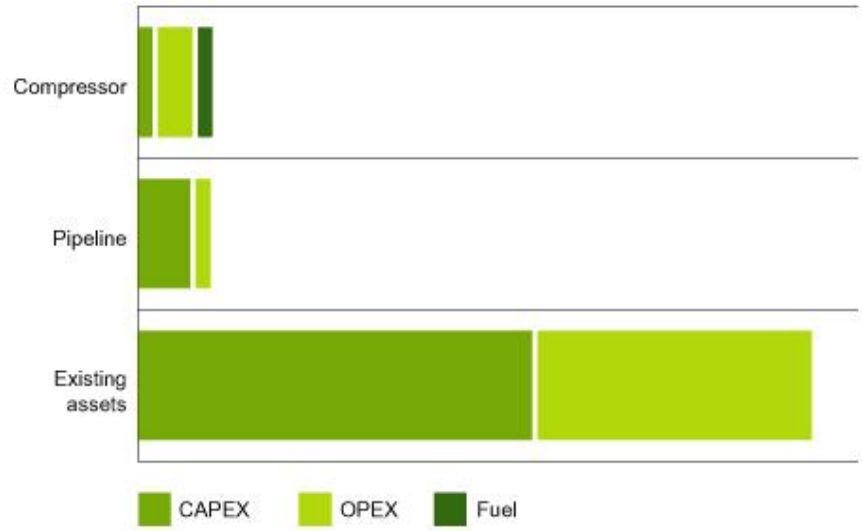
Tariffs also declined in 2013. This happened primarily because a surplus accumulated in previous years is extraordinarily being repaid to the system users over a three-year period.

The changed capacity/volume ratio results in a redistribution between the capacity and volume payments.

Relative increase in the variable payment

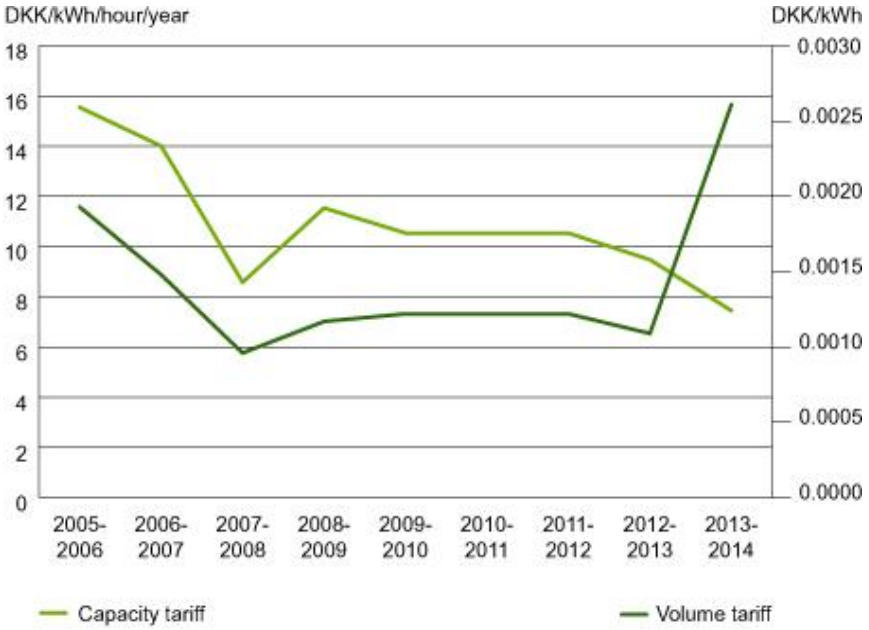
In future, capacity tariffs will be linked to the fixed costs of capital, including depreciation, amortisation and interest payments (CAPEX). Volume payments will be defined based on the variable costs of operation, maintenance and fuel (OPEX).

Till now, Energinet.dk set capacity tariffs so that they accounted for at least 75% of the total income, whereas volume payments accounted for the remaining 25%.



Breakdown of costs on existing assets, pipeline and compressor.

Given that operation and maintenance now account for a larger share of the total cost base, this change will result in the variable payment being increased, relative to the capacity payment.

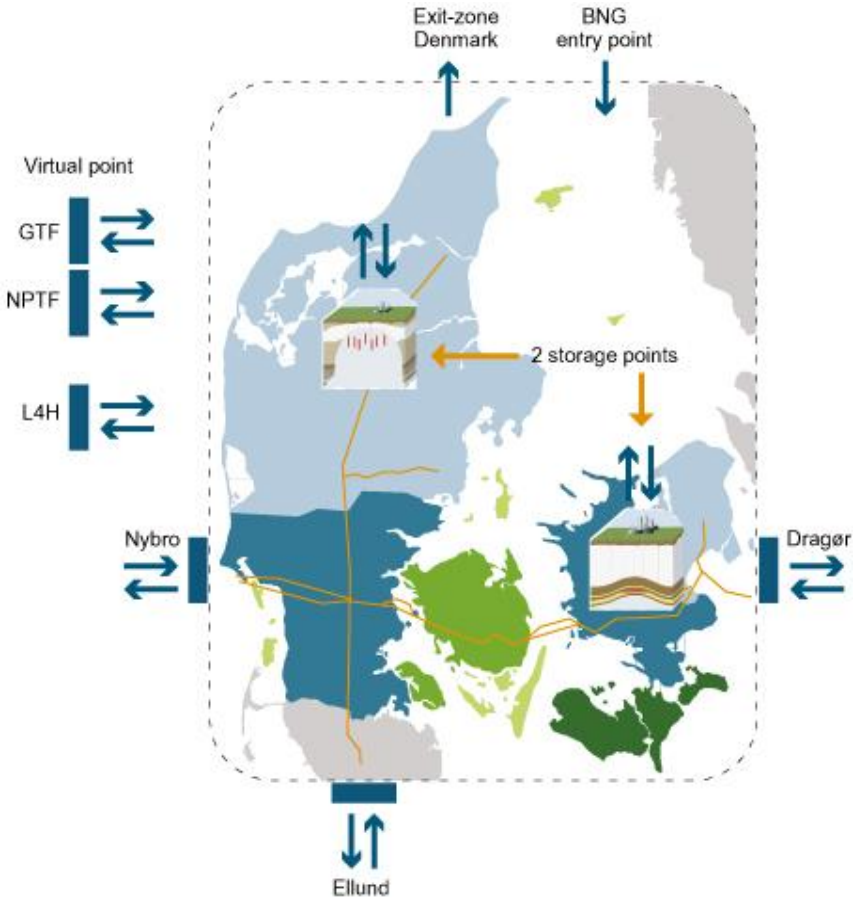


Transport tariffs from 2005 to 2014.

As a consequence of this, the price of capacity is reduced despite declining transport volumes. The objective is to increase customer access to and utilisation of the capacity in the transmission system, and to support a more flexible use of gas in the future market.

Differentiated capacity tariffs

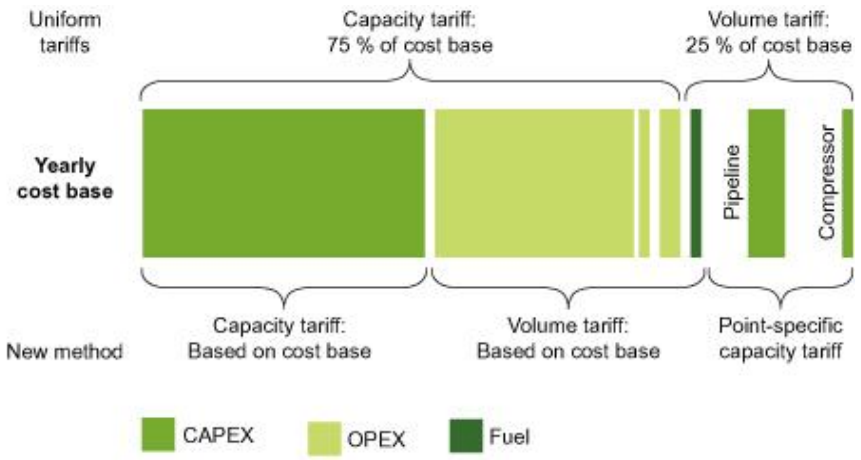
In its method notification, Energinet.dk proposed that capacity tariffs be differentiated in future. The costs of capital in connection with the compressor station at Egtved must thus be attributed to the Ellund entry point. Similarly, the costs of capital in connection with the Ellund-Egtved pipeline looping must be attributed to Exit Zone Denmark and Dragør exit. This is illustrated below.



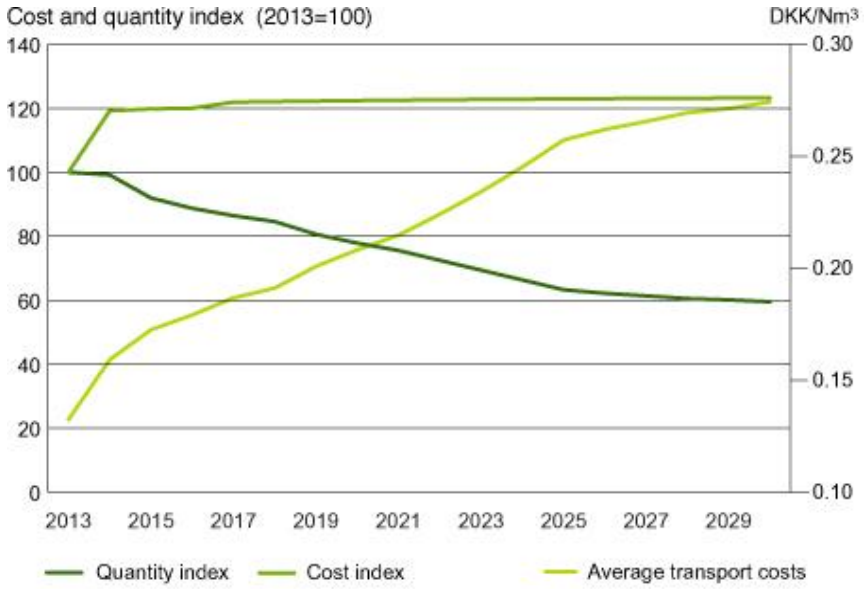
The figure shows how tariffs are differentiated.

The differentiation means that the capacity payment will be marginally different at the system's entry and exit points, whereas uniform capacity tariffs were charged previously.

As concerns the costs of capital and the operating and maintenance costs, the uniform capacity tariffs and the fixed capacity/volume ratio will be changed to differentiated tariffs with changed capacity/volume ratios.



Changed capacity/volume ratio combined with the point-specific capacity tariff.



Changes in transport quantities and unit costs will lead to higher transport costs.

Transport costs over the next 20 years

Transport costs are expected to rise in the long term due to declining volumes and slightly rising costs.

The figure shows the average unit cost per Nm³ transported in the period up to 2030 at a 40% decline in volumes over the period. The transport costs in the transmission system per Nm³ (here shown as an index) are expected to increase by approximately 20% due to the establishment of new facilities, fuel costs for compressors, ageing technical systems and write-downs for assets.

Facts

- CAPEX is the cost of capital less interest, depreciation and amortisation.
- OPEX is operating expenses and maintenance costs.
- Tariffs are being reduced in 2014, but must be increased in the long term.
- Danish transport costs per Nm^3 are expected to increase as consumption declines and costs rise or remain constant.
- The tariff method is being changed in line with European harmonisation and adaptation to changed conditions in the Danish gas market, where consumption declines and demand for flexibility rises.
- The differentiated capacity tariffs and the change in the capacity/volume ratio entered into effect on 1 October 2013. The method has been approved for a two-year period.
- A change to the emergency-supply model will lead to lower prices.
- Energinet.dk has previously used the same capacity prices in and out of all entry and exit points in the system.

3.4.2 Emergency supply tariffs

The emergency-supply payment has been changed as part of the implementation of the new common European regulation on security of gas supply.

The emergency-supply tariff was restructured as at 1 October 2012. It is now the distribution companies that collect the emergency-supply tariff from the consumers on behalf of Energinet.dk.

End users are divided into two customer groups, which pay a differentiated emergency-supply tariff:

- **Non-protected consumers** are approximately 30 industrial companies and central power stations, which together account for around 20% of the annual gas consumption in Denmark.

- **Protected consumers** are approximately 400,000 private customers, public enterprises, CHP and district heating plants and small businesses with a consumption of less than 4.7 million Nm^3 per year (applicable for the 2013-2014 gas year), which together account for approximately 80% of the consumption.

Difficult to compare prices

The previous common emergency-supply tariff of DKK 0.00201/kWh in 2012-2013 fell to a new weighted average emergency-supply tariff of DKK 0.00063/kWh in 2013-2014. This corresponds to a drop of 68.7%.

One of the reasons for the price decline is that the costs of effectively covering a smaller market have been reduced and optimised.

Sales of emergency gas lead to tariff reductions

One of the contributing factors to the reduction in the emergency-supply tariff is repayment of a surplus from earlier periods. The surplus is primarily due to profit on the sale of emergency gas.

In 2012-2013, Energinet.dk sold a part of the emergency gas reserved for use in an emergency-supply situation and stored in the storage facilities. The sale resulted in a book profit of DKK 44 million. This profit was added to the accumulated surplus and has to be repaid to the consumers in the form of tariff reductions over three years, starting this year.

3.4.3 *Harmonisation of tariffs in Europe*

Price structures and price-setting mechanisms will fundamentally change over the next few years.

There will be fundamental changes to the price structures and price-setting mechanisms over the next few years. The aim of the changes is to improve the competitiveness of the gas network in a tight market. They are also intended to contribute to a greater degree of harmonisation and integration with neighbouring markets.

Ellund-Egtved pipeline, Photo: Medvind/Bent Sørensen.

New marketplaces

As part of the development of the single European market, the gas markets have to become more effective and cohesive. Energinet.dk has therefore, in cooperation with other European TSOs, developed a common European capacity platform, PRISMA, the objective of which is to ensure harmonisation of products across borders. PRISMA was launched on 1 April 2013.

Previously, capacity at a border point was sold independently of the adjacent systems. In future, capacity at the Ellund and Dragør border points will be offered for sale on PRISMA, as a common product with German operators.

Capacity at the border points is matched with capacity in the adjacent systems and sold as a bundled product.

Ellund-Egtved pipeline, Photo: Medvind/Bent Sørensen.

The bundled capacity is offered at a total price. This encourages a higher degree of harmonisation of transport-system price structures and product composition, across national markets.

The common European regulations for harmonisation of tariff structures will be implemented over the next few years.

Facts

- ENTSOG is the European Network of Transmission System Operators for Gas.
- The PRISMA platform is the answer of seven countries' 24 TSOs to the question of where and how the harmonisation of the European gas market should take place. Energinet.dk has been involved in the project.

4. Issues of current importance

With the inauguration of the compressor station in Egtved, a bridge has been built to Europe, the European gas market and a greener future.

On 30 September 2013, the expansion of the Danish infrastructure for increasing the import capacity from Germany to Denmark was inaugurated and put into operation.

This means that a bridge has been built between Denmark and the extensive European gas infrastructure. And the supply of gas in Denmark is now fully integrated with the European market.

This will result in a greater exchange of gas across the Danish-German border, where buyers and sellers of gas will have easier access to a larger market and benefit from increased trade.

Martin Lidegaard, Danish Minister for Climate, Energy and Building, and Peter Hodal, Vice President, Gas Division, at the inauguration of the new compressor station in Egtved on 31 October 2013. Photo: Medvind/Bent Sørensen.

The European access also opens up for an increased growth potential within the production of green gases such as biogas and RE-gases in Denmark; both in terms of a greater market potential and increased exchange of technology.

The market integration also means that the cornerstones of an efficient and well-functioning gas market in Denmark to an increasing extent will be laid in a European rather than a national context.

Energinet.dk is working actively to ensure good European framework conditions for the gas market and for developing the potential for green gases in Europe. Read more in the themes:

- The European gas market is being challenged and developed
- Towards a greener gas system
- Gas for transport
- Development of gas technologies

Facts

- 'Gas in Denmark' is Energinet.dk's report to the Danish Energy Agency and is published every year.
- The 'Gas in Denmark 2014' report meets the following requirements:
  - Annual security of supply report; see Section 3 of the Executive order on maintaining security of natural gas supply
  - Coherent, holistic planning of the transmission network; see Section 7 of the Executive order on implementing natural gas supply networks

4.1 The European gas market is being challenged and developed

The Danish gas market is now integrated into the European market, where market regulations are harmonised to increase competition.

The rules for the single market for gas in the EU are currently being established. The common European gas market will ensure converging and competitive prices. The development will result in a more effective security of gas supply nationally and in the single market.

Minister for Climate, Energy and Building, Martin Lidegaard inaugurates compressor station in Egtved, Photo: Medvind/Bent Sørensen

As the European gas markets are harmonised, there is a need for the European players to work together, including member states, supervisory authorities and transmission companies such as Energinet.dk.

Energinet.dk actively involved

The development of the Danish gas market is heavily influenced by the single market. Energinet.dk is therefore actively involved in the European cooperation on several different fronts, including:

- Development of common rules for the single gas market
- Development of the gas sector's role in the transition to green energy.

The EU's objective is for the European energy markets to be integrated by the end of 2014. Even though there have been several steps in the right direction, several players in the market believe that it is unlikely that this objective will be achieved in such a short period of time.

Facts

- The most recent regulatory basis for the development of the single market for gas is regulation 715/2009
- In 2011, the EU heads of government decided that the European energy markets must be integrated by the end of 2014
- The Danish consumption of natural gas accounts for about 1% of the total consumption in the EU.

4.1.1 *Development of the single market for gas*

The EU is currently developing a common market for gas, which helps to liberalise the sector and integrate the markets. Energinet.dk is playing an active role.

The third liberalisation package was adopted in 2009 to speed up the development of the European energy market. Against this background, the EU has been working to establish common rules for the internal energy market and asked the transmission companies to take part.

The gas cooperation is formalised in the ENTSOG organisation, which was established in 2009. Here, Energinet.dk and 40 similar companies from all over Europe work to promote the development of the single gas market and cross-border trading.

Construction works at the Egtved-Ellund pipeline. Photo: Medvind/Bent Sørensen

Cooperation between TSOs

The work in ENTSOG focuses on developing drafts for common rules for gas transport across borders, coordinating the development of the European gas infrastructure and maintaining the security of gas supply in Europe. This requires considerable technical knowledge of the gas infrastructure and a willingness to enter broad compromises.

Energinet.dk's commitment to the cooperation is based on a willingness to ensure common European solutions to the greatest possible benefit of the users of the gas system. Energinet.dk is one of the reasons why Denmark is one of the leading countries in Europe in terms of implementing the European rules, among other things with regard to introducing capacity auctions at the German border. The rules are now an integral part of Rules for Gas Transport.

ENTSOG is currently working on common rules for the practical interaction between the gas systems. The next step is the considerable efforts required to develop common principles for transmission tariffs for the gas infrastructure. The work takes place in an open process, which can be followed on ENTSOG's website.

Single market by 2014

The EU's objective is for the European energy markets to be integrated by the end of 2014. Despite the progress, several players in the market find it unlikely that this objective will be met.

The common rules are the result of the joint efforts of TSOs, regulators and the European Commission. Some of the rules are behind schedule, but the markets are moving towards increased integration. The European gas market rules are completed and adopted by the European Parliament and the member states.

Facts

- TSO is an abbreviation for Transmission System Operator, which refers to companies with system responsibility such as Energinet.dk. There are both privately owned and state-owned TSOs in the EU.
- Energinet.dk has been re-elected to serve on the Board of Directors of ENTSOG in the period 2013-2015.
- ENTSOG's publications in 2013 included:
  - Overview of implementation of capacity allocation rules
  - Ten-year plan for the development of the European gas network
  - Overview of the summer's expected supply situation.

4.1.2 Multiple paths to green transition

The EU is on the way towards a green transition, where natural gas and infrastructure play an important role. Each country decides how they will achieve the green objectives.

The EU member states have committed themselves to fulfilling the so-called 2020 objectives which are:

- Greenhouse gas emissions must be 20% lower than in 1990
- 20% of energy must come from renewable energy sources
- 20% increase in energy efficiency.
-

The greenhouse-gas emissions objective varies from country to country. Denmark will cut its emissions by 20%. The corresponding figure for the UK is 16%, 14% for Germany and 16% for the Netherlands.

The role of natural gas is not fully clarified in the green transition, but the prospects look promising.

United Kingdom

In recent years, the UK government has increased its focus on the extraction and consumption of gas. This appears from its *Gas Generation Strategy* prepared in 2012.

The UK will strengthen its focus on developing the gas sector, first and foremost to strengthen the security of electricity supply in a country where many plants are due for replacement. Sufficient capacity is required to support renewable energy at the times when it cannot be produced. The UK also wants to promote the development of shale gas to support these objectives.

Germany

Much like Denmark, Germany has launched a very ambitious energy policy, in which the transition to green energy is essential. The political plan for the transition is called Energy Concept and was launched by Angela Merkel in 2010. The German transition is often termed 'Energiewende'.

Energy Concept presents objectives for both CO_2 emissions and renewable energy: Greenhouse gas emissions must be reduced by 40% by 2020. In the same year, the share of renewable energy in power generation is expected to reach 35%. The German climate objectives for 2020 are identical to the objective set out in the Danish government platform.

The German regulator, Federal Network Agency, continuously monitors the progress of the green transition in Germany and also the challenges facing the energy system in this process. Germany has decided to shut down its nuclear power plants, and they are therefore working actively to maintain the capacity from the gas-fired power plants in the country.

Netherlands

The Netherlands are defining the role of gas in the transition to green energy. However, the country is heavily dependent on natural gas, which covers approximately 45% of its energy needs and contributes significantly to government funding.

One of the main topics in the Dutch debate is the construction of new gas-fired power plants while the existing gas-fired power plants are not able to make money in the market.

Focusing on the use of gas also leads to a focus on reducing the CO_2 emissions from gas consumption.

Reducing CO_2 emissions from the use of gas

A common feature of these approaches is the recognition that biogas is a viable supplement to natural gas and should be promoted. At the same time, the countries have difficulty identifying adequate alternatives to natural gas.

Several countries have therefore expressed interest in developing the so-called Carbon Capture Storage technology (CCS), whereby CO_2 emissions as a result of gas combustion are stored underground. This technology is still at the development stage.

4.1.3 Green-gas cooperation in the EU

The gas infrastructure plays an important role in the green transition in Europe. The European TSOs work for a more climate-friendly energy system.

Particularly the countries in North-Western Europe are committed to contributing to the green transition in Europe. As a result, Energinet.dk has concluded a cooperation agreement with the gas transmission companies in the Netherlands, Belgium, France and Sweden to share experience on technologies that can strengthen the gas system's potential for promoting the green transition in Europe.

Among other things, the green European cooperation focuses on:

- Development of green certificates which can be used to support green gas trading across European borders
- Transport of biogas and hydrogen in the gas infrastructure
- Gas for road and sea transport
- Power to gas.

Cooperation in Gas Infrastructure Europe

Work is also being carried out in a broader European cooperation under the Gas Infrastructure Europe (GIE) organisation.

Minister for Climate, Energy and Building, Martin Lidegaard inaugurates compressor station in Egtved, Photo: Medvind/Bent Sørensen

Here, Energinet.dk chairs a working group which contributes to a European coordination of green technologies. In this working group, members share knowledge and experience with the European institutions that are working to create a common framework.

Overall, Energinet.dk is making an active effort to promote the green European cooperation, thereby contributing to an effective transition to green energy in Denmark.

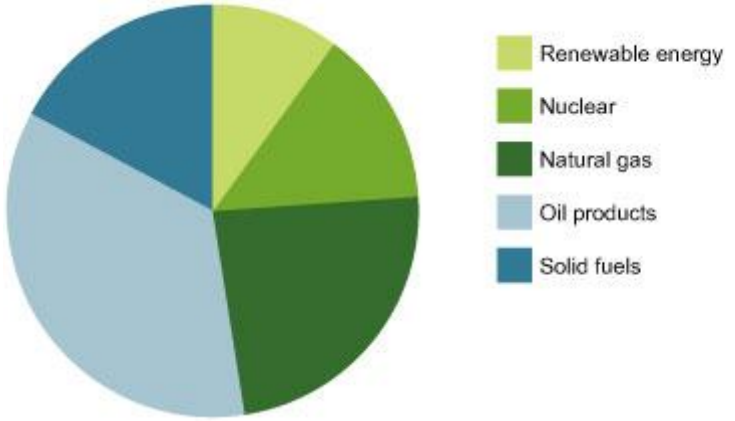
Facts

- GIE is a joint organisation for storage facilities, LNG facilities and transmission companies all over Europe
- For the first time, Energinet.dk has been elected to the Board of Directors of GIE for the period 2013-2015.

4.1.4 Gas key to the EU's energy mix

As the EU member states' own gas deposits are slowly being reduced, imports from the EU's neighbours increase. Norway is now the largest supplier of gas to Europe.

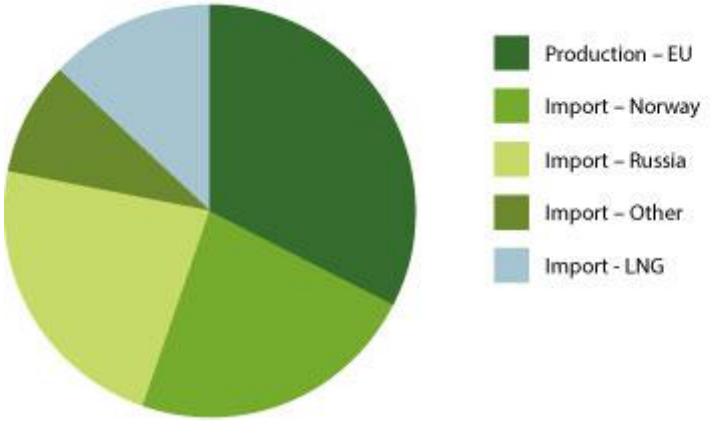
Natural gas is a key fuel in the European energy system, accounting for about a quarter of the European energy consumption.



European gross energy consumption in 2011 by fuel. Source: EU-27, Eurostat.

The biggest natural gas producers in the EU are the Netherlands, the UK and Germany. Together with Denmark and other countries they ensure that the EU itself can produce around one-third of its gas consumption.

In the past several years, Russia has been the biggest supplier to the EU member states, a role that was taken over by Norway in the course of 2012. Figures from BP's Statistical Review 2013 show that Norway sent slightly more gas to the EU in 2012 than Russia.



Supply of natural gas for Europe. Source: BP's Statistical Review 2013

The EU member states' gas deposits are slowly being reduced, leading to increased imports from the EU's neighbours (Norway, Russia and Algeria). Natural gas deposits in European shale strata may contribute to reducing the EU's dependence on imports.

Denmark only EU net energy exporter

Denmark is the only net exporter of energy in the EU. This is not least thanks to the natural gas production in the Danish part of the North Sea, which is the sixth-largest in the EU.

However, EU's own production is slowly declining as the available fields onshore and offshore are emptied. At the same time, ENTSOG's projections in their ten-year network development plan (TYNDP) show a relatively stable natural gas consumption in the EU with annual growth of approximately 1% per year over the next ten years.

The EU's dependence on natural gas imports is therefore expected to rise.

However, the EU countries have access to a substantial import infrastructure that ensures supplies from the EU's neighbouring countries, in particular from Norway and Russia, which are the main suppliers to the EU. These two countries alone are expected to have deposits, which can secure the EU's supplies for many years to come.

Shale gas

The EU's own natural gas production, however, may increase in the coming years when several countries will try to extract natural gas from their underground shale strata. In the USA, the extraction of shale gas has meant that the country has become self-sufficient in gas at low prices. This has reduced coal consumption and thus CO_2 emissions from the USA quite dramatically.

However, several extraction companies have caused environmental problems in the USA, which has resulted in considerable scepticism in the USA and the EU towards the methods used to extract shale gas. This has prompted several EU countries to ban the extraction of shale gas in their territory until the technology is proven to be safe for the environment. On the other hand, Poland and the UK, among others, are already seeing great opportunities for using the technology to extract gas nationally.

Danish energy policy aims to exploit the potential of all domestic energy sources, including shale gas, that are safe to use from a socio-economical, commercial and environmental perspective. The Danish Minister for Climate, Energy and Building has stated that if the extraction can be carried out safely within the above criteria, permission will be granted for shale gas production. Permission will be granted independently of whether Denmark uses the fossil gas nationally, or whether it is exported. This view is shared by the majority of the Danish Parliament.

At the present time, it is difficult to assess the extent of the deposits in Europe, and to what extent they can be extracted at a reasonable cost.

Facts

- Natural gas can be transported thousands of kilometres with minimal energy consumption.
- Natural gas is increasingly being shipped from the producer to the consuming country as an alternative to pipelines. When gas is cooled, it occupies 600 times less space and is referred to as LNG (Liquefied Natural Gas).
- Shale gas is not chemically different from natural gas, but the extraction method is different. Where shale gas can be found in shale strata, natural gas is traditionally found in sandstone strata.

4.1.5 Changing price structures

The pricing of natural gas changes in line with the increasing trading on the exchanges, thereby decoupling oil and natural gas prices.

Gas is often produced when drilling for oil, and the production of natural gas has therefore traditionally been closely tied to oil production. Oil and gas also substitute each other in industry and private homes. So, according to established practice, natural gas is not priced separately, but based on the oil price.

In addition, the producers want to know their earnings many years ahead when making decisions about major investments in the extraction phase. Traditionally, they have therefore sold their gas on contracts which obliged the purchaser to buy a certain volume of gas for a period of 10-30 years. The price of the gas was agreed based on the oil price.

In recent years, this relationship between the oil price and the natural gas price has been further reduced. The gas market will thus increasingly resemble other energy markets.

Harmonisation of prices across contract types

With the liberalisation of the European gas market, focus has been on changing the pricing model to increasingly resemble the model for other commodities sold on exchanges. This ensures that there is an updated price signal to the market, constantly matching supply and demand.

In the past year, the price on the exchange was below the price gas purchasers must pay if they have purchased the gas via a long-term contract. Many gas purchasers have chosen to use the exchange instead of entering into new long-term contracts. Among other things, this reflects the market's valuation of the risk of trading direct on the exchange instead of entering into long-term contracts.

There are a number of gas traders that are still bound by the long-term contracts, which were often signed with, for example, Gazprom or Statoil. This has given rise to individual, confidential renegotiations, in which the price to some extent is adapted to the current market, thereby eliminating the difference between the contract price and the exchange price to some degree.

Increased exchange trading

Generally, trading on the European gas exchanges is growing in present years, and both producers and gas purchasers have become more confident that they can sell as well as purchase gas at competitive prices. This means that the European gas market is increasingly resembling other markets.

The players point to the fact that there are challenges associated with planning new investments in a market where gas producers and other investors do not know the future gas price. On the other hand, as a result of increased liquidity on the gas exchanges, market players have better options for choosing between contract types to hedge risks, including financial contracts.

These discussions are a good example of the gas market becoming more and more like other markets as uncertainty about gas prices can now be handled through several different types

of contracts. It is precisely the players' choice that leads to a reduction in the share of long-term contracts. The result is that the gas portfolios become more diversified with both long and short-term contracts.

Facts

- The European Commission wants to promote trading on gas exchanges to strengthen liquidity.
- The largest and most liquid gas exchange in the EU is the British NBP hub. Other major exchanges can be found in the Netherlands and Germany.
- The Danish gas exchange Gaspoint Nordic A/S is also seeing increased demand.

4.1.6 Low CO_2 emission allowances put under pressure

Natural gas must support the green energy transition in Europe. Low CO_2 prices put the market for natural gas under pressure, whereas coal is gaining ground.

In its Energy Roadmap 2050, the European Commission points out that natural gas has great potential for contributing to the green energy transition in Europe, because natural gas only emits half as much CO_2 as coal.

Coal's competitiveness strengthened

Coal still accounts for a significant share of the European energy consumption. It will therefore bring substantial climate benefits if natural gas replaces coal in Europe. In order to promote this development, the EU established a common CO_2-emission allowance market in 2005 with the aim of promoting investments in CO_2-reducing technologies.

However, the financial crisis in Europe has reduced the demand for CO_2-emission allowances. This, together with the growing share of renewable energy, has caused the CO_2 price to slump to a level where CO_2 can be emitted almost at no cost in the EU. That was not the intention of the emission-allowance market.

Development in CO_2-emission allowance prices in the past three years. Source: PointCarbon.

This boosts the competitive advantage of coal as the CO_2 cost of burning coal is reduced considerably while the price of coal has fallen. Against this background, it is currently less profitable to invest in gas-fired power plants.

Need for improving emission-allowance market

Denmark and a group of other EU countries that also focus on climate change have been working with the European Commission to improve the framework for the CO_2-emission allowance market via the so-called back-loading scheme. The aim of the scheme is to reduce the number of emission allowances in order to increase the price.

Member states have not yet agreed on a revision of the emission-allowance system, whereby CO_2-emission allowances will be removed for a specific period of time. On 8 November 2013, the European Parliament decided to support the Commission's proposal subject to certain amendments. The next step in the process is the trialogue negotiations between the Council, the EU Commission and the Parliament.

Facts

- The EU's emission-allowance trading system is the world's largest market for CO_2
- Back-loading means that 900 million emission allowances will not be put to auction in the period 2013-2015, but are saved for 2019-2020. The intention is to make the emission allowance price go up.
- A natural gas-fired power plant emits around half as much CO_2 as a coal-fired power plant.

4.1.7 European gas-fired power plants challenged

The competitive situation for natural gas means that gas-fired power plants in Europe have found it difficult to make ends meet.

Natural gas-fired power plants in Europe are currently under pressure on two fronts, which makes it difficult for the owners of even some of the most modern and efficient gas-fired plants to have a reasonable return on their investments.

On the one hand, the growing share of capacity based on renewable energy is helping to reduce the need for plant capacity based on fossil fuels.

On the other hand, the low prices of CO_2-emission allowances and the historically low coal prices compared to natural gas mean that coal-fired power plants have lower production costs.

Gas-fired power plants as backup

Although the outlook for gas-fired power plants in Europe is gloomy, the gas-fired power plants are expected to play an important role in the green energy transition. The gas-fired power plants must to a far greater extent supply electricity and heat in non-windy conditions, increasingly serving primarily as backup facilities that are in demand only for short periods of time, which challenges the existing business model.

German plants considering closure

In Germany, several plant owners have announced that they are considering closing or even moving some of their gas-fired power plants.

This has sparked a debate concerning the security of electricity-capacity supply in Germany, which is under particular pressure in Southern Germany. The authority responsible for security of supply, BundesnetzAgentur, therefore monitors the electricity capacity development in the energy market closely in a situation where Germany is shutting down its nuclear power plants.

Facts

- Natural gas emits approximately half as much CO_2 per produced kWh as coal does.
- Germany's second largest electricity producer RWE produced 66% of its electricity using coal in the first nine months of 2011. In 2012, the corresponding figure rose to 72%.
- The financial crisis in Europe has led to a reduced demand for energy in general.

4.1.8 *European gas-storage facilities under pressure*

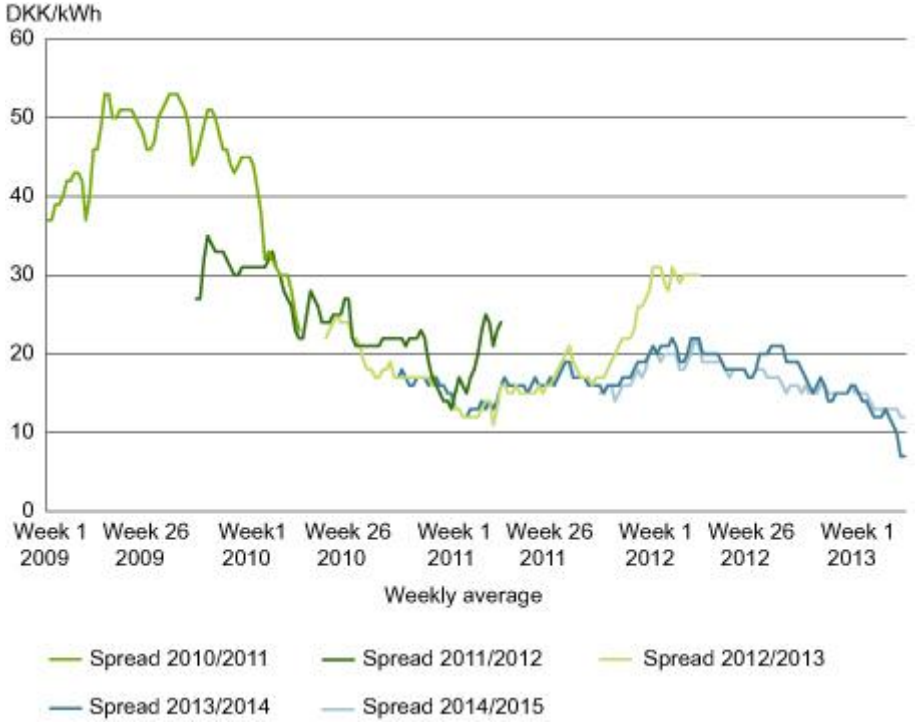
The reduced demand in the European gas market impacts the storage facilities, whose services are not in as much demand as previously.

With the liberalisation of the European gas market, the gas-storage facilities have become independent business units that have maintained their earnings by offering gas-storage capacity. Among other things, the capacity ensures the security of gas supply during the cold winter period where gas is in particularly high demand.

Reduced storage requirement in Europe

The limited demand for natural gas in Europe has now led to a surplus of natural gas and transport capacity in Europe. As a result, there are no discernible fluctuations in gas prices between summer and winter, which strains the finances of European storage companies.

The seasonal difference thus fell from DKK 45-60/MWh before 2008 to less than DKK 15/MWh in 2013, which has a direct effect on the gas-storage facilities' value. If this situation continues, it will result in gradual capacity adjustments in the European market.



Forward on price spread between summer (Q2+Q3) and winter (Q4+Q1). Source: TTF.

What can change storage requirements in Europe?

The storage capacity requirement could change a great deal if the financial development accelerates, or if the relationship between coal and gas prices changes, making it difficult to predict the long-term storage requirement.

In the long term, the storage requirement (in addition to seasonal adjustments) will, among other things, be determined by:

- Development in the economic activity
- Relationship between coal and gas prices

- Requirement for storage capacity for the production of biogas and other RE gases
- Extent to which the gas system is used as a reserve and peak-load storage facility
- Security of supply for supplies to Europe (Russia, Norway, Algeria etc.).

In future, the European gas-storage facilities will have to adapt to the development in new markets and the changed market conditions.

Contribution to security of supply

The storage facilities play a key role in dealing with critical supply situations as they have a significantly larger withdrawal capacity than is seasonally necessary. The purely seasonal use of the storage facility is thus traditionally an important contribution to the overall security of supply for both gas, electricity and heat.

In the present situation, the difference between the value of storage gas from summer to winter is so small that it is not certain that the market players will choose to fill the storage facilities. This means that the storage facilities will not necessarily be available in situations where the security of gas supply is being challenged.

Facts

- In Denmark, there are two gas-storage facilities, Stenlille and Lille Torup. The gas-storage facilities are operated commercially and owned by DONG Energy and Energinet.dk, respectively. The storage facilities have a total capacity of 1 billion Nm^3.
- In Europe, the total storage capacity is more than 70 billion Nm^3.

4.1.9 Harmonisation of gas qualities

The increased cross-border gas trading calls for greater harmonisation of gas qualities across the EU. Denmark participates actively in this work.

In recent years, a growing share of the Danish gas supply has come from the Danish North Sea production and gas imports from the North German system. At times, this has led to varying gas qualities as the gas supply from Germany is of a different and more varying quality than the Danish North Sea supply.

European harmonisation of gas qualities

Together with the Netherlands, France, Spain, Germany and Denmark, Denmark is participating in an EU-funded project headed by Marcogaz and EASEE-GAS.

The purpose of the project is to identify a viable path to implementing the broadest possible joint gas quality specification that takes into account variations in the appliance population and installation practices in the five participating countries.

The objective for 2013 is to complete a mapping of the challenges facing each country's appliance population. The mappings are then compared to identify general challenges that need to be solved jointly.

Parallel to this, a common European gas quality standard is being prepared by CEN in TC 234 WG 11. The project's final conclusion, which is expected in 2014, will be incorporated in the CEN standard.

In Denmark, the project is headed by the Danish Safety Technology Authority and Energinet.dk. The group works with a national reference group, which encompasses relevant players in the supply chain and gas consumers.

Upgraded biogas

As the gas imports from the European gas system increase, more biogas will be injected into the network in the long term.

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, which is at the lower end of the variation range permitted in the Gas Regulation.

In the new section for the Gas Regulation, the Danish Safety Technology Authority lays down requirements for the quality of upgraded biogas being fed into the gas system. This ensures that the upgraded biogas can be used safely by consumers on an equal footing with natural gas.

Facts

- The Danish Safety Technology Authority is the authority responsible for the Gas Regulation, which regulates the gas quality requirements.
- In early 2012, the Danish Safety Technology Authority published a new section for the Gas Regulation with an extension of the gas-quality specification. A measuring programme for gas consumers has been planned as part of the extension and acceptance of a greater variation in gas quality. The measuring programme will be initiated when gas is supplied within the extended interval.

4.2 Towards a greener gas system

Energinet.dk and the distribution companies have removed technical and market-related obstacles, allowing biogas to be supplied and traded in the gas system.

Energinet.dk is working to introduce gas from renewable energy (green gas or RE gas) into the network. Biogas from liquid manure will make the gas system greener, with other RE gases to be added later.

A greener gas system is a key element to converting the energy system to 100% renewable energy by 2050. Via the gas network, RE gases can reach new markets and new applications such as transport. Small volumes of biogas are already being transported in the gas system.

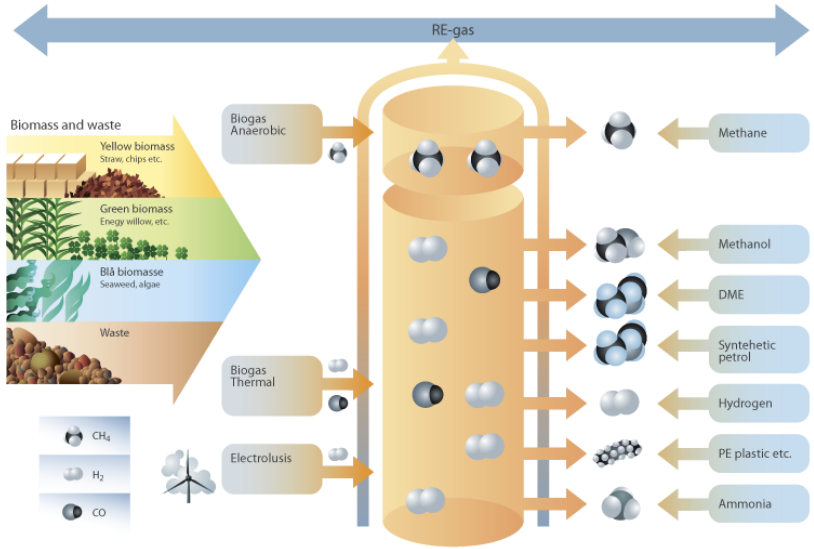
Energinet.dk expects biogas volumes to increase significantly in the years to come as several of the technical and market-related obstacles have been eliminated. This includes, among other things, the possibility of supplying biogas to the gas network, after which it can be traded and used as natural gas. In 2013, common rules on bio-natural gas trading were introduced, allowing biogas to be traded across borders.

What are RE gases?

Biogas and other RE gases are renewable energy from sources that are replenished on an ongoing basis. Since the biomass has absorbed the same amount of CO_2 during its growth as is emitted by burning, biogas helps to reduce CO_2 emissions when it replaces fossil fuels.

Three RE gases are expected to play a role in the future energy system. This is illustrated in the figure on the left:

- Biogas from anaerobic degasification (top)
- Biogas from thermal gasification (centre)
- Gas produced by means of electrolysis based on renewable energy sources (bottom)



Biomass can be converted into methane or synthesis gas, which can be used as chemical building blocks in a wide variety of products.

Biogas can be produced through the anaerobic decomposition of liquid manure and plant matter to produce gas containing approximately 65% methane and 35% CO_2.

Biogas can also be produced by converting biomass to gas through thermal gasification. This produces synthesis gas consisting of hydrogen and CO.

Synthesis gas can also be produced from water using electrolysis, whereby water is split into hydrogen and oxygen. If the electricity used derives from wind turbines, solar cells or other renewable energy sources, the hydrogen produced will be fossil-free.

Role of RE gases

Gas from renewable energy may be an important element of tomorrow's energy system as gas can be produced flexibly from biomass, waste and, in the longer term, even from electricity based on renewable energy.

The RE gases can then replace fossil fuels in a number of sectors and in the long term constitute the chemical building blocks in a number of products. Examples of these fuels are shown on the right in the figure above. The fuels may, for example, be used in the transport sector as a replacement for petrol and diesel.

Facts

- Synthesis gas consists of H2 and CO and can be converted to a number of other fuels using catalysis.

4.2.1 Biogas on its way into the network

Biogas supplied to the network is already being used in our neighbouring countries. In Denmark, the development is especially being delayed due to delayed approval of a subsidy scheme.

The objective of the energy agreement in 2012 was that 50% of livestock manure was to be used for biogas, corresponding to an increase from 4 PJ today to 17 PJ in 2020. At the same time, upgrading was given the same status as the use of combined heat and power.

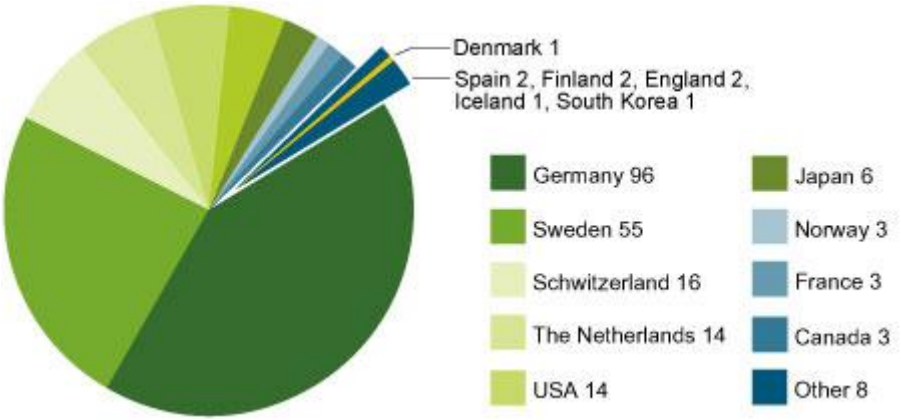
Since spring 2012, a large number of projects have been initiated, but the realisation of them is delayed as the subsidy schemes have not yet been accepted by the EU.

The Danish Energy Agency assesses that a tripling of biogas production to 12 PJ is possible in the coming years. A survey with 40 participating projects in summer 2013 showed that 18 were planning to upgrade the gas, so that it can be sent straight into the gas network, whereas 12 were planning to sell it directly for combined heat and power. The remaining ten either did not respond or had chosen a different solution.

In 2013, Energinet.dk processed three applications from very large biogas plants planning to sell to the transmission network. In addition, Energinet.dk has information about approximately 35 projects that are examining the possibility of selling biogas to the network.

Biogas widely traded in the network in the neighbouring countries

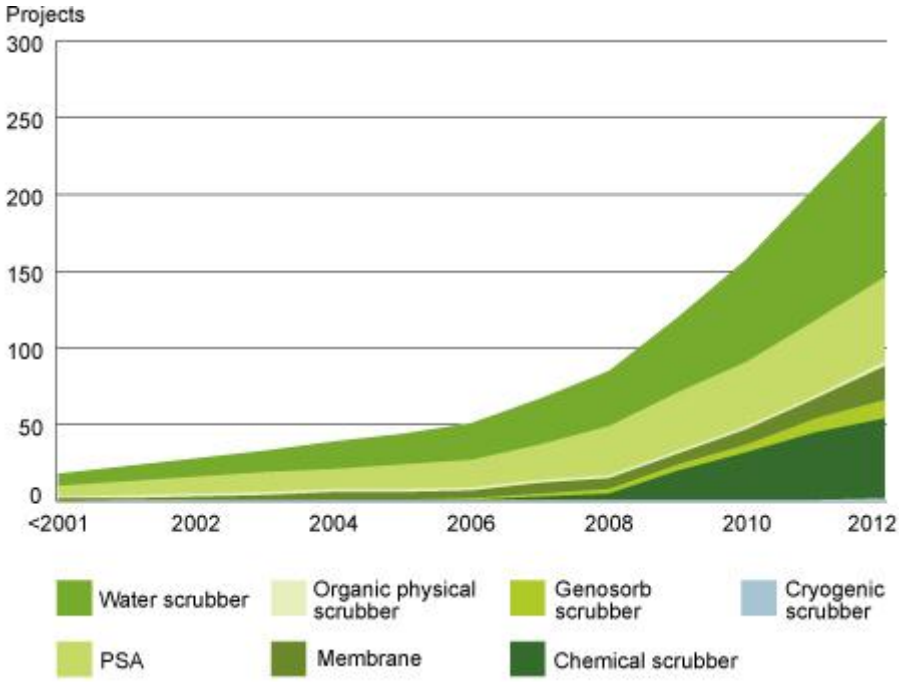
Upgrading and injection of biogas into the gas network is a well-known technology, which is growing rapidly in the neighbouring countries. In Denmark, there is only one demonstration plant upgrading biogas to the network, whereas there are more than 250 commercial upgrading plants in the rest of the world. They can be found mainly in Germany and Sweden.



Number of biogas projects broken down by country. Source: IEA Task 37.

Various upgrading solutions are commercial

The number of upgrading plants has seen rapid increase, particularly in the past decade. As can be seen from the figure, there are a number of upgrading technologies on the market, each with its own advantages and drawbacks.



Development in the number of plants in service broken down by different biogas upgrading technologies. Source: IEA Task 37.

In 2013, DONG Energy and Naturgas Fyn in Denmark announced framework agreements with suppliers of water scrubber plants. Water scrubbers is the most widely used upgrading technology and is the one used in DONG Energy's demonstration plant near Fredericia.

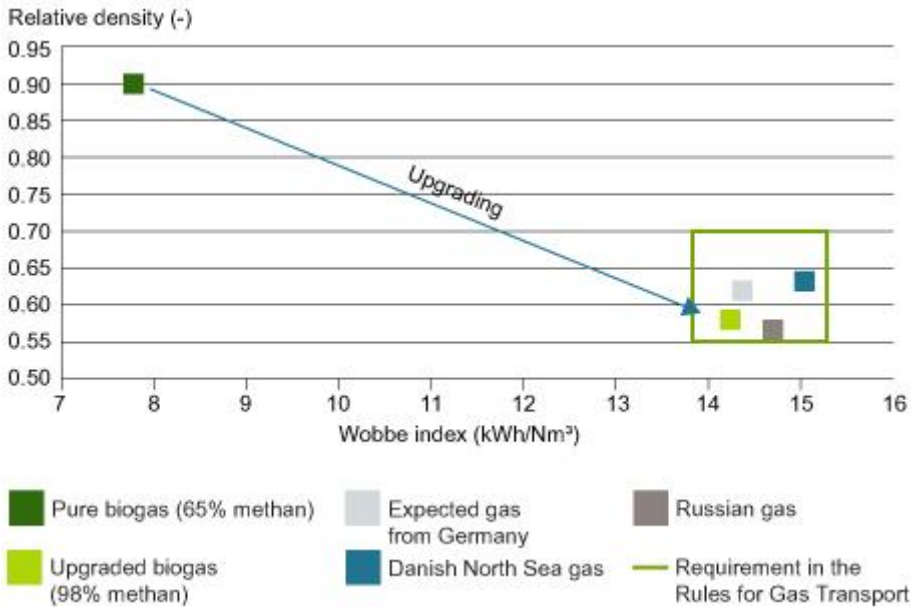
Also, at the Hashøj biogas plant, an amine-based scrubber upgrading plant, which upgrades part of the gas production, has been demonstrated in the past year. This plant is not used to upgrade the gas for the transmission or distribution network.

4.2.2 How is biogas upgraded and injected?

Biogas is upgraded to bio-natural gas before being supplied to the gas network. It is then traded and used as natural gas.

Biogas is produced by decomposition of organic material, such as liquid manure or slaughterhouse waste. Biogas typically consists of approximately 35% CO_2 and 65% methane. Biogas also contains water vapour, hydrogen sulphide and other trace elements.

Before the biogas can be supplied into the gas system, it must be upgraded so that it has combustion characteristics similar to those of natural gas, allowing it to be used in the existing installations currently using natural gas.

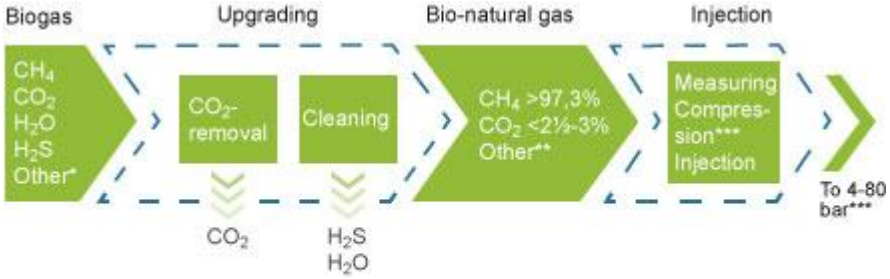


Due to combustion characteristics, biogas must be upgraded before it can be supplied into the gas system.

What happens during the upgrading process?

The upgrading process involves both the removal of CO_2 and cleaning of H_2S and water vapour. For CO_2 removal, different process techniques are used: amine-based scrubber, water scrubber or pressure swing absorption (PSA).

The biogas typically goes through a cleaning process which removes water, sulphur etc.



* Trace elements, O_2 mm
** Cf. Requirements in the Danish Gas Regulation
*** After-compression is not always necessary
**** Depending on network

Schematic overview of elements in biogas upgrading to the gas system.

The upgraded biogas – bio-natural gas – must be measured before it is supplied into the gas system in the interest of settlement of the gas and control of the gas quality.

Depending on which network the bio-natural gas is to be supplied to, the pressure must be increased sufficiently through compression.

Facts

- Section C-12 of the Danish Gas Regulation specifies the requirements for gas distributed in Denmark. The Danish Safety Technology Authority is the authority responsible for the Gas Regulation.
- Energinet.dk specifies the requirements for gas in the transmission grid in Rules for Gas Transport. The requirements apply to border points and entry/exit points in the transmission grid. Specifications can be found in Rules for Gas Transport, appendix 1, and in the Gas Regulation, C-12.

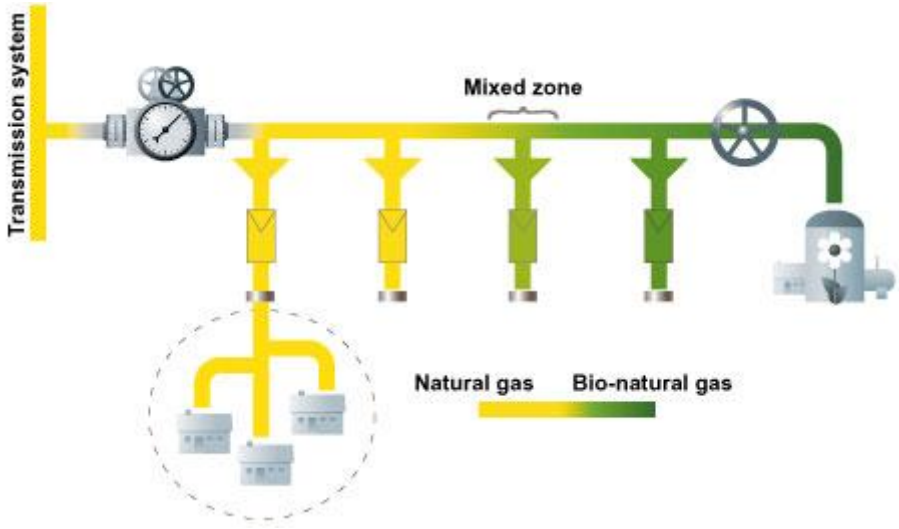
4.2.3 How does biogas affect the gas system?

Bio-natural gas has a different calorific value from that of natural gas. This poses a challenge to correct settlement of consumer accounts.

Upgraded biogas (bio-natural gas) has similar combustion characteristics to natural gas and consists of a mixture of methane and CO_2. Bio-natural gas typically has a low calorific value and a Wobbe index, which is at the lower end of the variation range permitted in the Gas Regulation.

The network companies are obliged to ensure sufficiently accurate settlement of gas consumer accounts. The calorific value of the gas is an important element in the settlement basis as it is used to correct the cubic metre readings on the consumers' gas meter to reflect energy consumption.

The calorific value of bio-natural gas typically differs from the calorific value of the other gas in the network. This may pose new settlement challenges to the network company depending on the connection point and flow conditions in the respective network.



Networks supplied with both natural gas (yellow) and bio-natural gas (green). When the two gas fronts meet, consumers will receive a mixture of natural gas and bio-natural gas.

How to ensure correct settlement of consumer accounts

Network companies have several possible solutions to ensure that consumer accounts are settled correctly, for example by:

- Establishing connection of bio-natural gas at M/R stations
- Dividing the network into smaller sections, each with well-defined supply
- Installing additional gas-quality measuring equipment in the network
- Calculating the gas quality in different parts of the network through
- 'quality tracking'
- Settling parts of the network at a lower calorific value
- Adding propane to raise the calorific value
- Combining the above solutions.

It is the network companies that choose the most effective tools to ensure correct settlement. The Danish network companies have no plans to use propane addition as a solution to the settlement challenge as it is an expensive and fundamentally wrong approach to the greenification of the energy sector.

4.2.4 Bio-natural gas now tradeable

In 2013, common rules for bio-natural gas trading were introduced. Energinet.dk further develops the bio-natural gas certificates, allowing them to be traded across borders.

The launch of Rules for Bio-Natural Gas on 1 May 2013 made it possible to send upgraded biogas into the gas network via the distribution and transmission systems. Bio natural gas can now be traded commercially on an equal footing with ordinary natural gas, and biogas producers can sell their biogas on the internationally connected gas market and obtain the gas price applicable at any time.

This way, bio-natural gas from Western Jutland can be sold in Sweden or any other country in Europe.

Linkogas biogas plant, Lintrup, Jutland.

Certificates can be sold

In addition to income from upgrading funding and the sale of gas, the bio-natural gas producers may sell bio-natural gas certificates documenting that a similar volume of natural gas has been replaced by biogas.

Bio-natural gas thus has three income elements:

- Current gas price in the gas market
- PSO funding for upgrading (awaiting EU approval)
- Value of RE certificate

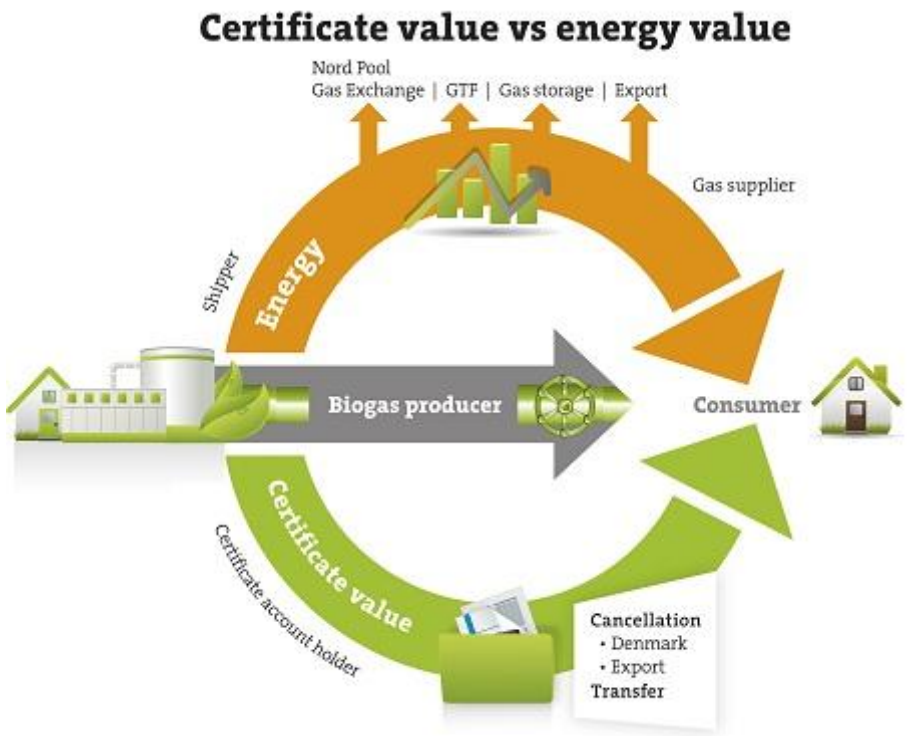
Energinet.dk and the network companies are working on expanding the rules to also include gasification gas from, for instance, wood waste and synthesis gas from, for example, surplus wind.

The bio-natural gas certificates guarantee that the certified volumes of RE gas replace a similar volume of natural gas. The scheme makes it possible to trace the bio-natural gas through the supply chain – from the biogas producer, via the upgrading plant and on through the gas system to the consumers. This way, buyers can verify the origin of the gas they buy.

International cooperation

However, there is a long way to go before an actual European market for certificates becomes reality. The Danish certificate model does not yet meet the EU's documentation requirement for sustainability and mass balance so as to help fulfil the objective of 10% renewable energy for transport in 2020.

Energinet.dk and other European bio-natural gas certificate registers therefore signed a Letter of Intent to strengthen cooperation in finding a common solution. In 2014, Energinet.dk will focus on further developing the certificates in conformity with the Danish gas market model.



The bio-natural gas certificate documents that biogas replaces a similar volume of natural gas.

4.2.5 Biogas for transport

Biogas can play an important role as an alternative fuel in the transport sector, especially in heavy transport, both socio-economically and in terms of the climate.

Biogas for transport is seeing strong growth in our neighbouring countries. In Denmark, the framework conditions have so far hampered the increased use of gas – and thereby also biogas – in the transport sector. Market players are in the process of establishing the first gas-filling stations to introduce the technology and provide experience in a Danish context. This will pave the way for biogas to be used for transport.

Photo: Naturgas Fyn

Increased focus on gas for transport

There is broad political consensus that the total energy supply must be transformed to renewable energy by 2050. The transport sector is the sector which is currently furthest from this goal. In the Danish energy agreement 2012, policy decisions were made about initiatives and analyses aimed at ensuring that the transport sector can also begin this transformation.

Initially, DKK 20 million has been earmarked for supporting infrastructure development. Among other things, a partnership for gas in heavy transport has been established with key Danish players. The partnership is jointly managed by the Danish Energy Agency and the Danish Transport Authority, and Energinet.dk is among the partners.

In cooperation with the partnership, DKK 2 million is spent in 2013 on analyses that are to clarify the operational and socio-economic aspects prior to the establishment of a gas infrastructure for transport in 2014 and 2015.

Biogas for transport makes socio-economic sense

For society, the use of biogas as fuel in the transport sector is already one of the cheapest initiatives capable of replacing the use of oil in transport and reducing CO_2 emissions.

The Alternative fuels report published by the Danish Energy Agency analyses various fuels for passenger vehicles and heavy transport (buses and lorries) in the period up to 2030. The analysis shows that socio-economically biogas is among the best alternatives. This also applies in relation to petrol and diesel for both passenger vehicles and heavy transport throughout the period. In terms of the climate, biogas offers the maximum CO_2 reduction.

Run on biogas using RE gas certificates

When biogas is upgraded and injected into the nationwide gas network, it is mixed with the natural gas. Energinet.dk issues RE gas certificates for all biogas upgraded to the gas network.

For example, when a gas-filling station sells biogas to a consumer, the filling station buys a corresponding number of RE gas certificates. The certificate system thus ensures that the volume of gas withdrawn and bought as biogas by the consumer actually corresponds direct to an equivalent volume of biogas that was produced, upgraded and fed into the nationwide gas network.

The first initiatives

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 also available in a gas version.

Denmark has an extensive gas network, which is a major advantage in terms of establishing filling stations. Furthermore, the Danish Energy Agency expects that, up to 2020, there will be a production in Denmark of significant volumes of biogas that can also be used for transport and thereby help fulfill the transport sector's RE objective.

In 2013, a number of players in the Danish gas market took the first tentative steps with the establishment of infrastructure and demonstration of gas in heavy transport. In summer 2013, Naturgas Fyn established a commercial gas-filling station to serve the Municipality of Fredericia's city buses and waste-collection vehicles. The gas-filling station will be open for passenger vehicles 24 hours a day. There were already two small gas-filling stations in Skive (HMN) and Odense (Naturgas Fyn).

Three gas-filling stations in Copenhagen

E.ON and OK recently announced that they will be opening three gas-filling stations in Copenhagen. The ambition is for more to follow. The first station is scheduled to open on OK's installation on Jydekrogen in Vallensbæk at the end of 2013.

Sweden and Germany are seeing more activity in this area. COWI has prepared the Gas for the transport sector report for Energinet.dk. The report presents an overview of experience from Sweden and Germany with the introduction of gas in the transport sector, and the extent to which this experience can be applied to a Danish context.

4.2.6 International biogas cooperation

Energinet.dk contributes actively to developing the European market for bio-natural gas and finding common solutions to the transition to a greener gas system.

Energinet.dk has taken the initiative to strengthen the biogas cooperation in a number of forums within biogas as well as the traditional gas market.

The strengthened cooperation includes the promotion of technical and market solutions to the challenges of the green transition, for example:

- Further development of certificates
- Facilitating cross-border trading

- Common gas quality and technology requirements
- Identification of common projects
- General exchange of knowledge

Cooperation with European bio-natural gas-certificate registers.
On 17 September 2013, Energinet.dk signed a cooperation agreement with six European certificate registers for bio natural-gas.

The purpose of the cooperation agreement is to find common solutions that facilitate cross-border certificate trading. In the long term, they must meet the EU's sustainability requirement and help fulfil the transport sector's objective of 10% renewable energy in 2020.

Five European TSOs lead the way

Energinet.dk and the gas infrastructure companies Fluxys (Belgium), Gasunie (the Netherlands), GRTgaz (France) and Swedegas (Sweden) have signed a joint declaration to reach 100% CO_2-neutral gas supply in their networks by 2050.

The TSO cooperation considers biogas to be a special focus area where additional joint efforts are required in the coming years. In addition to closer cooperation, the ambition is also to strengthen the partnership with other European organisations such as Gas Infrastructure Europe (GIE).

The five companies will share knowledge, examine the possibilities for common demonstration projects and work to promote the establishment of an efficient RE-gas market in Northern Europe.

Gas quality, technical challenges and research requirements

Increased cross-border gas trading calls for increased harmonisation of gas qualities and common solutions to technical challenges across the EU.

Energinet.dk is participates actively in this work, among other things through the Marcogaz association, where the work on infrastructure has special focus on gas quality and biogas.

One of the intentions is for the authorities' regulation of the area to be based on the gas sector's own requirements and experience. Marcogaz has partnership projects on the technical aspects of green gases, including upgrading and injection of biogas into the network and the gas infrastructure's green-gas quality requirements.

The long term

The cooperation under the European Gas Research Group (GERG) focuses on the long term. The group identifies and prioritises the technical challenges for the gas system and the need for development. For example, GERG's strategic research road map has made knowledge building and research within biogas a priority, for example by examining and verifying the possibilities and effect of injecting a large volume of biogas into the existing gas network – and in the long term hydrogen.

Facts

- The 10% target in the transport sector appears from the RE directive prepared in 2008.

4.3 Gas for transport

Gas is expected to assume an important role in the transport sector as it is a good environmental and socio-economic alternative to petrol and diesel.

There is broad political consensus on transforming the total energy supply to renewable energy by 2050. The transport sector is the sector which is currently furthest from this goal.

In the broadly backed energy agreement concluded in March 2012, policy decisions were made about initiatives and analyses aimed at ensuring that the transport sector can also begin this transformation.

Gas fuelling, Photo: E.ON Denmark.

Gas for transport makes socio-economic sense

For society, the use of biogas and natural gas as fuels in the transport sector is already one of the cheapest initiatives capable of replacing the use of oil in transport.

The Alternative fuels report published by the Danish Energy Agency in February 2012 discusses various fuels for passenger vehicles and heavy transport (buses and lorries) up to 2030.

The analysis shows that biogas and natural gas are among the best socio-economic alternatives. This also applies in comparison to petrol and diesel for both passenger vehicles and heavy transport throughout the period. In terms of the climate, biogas offers the maximum CO_2 reduction.

Gas for transport in Denmark and the neighbouring countries

Natural gas and biogas have not traditionally been used for transport in Denmark, but there is an increasing interest in investigating the possibilities and demonstrating the technology in a Danish context. Naturgas Fyn, HMN Naturgas, OK and E.ON are some of the key players that work actively to develop the market and have invested in the first filling stations and gas vehicles.

Under the energy agreement, DKK 20 million was earmarked to support the demonstration and expansion of the infrastructure for gas for transport. An analysis was conducted in 2013, which will serve as the basis for allocation of the funds in 2014. To support the development, a partnership for gas in the transport sector has been established with key Danish players.

In Sweden and Germany, there is greater activity in the area, and the political objectives are supported by the countries' tax policy. COWI has prepared the Gas for the transport sector report for Energinet.dk. The report presents an overview of experience from Sweden and Germany with the introduction of gas in the transport sector, and the extent to which this experience can be applied to a Danish context.

Run on biogas with RE gas certificates

When biogas is upgraded and introduced into the nationwide gas network, it is mixed with the natural gas. Energinet.dk issues RE gas certificates for all biogas upgraded to the gas network.

For example, when a gas filling station sells biogas to a consumer, the station purchases a corresponding number of RE gas certificates. The certificate system thus ensures that the volume of gas the consumer has withdrawn and purchased as biogas actually corresponds directly to an equivalent volume of biogas. Biogas has been produced, upgraded and injected at some point in the nationwide gas network.

Liquefied natural gas in sea transport

Liquefied natural gas (LNG) is an interesting fuel for sea transport in terms of environmental, health and climate parameters.

In addition, LNG world market prices are lower than corresponding prices for conventional fuel oil for sea transport, and a number of Danish ports and shipping companies have expressed an interest in LNG for sea transport.

4.3.1 *Infrastructure for gas in transport*

Energinet.dk is working on establishing a gas infrastructure for the transport sector with new gas filling stations and cooperation between the energy and transport sectors.

The first small Danish fleet of 14 gas vehicles was purchased by Naturgas Fyn in autumn 2011. At the same time, Naturgas Fyn established a gas-filling station in Odense. Since then, a number of new initiatives have been introduced in the whole of Denmark.

New gas-filling stations

In summer 2013, Naturgas Fyn established a new commercial gas-filling station in Fredericia to serve the Municipality of Fredericia's city buses and waste collection vehicles. The station will also be open for passenger vehicles 24 hours a day.

In Skive, HMN Naturgas and the Municipality of Skive have opened a public gas-filling station, which is to supply the Municipality of Skive's and HMN Naturgas' gas vehicles as well. Initially, customers will only be able to purchase natural gas, but it is expected that upgraded biogas will be available in a few years via the certificate model.

E.ON and OK recently announced that they will be opening three gas-filling stations in Copenhagen. The ambition is for more to follow. The first station is scheduled to open on OK's installation at Jydekrogen in Vallensbæk at the turn of the year 2013/14.

Several municipalities have expressed an interest in acquiring gas-fuelled buses that can run on biogas. Holstebro has decided to establish a gas-filling station in cooperation with Vestforsyning and Midttrafik. The station is being put to tender and opens in July 2014 with a view to ensuring that ten city buses run on bio-natural gas instead of diesel. In the long term, the plan is for Vestforsyning's own 50 vehicles to be able to fill up with gas at the filling station. To this should be added the private vehicles in the municipality that can run on gas. It is estimated that the filling station will have an annual gas consumption of at least 270,000 Nm^3.

Roll-out of gas-filling infrastructure

In the energy agreement concluded in 2012, the parties decided to support the infrastructure for alternative fuels with a total of DKK 70 million in the period 2013-2015.

An amount of DKK 20 million was earmarked for initiatives involving gas in heavy vehicles. Of this, DKK 2 million is spent on analyses in 2013 to clarify the operational and socio-economic aspects prior to the establishment of the infrastructure in 2014 and 2015.

Strategic partnership

Based on the energy agreement, a strategic partnership for gas in the transport sector was formed in 2013 between the Danish Energy Agency, the Danish Transport Authority and central players in this field. Energinet.dk participates together with a number of energy companies, fleet operators, non-governmental organisations, research institutions and authorities.

The aim of the partnership is to ensure a higher degree of involvement in and ownership of the allocation of the pool funds, and to make sure that the stakeholders in this field create a transparent and broad platform for the continued work on gas in the transport sector.

The agencies have put forward a number of key conditions for the partnership and the further roll-out of gas in the Danish transport sector:

- The immediate CO_2 effect of replacing diesel with natural gas is limited.
- Gas is more suitable for heavy transport because, in terms of energy efficiency and CO_2 replacement, fossil fuels in light (passenger) transport are best replaced by electricity.
- If the aim of increasing the share of gas in transport is CO_2 replacement, natural gas in the transport sector should be replaced by biogas in the long term.
- There may be other significant benefits associated with the increased use of gas in the transport sector, including security of supply and security of prices.

Finally, in continuation of the Climate Policy Plan, the Danish Minister for Transport decided that a road map is required for how the transport sector should, in the short and long term, work towards the government's objective of making the transport sector fossil fuel-free in 2050. The gas sector is invited to join a monitoring task force.

4.3.2 Alternative fuels

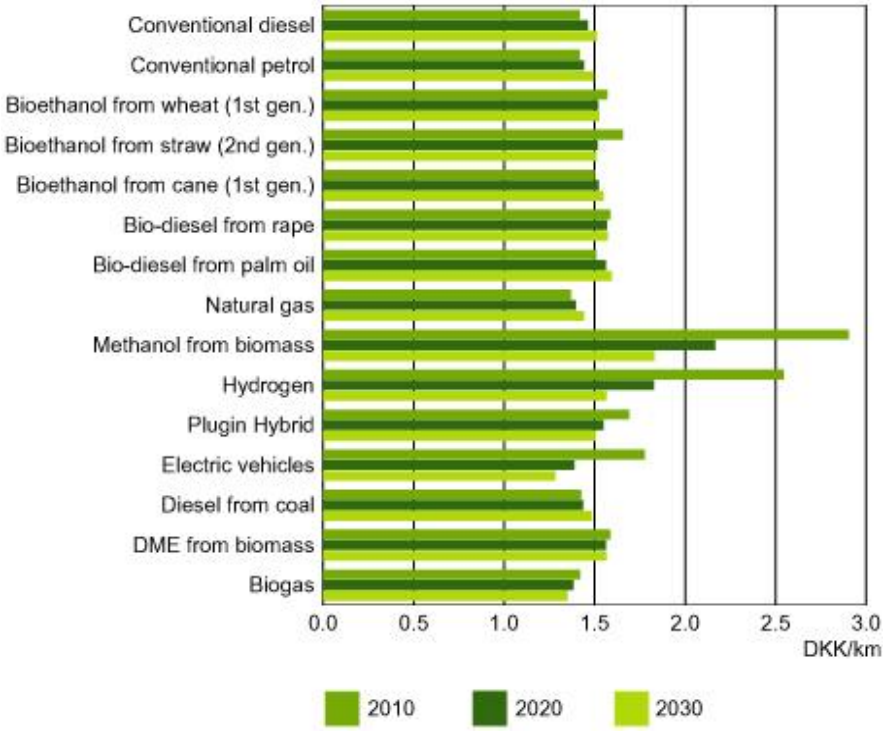
Biogas is one of the socio-economically best alternatives to traditional fuels for both passenger vehicles and heavy transport.

In May 2013, the Danish Energy Agency published an updated edition of the Alternative fuels report. The report analyses various fuels for passenger vehicles and heavy transport (buses and lorries) in the period up to 2030.

The analysis shows that biogas and natural gas are among the socio-economically best alternatives to traditional fuels for both passenger vehicles and heavy transport throughout the period. The findings apply to both petrol and diesel. The analysis takes into account the costs of the necessary infrastructure.

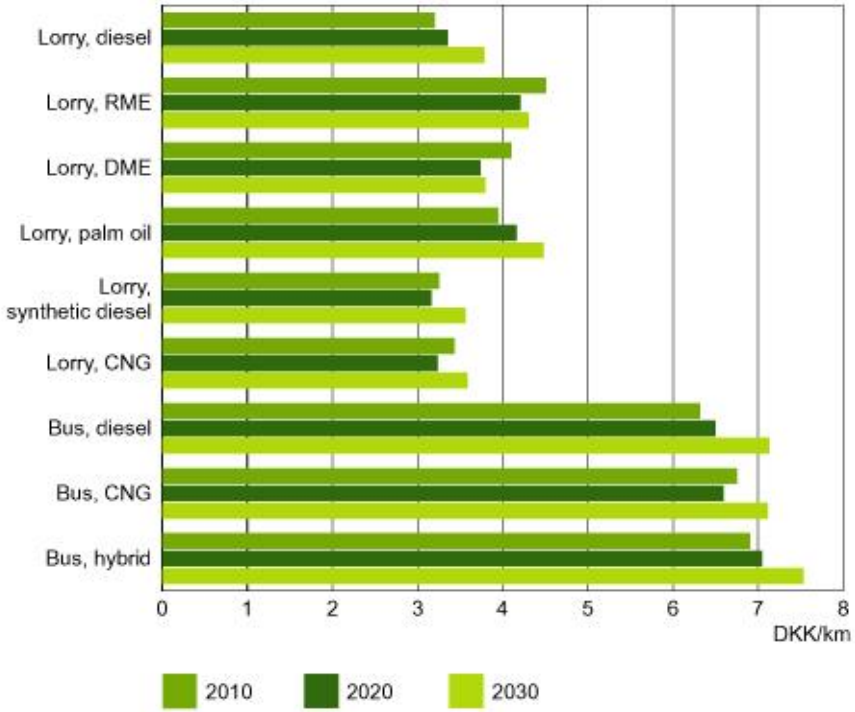
What about electric vehicles?

Electric vehicles are very energy-efficient, and, in terms of the environment and climate, they are an excellent alternative to petrol and diesel-fuelled passenger vehicles. However, from a socio-economic perspective, electric vehicles only become really interesting for passenger transport from 2020 as shown in the figure below.



The figure shows the socio-economic costs of passenger vehicles in 2010, 2020 and 2030. Source: Danish Energy Agency.

In the field of heavy transport, pure electric power is not expected to become an alternative for many years ahead, among other things due to limitations in battery technology. In the field of heavy transport, gas is believed to be the socio-economically best alternative for many years ahead as illustrated in this figure:



The figure shows the socio-economic costs of passenger vehicles in 2010, 2020 and 2030. Source: Danish Energy Agency.

Biogas best for the climate

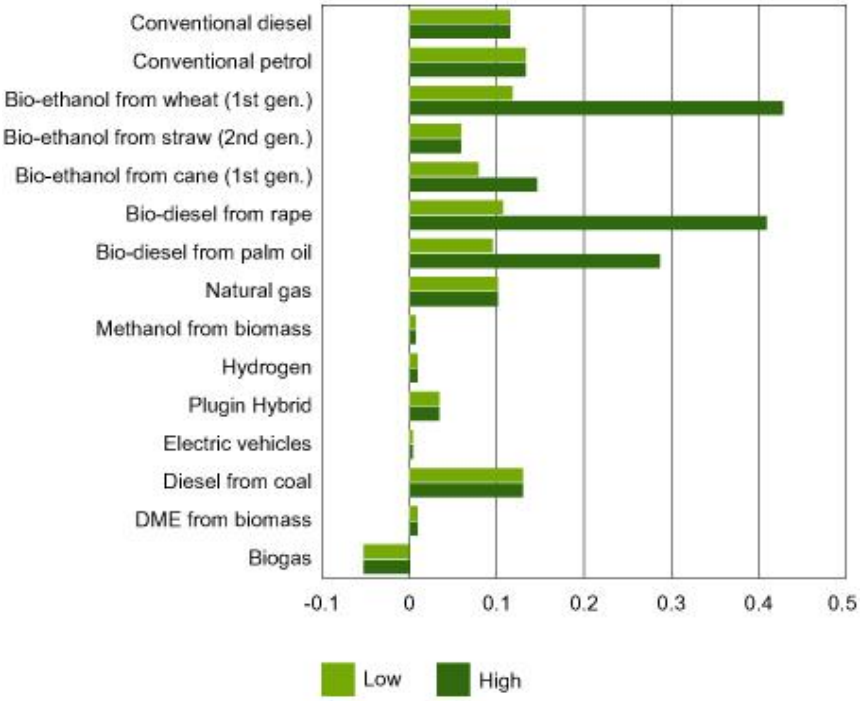
Natural gas is a fossil fuel and therefore emits CO_2. According to the analysis, the immediate effect of replacing diesel with natural gas is limited because of new requirements for more effective diesel and petrol engines, among other things. If the aim of increasing the share of gas in transport is CO_2 replacement, natural gas in the transport sector should be replaced by biogas in the long term.

Upgraded biogas can directly replace natural gas as fuel in a gas vehicle. Biogas has a major positive climate effect because methane from, for example, liquid manure is used to produce biogas rather than simply evaporating from pasture. Methane has a greenhouse effect about 25 times greater than that of CO_2.

Electric vehicles are expected to become increasingly climate-friendly as a greater proportion of our electricity is derived from renewable energy.

Contested climate effect of first-generation biofuels

The climate effect of first-generation biofuels is highly contested. This is because biomass could alternatively be used for food or feed. The Danish Energy Agency therefore analysed the climate effect of various fuels in the Alternative fuels report. The analysis includes the land used for growing biomass for the biofuels (ILUC effect).



Climate effect for passenger vehicles with different ILUC levels. Source: Danish Energy Agency.

The Danish Energy Agency is currently working on a better quantification of the ILUC effect. As a consequence of this, it is expected that the ILUC effect for solid biomass, for example, will be included.

The report shows, for example, that bioethanol produced from straw, which is a waste product from grain cultivation, has a much better climate profile than diesel, petrol or natural gas.

At the same time, there is much disagreement about the climate effect of bioethanol produced from wheat and biodiesel produced from oilseed rape or palm oil. The European Commission is working for more stringent biofuel requirements.

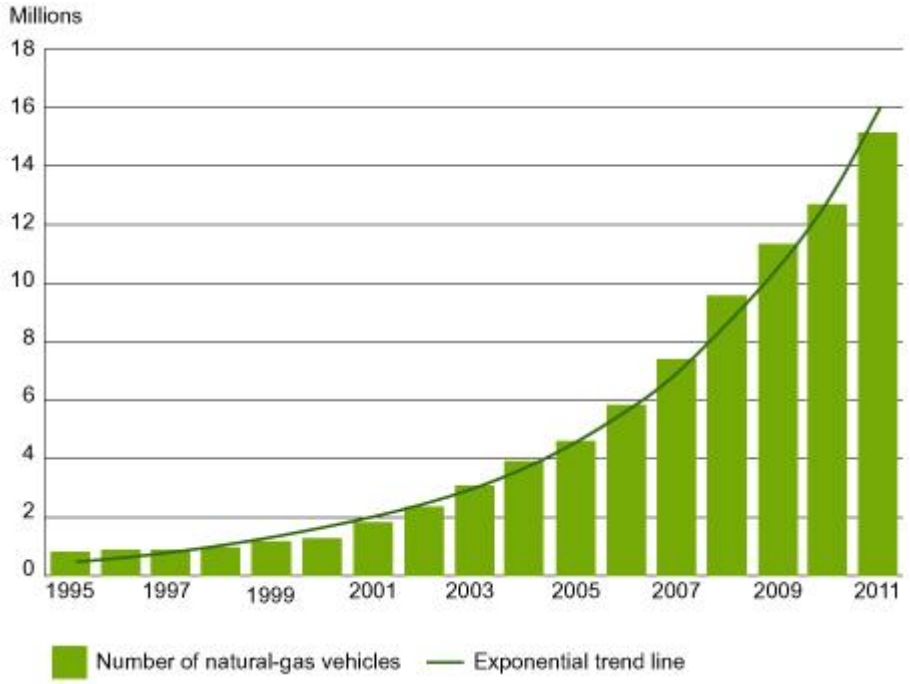
Facts

- First-generation biofuel is made from starchy and sugary raw materials such as grains, corn and sugar beets.
- Second-generation biofuel is made from raw materials with a dry matter content, such as straw, wood and organic waste.
- ILUC is an abbreviation for Indirect Land Use Change.

4.3.3 Gas for transport in the neighbouring countries

The last ten years have seen a dramatic increase in the use of gas for road transport around the world, but not in Denmark, which is lagging behind.

There were over 15 million gas-fuelled vehicles globally in 2011. Approximately 1.5 million of these were in Europe. Denmark saw the reintroduction of gas vehicles when Naturgas Fyn purchased the first small fleet of 14 vehicles in autumn 2011.



The last ten years have seen a dramatic increase in the use of gas for road transport around the world, Source: Natural Gas Vehicles Association.

Development in Germany and Sweden

Germany had approximately 95,000 gas vehicles in 2011. The tax on gas for transport and environmental zones in many large cities in Germany is low. Gas vehicles currently have much lower emissions of NO_x and other particles, particularly compared to diesel vehicles.

The Swedish Government has the objective of making the transport sector free of fossil fuels, and this has had a major impact. There were around 36,000 gas vehicles in Sweden in 2011.

Several factors contribute to the large number of gas-fuelled vehicles in Sweden:

- Biogas from forestry can be used in gas vehicles instead of natural gas.
- Petrol stations are required to have at least one filling station offering renewable energy. This is typically bioethanol, but can also be biogas.
- Gas vehicles receive preferential taxation.
- Regional and local governments have also played an active role through traffic policy objectives. For example, growth has been propelled by biogas-fuelled bus transport in Southern Sweden. One in every five new buses in Sweden currently runs on gas.

Denmark has great potential for using gas for transport

Denmark has a well-established gas network, which is a major advantage for the establishment of gas-filling stations. Significant volumes of biogas are also expected to be produced in Denmark up to 2020, which can also be used for transport and thereby help fulfil the transport sector's RE objective.

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 also available in a gas version.

Why haven't gas vehicles been introduced in Denmark?

From a socio-economic perspective, gas is already a better fuel than petrol or diesel. This is one of the conclusions of the Gas for transport report prepared by COWI for Energinet.dk in 2012.

The primary reason Denmark continues to lag behind is its failure to expand the filling-station infrastructure. This is the conclusion of the Potential and barriers for biogas and natural gas for transport in Denmark report prepared in August 2012 within the Transport Innovation Network and Øresund Ecomobility projects in cooperation with DONG Energy, E.ON and Naturgas Fyn.

Another barrier is the Danish tax structure, which does not promote gas for transport as is the case in the neighbouring countries Sweden and Germany. These countries pursue an active tax policy with a view to stimulating the development of gas for transport.

Growing interest in gas for transport in Denmark

In recent years, both politicians and gas market players have shown increasing interest in gas for transport.

The broadly backed energy agreement concluded in spring 2012 focuses on introducing gas in the heavy transport sector. Gas market players have also entered the fray. Naturgas Fyn and HMN Naturgas have both constructed public gas-filling stations, and E.ON and OK have announced that they will establish filling stations in the Copenhagen area. Several municipalities have also expressed an interest in acquiring gas buses that can run on biogas.

Facts

- The transport sector's RE objective is laid down in the EU's renewable energy directive prepared in 2009. Each member state is obliged to ensure a 10% share of renewable energy in the transport sector.

4.3.4 Market support for gas in transport

Biogas should play a significant role as fuel in the transport sector, but this has to be supported by the market, legislation and EU regulations.

The most effective solution is if gas is supplied to filling stations from the existing gas system. This ensures that customers can choose between filling up with biogas or natural gas via certificates.

Today, the renewable energy regulations of the EU's transport objective do not support the inclusion of biogas supplied from the gas system via biogas certificates.

The Renewable Energy Directive from 2009 needs to be amended such that, in future, biogas traded via certificates can be included when calculating the share of renewable energy used for transport.

The directive stipulates that the transport sector must use 10% renewable energy by 2020. To date, this goal has been furthered in Denmark by requiring oil companies to mix biofuels into the petrol and diesel they sell.

European Commission working on more stringent biofuel requirements

In October 2012, the European Commission proposed an amendment of the directive. The amendment is to ensure that biofuels used to fulfil the 10% objective are produced sustainably.

The proposed amendment limits the possibilities of fulfilling the objective using biofuels produced from food products or using agricultural land where food products have been supplanted.

The proposal is generally positive in terms of promoting biogas for transport as biogas produced from manure and other waste will be more competitive.

The proposal does not, however, allow for the possibility of including biogas traded via certificates, unless the Commission's requirements for documentation of sustainability and mass balance are met.

4.3.5 LNG: Liquefied natural gas in sea transport

There are many opportunities and great potential for introducing liquefied natural gas in sea transport, but also challenges.

Natural gas is significantly cleaner than diesel and particularly the heavy diesel oil traditionally used in sea transport, both in terms of sulphur (SO_x) and nitrous oxide (NO_x) emissions.

LNG (Liquefied Natural Gas) is highly compressed, and an LNG tank therefore contains much more energy than the corresponding volume in gas form. Liquefied natural gas is therefore particularly interesting as a fuel for sea transport in relation to both the environment and health.

The prices of LNG on the world markets are lower than the equivalent prices of conventional fuel oil for sea transport. A number of Danish shipping companies have expressed an interest in using LNG for sea transport.

LNG can dramatically reduce pollution

Many ships pass through Danish waters due to Denmark's location at the entrance to the Baltic Sea. Today, emissions from sea transport contain a number of substances that are harmful to human health and the climate, and which have been attracting increasing attention in recent years. Particularly the content of SO_x and NO_x in flue gases is subject to attention.

More stringent environmental requirements from 2015

The emissions requirements in the North European ECA area will be tighten significantly from 1 January 2015 when the sulphur cap is lowered to 0.1%. Tolerances will be will be further tightened from 1 January 2016 with a requirement for new constructions complying with strict NO_x emissions requirements.

To comply with environmental requirements, ships should therefore install flue-gas treatment systems or use alternative fuels such as diesel and LNG. Ships propelled by LNG

can immediately fulfil the stringent new requirements. However, shipping companies assess that LNG is particularly attractive for new vessels, whereas the establishment of flue-gas treatment or use of diesel is preferred on existing ships.

New infrastructure required

In order for shipping companies to convert a proportion of sea transport to LNG as a fuel, an infrastructure to support this needs to be established, such as gas 'filling stations' at ports where gas can be bunkered.

The LNG infrastructure is being expanded in our neighbouring countries by the Baltic Sea such as Sweden, Germany and Poland. Several Danish ports and shipping companies are expressing an interest in establishing LNG bunkering facilities, but concrete projects are few and far between. The Danish Maritime Authority and the shipping industry have identified a number of barriers for realising the LNG initiatives in Denmark.

A large LNG tank for bunkering ships located in the vicinity of an existing gas network could relatively easily be configured to convert LNG to traditional natural gas to be supplied into the gas network. It is therefore possible to integrate the LNG infrastructure with the existing gas network to achieve a wide range of market and supply-related synergies.

Hirtshals leads the way

The Fjord Line ferry line, which sails between Hirtshals and Norway, has purchased two ferries that only run on LNG. The first, MS Stavangerfjord, was deployed in summer 2013. Hirtshals thus becomes the first location in Denmark to use LNG on departing vessels, and it was also the first location where LNG was bunkered.

According to the plan, bunkering would take place from LNG facilities in Norway. In the beginning, however, bunkering primarily took place in Hirtshals as Norwegian legislation did not yet allow bunkering with passengers on board. However, this issue has been solved so that Fjord Line can move the majority of the fillings to the Norwegian town Risavik and avoid having to send a large number of road tankers to Hirtshals to fill the ferries in Denmark.

Fjord Line purchases LNG from Skangass, whose plant is only a few hundred metres from Fjord Line's terminal in Risavik.

The Port of Hirtshals continues the work to establish an LNG terminal in the port.

Other ferries on the way

Other shipping companies in Denmark are also working to get LNG ships. For example,

- The Samsø ferry has ordered an LNG-fuelled ferry for delivery in 2014.
- Scandlines has signed a Letter of Intent with a Finnish shipyard on building ferries for the Gedser-Rostock route, which are scheduled for commissioning in 2015.

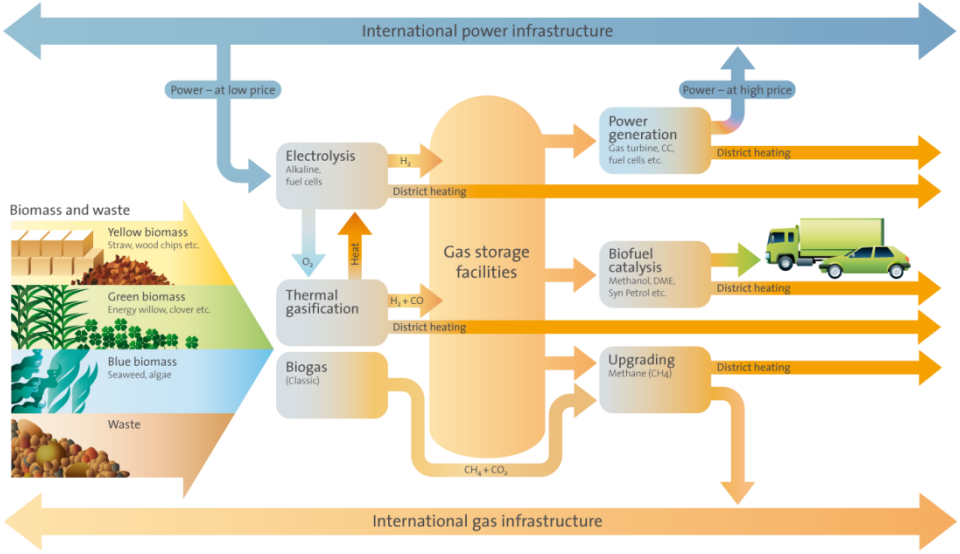
Illustration of the new Samsø LNG-fuelled ferry. Source: Samsø kommune

4.4 Development of gas technologies

The transition to a fossil-free energy system requires development of new gas technologies that enable integrating electricity, gas, heating and transport.

A fossil-free energy system in which fluctuating wind power accounts for a large part of the electricity generation requires development of a coherent energy system which integrates electricity, gas, heating and transport. This entails the development of new gas technologies that can bridge the gap between the gas sector and the other sectors.

For a number of years, research has been conducted into various technologies, resulting in the development of technologies for the production of RE gas as well as technologies for the consumption of RE gas. Particularly in recent years, focus has also been on exploring possibilities of utilising the gas infrastructure to transport and store hydrogen and other RE gases.



Relationship between the electricity and gas systems, including the various technologies for the production, consumption and storing of RE gas.

From electricity to gas

The generation of electricity from wind and solar power fluctuates, and storing electricity in batteries is currently very costly, considering the storage capacity that would be required. There are no prospects of this situation changing.

Some of the electricity generated therefore needs to be converted to an energy carrier that is suitable for storage, eg gas. In this context, the gas system is suitable for storage due to its flexibility and its capacity for storing large volumes over several months relatively inexpensively. So there is, among other things, a need for technologies that can convert electricity to gas.

And the other way round

Conversely, there is also a need for technologies that can reconvert gas to electricity, when necessary. Furthermore, technologies are required which can directly utilise the green gases in areas in which electricity is not expedient, eg for heavy land transport, sea transport and certain industrial processes.

The heat generated when electricity is converted to gas, and when gas is converted to electricity, can be used for heating, either via individual solutions or in the district-heating network.

Bridging the gap

Gas from renewable energy sources may be an important link in the future energy system as it can be produced flexibly from biomass, waste and, in the long term, even from electricity based on renewable energy. In order to achieve effective interaction, the use of the existing gas infrastructure to transport and store RE gases is an expedient solution.

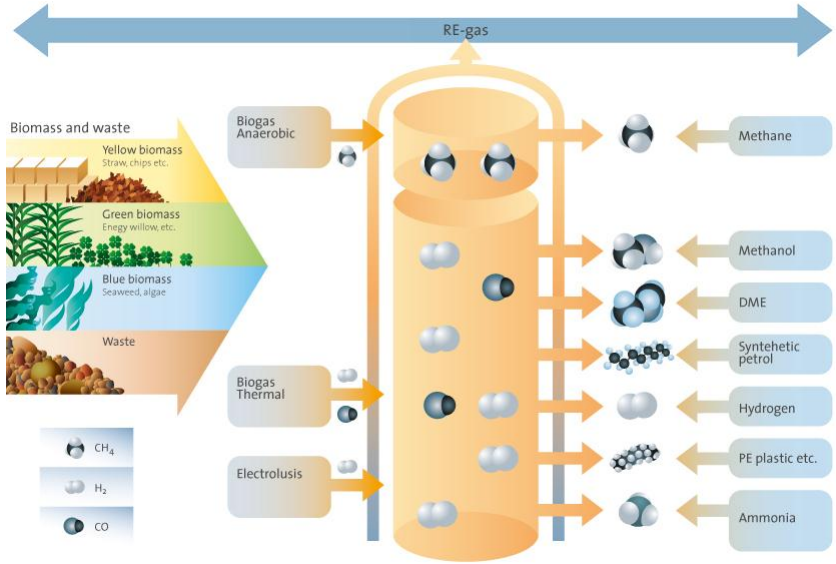
4.4.1 *Technologies for the production of RE gas*

Energinet.dk is working to create a greener gas system. This requires development of technologies for the production of RE gases.

Renewable (RE) gases are gases that are produced from renewable energy such as biomass and wind power, ie energy from sources that are not exhausted through use, but are replenished continually or within relatively few years.

RE gas may be various gases such as:

- Biogas from anaerobic decomposition of biomass
- Gas from thermal gasification of biomass
- Gas produced by means of electrolysis based on renewable energy sources



Various RE gases and their utilisation.

Facts

- RE gas is defined as gas produced without the use of fossil resources, just as electricity from wind power is produced without the use of fossil sources.
- The carbon in RE gas must come from biomass or collected CO_2, and any electricity used in the production of RE gas must come from RE electricity.
- The CO_2 released during the combustion of carbonic RE gas is therefore balanced by the amount of CO_2 used to produce the RE gas.
- Synthesis gas consists primarily of H_2 and CO and can be converted to a number of other fuels using catalysis.

4.4.1.1 Thermal gasification

The vision is for green synthesis gases being injected into the gas network via cleaning and catalytic processes.

In thermal gasification, biomass is combusted in a process using less oxygen than is required in normal combustion. Biomass is thereby converted to the energy gases carbon monoxide (CO), hydrogen (H_2) and methane (CH_4). Depending on the gasification process applied, synthesis gas also contains a fair amount of tar and particulate matter. It may therefore be necessary to remove these impurities from the gas.

Several projects involving thermal gasification are currently being undertaken, supported by both Danish and European research and demonstration funding.

Some projects are aimed at the production of local CHP based on gasification of biomass. In continuation of this, the gas is used to generate electricity and heat by means of a gas engine.

Other projects are aimed at the production of gas that can be used in power stations and, in the long term, be injected into the gas network.

Energinet.dk does not expect gasification plants to become very widespread in Denmark until 2020.

Synthesis gas must be cleaned

In the demonstration projects, work is, for example, going into gasification of tricky biomass types such as straw and other residual products, which contain many salts. Salts normally lead to problems with corrosion.

In addition, the gas contains large amounts of tar and particulate matter. This is not a problem when the gas is fired together with, for example, coal in a power station.

But when the gas is to be used in gas turbines in the long term, the gas must be cleaned. Work is therefore going into developing suitable purification processes.

Synthesis gas in the gas system

Due to the high levels of carbon monoxide in synthesis gas, it is not expected to be possible to transport gasification gas in the gas system without conversion to methane ('methanisation').

Within a 5-10-year horizon, it will be possible to clean the gas and, via catalytic processes, convert it to biomethane, which can be injected into the gas network.

Example: Pyroneer

DONG Energy's Pyroneer plant at the Asnæsværket power station in Kalundborg is an example of a plant on Danish soil which produces synthesis gas via gasification.

DONG Energy has established a 6 MW demonstration facility by the Asnæsværket power station in Kalundborg. The Pyroneer plant demonstrates a gasification process which takes place at relatively low temperature – approximately 700°C.

DONG Energy's gasification plant Pyroneer in Kalundborg. Source: Dong Energy.

Facts

- DONG Energy's 6 MWth gasification plant Pyroneer is funded by ForskEL.
- Skive Fjernvarme: Pressurised, fluidised bed-gasification plant funded by the EUDP.
- Hillerød Forsyning: 300 kWe gasification plant for local CHP developed by BioSynergi ApS and funded by EUDP/ForskEL
- Hillerød Forsyning: 500 kWe gasification plant for local CHP developed by DTU and Weiss A/S and funded by ForskEL
- Synthesis gas consists primarily of H_2 and CO and can be converted to a number of other fuels using catalysis.

4.4.1.2 Electrolysis

The vision is for hydrogen production via electrolysis to contribute to storing fluctuating electricity generation from wind and solar power in the gas system.

Renewable (RE) gas can be produced by means of electrolysis plants, which use electricity to split water and CO_2 into the gases oxygen, hydrogen and carbon monoxide (CO). That is how gas is produced from electricity. If electricity from wind turbines, solar cells or other renewable energy sources is used, the gases obtained from the electrolysis can be characterised as RE gases.

Electrolysis plants may be able to play a vital role in relation to balancing the electricity system, as large amounts of wind power can be stored in the gas system using this technology. Potential in connection with integration of the electricity and gas systems through electrolysis.

Hydrogen production

In Denmark, focus is on three different electrolysis technologies:

- Alkaline electrolysis, which is the most highly developed
- Fuel cell-based PEM electrolysis
- Fuel cell-based SOEC electrolysis.

Hydrogen can be used directly for various purposes, eg in fuel cells, or it can be injected direct into the gas network if the resulting composition of the gas meets the quality requirements.

Use of residual product

Oxygen is not an energy gas, but can be used for other purposes, such as in wastewater treatment plants or fish farms.

In the long term, oxygen can also be used in so-called oxy-fuel processes, where combustion or gasification takes place using pure oxygen instead air.

EXAMPLE: Hydrogen production project

One example is Audi's 6 MW alkaline electrolysis plant in Werlte, Germany, which produces hydrogen. Together with CO_2, the hydrogen is chemically converted to methane, which is subsequently injected into the gas network. The plant opened in 2013, and via a special certification scheme managed by Audi, owners of Audi's A3 g-tron gas vehicle can fill up their vehicles with green methane from the natural gas network.

Another example is E.ON's plant in Falkenhagen, Germany, which is a 2 MW alkaline electrolysis plant where the hydrogen produced is injected direct into the gas network. Inaugurated in August 2013, the plant produces 360 Nm^3 hydrogen per hour.

In the coming period, Energinet.dk expects major demonstration plants to be established in Denmark, which will show how both alkaline and PEM electrolysis can interact with a power system with a high volume of wind-generated electricity and convert the electricity to energy gas suitable for storage.

Fuel cells from IRD Fuel Cell in Svendborg, Denmark. Souce: XXXX

Facts

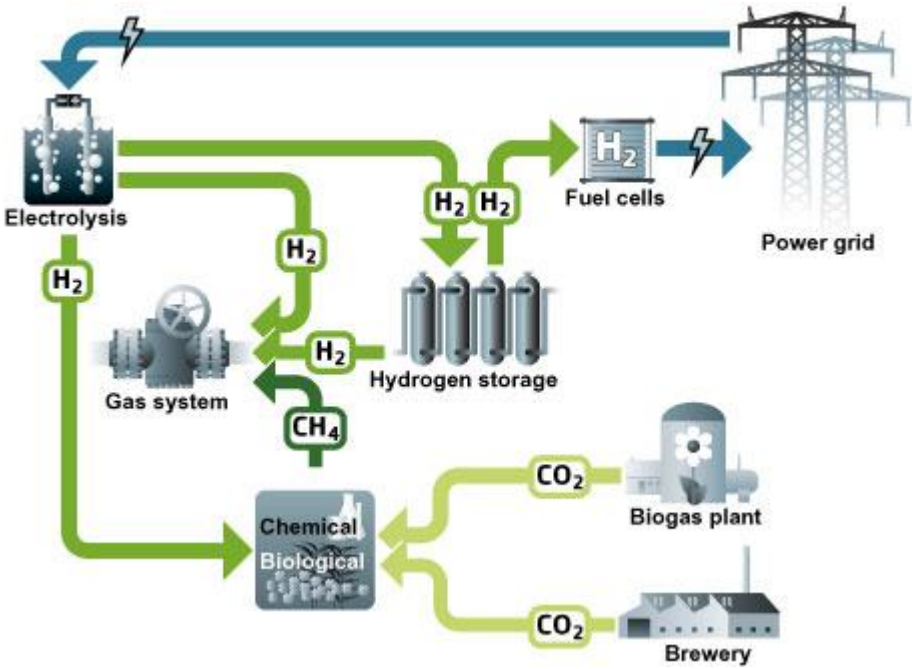
- Based on water and electricity, electrolysis plants can produce oxygen and the energy gas hydrogen. In the process, heat is produced, which can also be utilised. There are various types of electrolysis.
- Alkaline electrolysis takes place in units equipped with two nickel electrodes with catalytic surfaces. The electrolyte consists of an aqueous solution of potassium hydroxide. When the electrodes are energised, oxygen and hydrogen are produced, and kept separate via a membrane. Alkaline electrolysis is already used in large industrial plants, but there is a need to boost efficiency if the technology is to be used for energy purposes.
- PEM electrolysis, in principle, resembles PEM fuel cells. The electrolytic cell is built up around a polymer membrane in contact with two so-called gas diffusion electrodes, one developing oxygen and the other hydrogen from water added.
- SOEC electrolysis takes place in a ceramic solid-oxide electrolytic cell, which is able to produce hydrogen and oxygen from electricity and water vapour at temperatures of 750-950°C. In the long term, SOEC electrolysis can also be used to produce synthesis gases on the basis of CO_2 instead of water.

4.4.1.3 Methanisation

The vision is for hydrogen to be methanised so that it can be injected direct into the existing gas network in a cost-effective manner.

Hydrogen from electrolysis can be used together with CO_2 to produce methane. This is called methanisation.

The CO_2 source may, for example, be biogas, which contains approximately 35% CO_2, but the CO_2 may also come from other sources, eg breweries, bioethanol factories or possibly power stations.



Potential in integration of the electricity and gas systems through methanisation.

The advantage of producing methane rather than hydrogen is that the gas can then be used direct and in unlimited volumes in the natural gas network.

Methanisation of CO_2 can take place:

- Chemically, using catalysts
- Biologically, by means of microorganisms

The gas produced through thermal gasification of biomass and consisting of hydrogen (H_2), carbon monoxide (CO) and methane (CH_4), can also be methanised. In this case, hydrogen and CO react by means of catalysts to form methane.

Examples: Electrochaea & GoBiGas
Several interesting demonstration projects are currently working on the methanisation process.

The US firm Electrochaea has established a branch in Denmark and is currently testing microbial upgrading of biogas using hydrogen. Energinet.dk expects that Electrochaea will demonstrate the process on a large scale in Denmark in the course of 2014.

Another example is GoBiGas, a big demonstration project in Gothenburg, Sweden, which is working to produce synthetic natural gas from gasified wood. The synthetic gas is fed into the existing natural-gas network, and the project will thus end up delivering a large amount of green energy to the Gothenburg area. The methanisation and gas-cleaning part are supplied by Danish Haldor Topsøe.

The first stage, 20 MW, is scheduled to be completed in 2013. The second stage, 80-100 MW, is expected to be completed in 2016.

In the ForskEL-funded project Gasolution, Haldor Topsøe is also working on methanising the gas from DONG Energy's Pyroneer gasifier.

Facts

- The Electrochaea project is funded by ForskEL and the EUDP
- GobiGas is funded by the Swedish Energy Agency
- Gasolution is funded by ForskEL Synthesis gas consists primarily of H_2 and CO and can be converted to a number of other fuels using catalysis
- Synthetic natural gas (SNG) can be produced from synthesis gas through methanisation.

4.4.2 New gas-consumption technologies

Gas-based consumption technologies maintain their relevance during the transition to green energy. This applies to both natural gas and RE gas.

RE gas can be different gases such as biogas, hydrogen or methane, and these can be utilised to varying degrees in both existing and new gas technologies.

Several types of gas can be utilised in respect of some technologies, whereas other technologies are more sensitive to the different characteristics of the gases:

- Methane, which is produced from renewable energy sources, can be injected direct into the gas system. This means that it will have the same uses as natural gas has today.

- Natural gas and renewable energy gases can be utilised in combination with new technologies such as, for example, combined heat pumps.

- Biogas can be used direct to produce combined heat and power in an engine unit, which is a well-known technology. When upgraded, it can be injected direct into the gas network. Biogas can also be used as fuel in both vehicles and ships.

- Hydrogen can be used in fuel cells, where – combined with oxygen from the air – it is chemically converted to electricity, heat and clean water. Fuel cells can be used, for example, for micro-CHP and hydrogen-fuelled cars.

Facts

- RE gases are gases produced from renewable energy such as biomass and wind power
- In Denmark, approximately 400,000 households are heated with natural gas.

4.4.2.1 Micro-CHP

Micro-CHP units demonstrate the utilisation of green gases in the individual household, where the units can generate heat and electricity.

A micro-CHP unit based on fuel cells can be used to generate electricity and heat for ordinary single-family houses, and can thus replace a natural gas-fired boiler's heat generation. The electricity generated can be used in the household or delivered to the electricity grid when the amount of electricity generated exceeds the household needs.

Example: Micro-CHP on the island of Lolland and in Varde

In the Dansk Mikrokraftvarme project, three different applications of fuel cells in micro-CHP are demonstrated:

- SOFC technology, which operates at a high temperature of approximately 800°C and uses methane.
- LT-PEM technology, where the temperature is below 100°C. Methane is used (eg natural gas), which is converted to hydrogen.
- LT-PEM technology, where the temperature is below 100°C. Here, pure hydrogen is used.

For a number of years, the hydrogen-based PEM technology has been installed and tested in the small town Vestenskov on the island of Lolland. Here, hydrogen is produced in a central electrolysis plant and transported to consumers via a buried local hydrogen network. The demonstration has since been extended to include 32 households with fuel cell plants.

Similarly, the PEM technology with conversion of methane has been demonstrated successfully in 2011-2013 in 20 installations in Varde, where natural gas was used. Together, the installations achieved more than 116,000 delivery hours.

Future developments

The PEM technology is highly efficient, but the challenge will be to make the plants more cost-efficient, durable and reliable before they are completely ready for introduction on the commercial market.

The individual fuel-cell plant only has a capacity of 1-2 kW, but if several thousand plants are linked and can be controlled centrally, they can serve as a virtual power station, which can be started when there is a need for electricity generation in the electricity system.

Facts

- Dansk Mikrokraftvarme is funded by a DKK 50 million appropriation under the Danish Finance Act and, in the initial phase, by ForskEL.
- Fuel cells generate electricity and heat by means of a chemical reaction of hydrogen, methane or methanol with oxygen.
- PEM fuel cells contain a polymer membrane which separates hydrogen and atmospheric air. Hydrogen protons migrate across the membrane and react with oxygen in the air to form water, electricity and heat. The temperature in the cells can either be about 80°C (LT-PEM) or 150-200°C (HT-PEM).
- SOFC fuel cells consists of ceramic fuel cells operated at a temperature of 700-800°C. Unlike the PEM cells, oxygen ions from the air migrate across the membrane and react with the fuel, eg hydrogen or methane. Combined with the high temperature, this means that they are not very sensitive to impurities in the fuel.

4.4.2.2 Combined heat pumps

The use of heat pumps in households can be combined with other heating technologies, thereby improving synergies between the electricity and gas systems.

Electric heat pumps have great potential in relation to greenification of the individual heating in Denmark. The advantage of both air/water and liquid/water heat pumps is that they can convert electricity to heat very efficiently (1 kWh electricity can be converted to 2-4 kWh heat).

Challenge for conventional heat pumps

One of the challenges is that the heat pump must run during the hours when there is a need for heating, as substantial heat storage, particularly in old houses, is relatively expensive. In addition, the heat pump's efficiency is at its lowest in the hours when it is most cold outside, thereby further increasing electricity consumption.

This means that there is a risk of the otherwise environmentally sound heat pumps consuming relatively large amounts of electricity. This would also be the case in periods with calm weather when Denmark's many wind turbines do not generate electricity.

Use of combined solutions

Some of the challenges can be overcome by using combined heat pumps. Here, a heat pump is used in combination with a conventional gas-fired boiler.

Combined plants enable streamlining the heat pump's heat generation relative to the electricity generation. In this way, a heat pump can be replaced, in full or in part, by the gas-fired boiler during the coldest winter periods or when the electricity price is high.

4.4.2.3 Hydrogen for transport

The hydrogen car will bring more renewable energy into the transport sector if the hydrogen is produced by means of electricity from sources such as wind and solar power.

A hydrogen car is an electric vehicle which uses fuel cells to generate the electricity that drives the car's electric motor. Hydrogen has a longer range than the battery-powered electric vehicle. At the same time, hydrogen refuelling is just as quick as petrol and diesel refuelling.

Some of the challenges facing the hydrogen car is the inadequate hydrogen refuelling infrastructure, and, so far, producing hydrogen in large quantities is also not economically viable.

Hydrogen infrastructure in Denmark

In Denmark, there are currently more than ten hydrogen filling stations distributed across the country, two of which are available to the public. The newest public hydrogen station was established in Copenhagen. Two additional hydrogen stations are planned in Copenhagen.

Hydrogen filling station in Copenhagen. Photo: hydrogenlink.net.

Hydrogen cars in the City of Copenhagen

As an experiment, the City of Copenhagen invested in 15 hydrogen-powered cars in 2013.

The acquisition is part of the City of Copenhagen's objective of being CO_2-neutral in 2025. The purpose is also to reduce local pollution and thus create a better urban environment.

Hydrogen vehicle in Copenhagen. Photo: hydrogenlink.net.

Facts

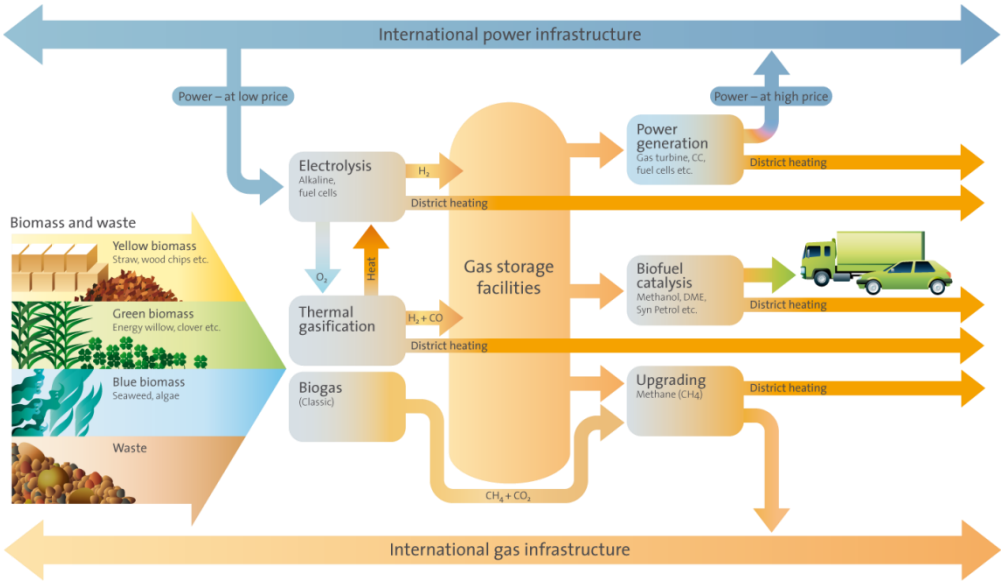
- The City of Copenhagen's demonstration project is supported by funding from the EU's Fuel Cells and Hydrogen Joint Undertaking (FCH-JU).

4.4.3 *Hydrogen in the gas infrastructure*

Gas may be an important element in the future energy system, because it can both be transported efficiently and stored in large volumes.

Gas from renewable energy sources may be an important link in the future energy system as it can be produced flexibly from biomass, waste and, in the long term, even from electricity based on renewable energy.

In order for this interaction to be as effective as possible, the use of the existing gas infrastructure to transport and store RE gases is an expedient solution.



Perspectives where gas from renewable energy sources is integrated with electricity, district heating and liquid fuels.

Gas can be transported and stored in relatively large volumes in the gas system and can be used directly as gas for transport, in industrial processes and for peak-load electricity generation. Gas can also be converted to liquid fuels.

No energy loss

Gas can be transported and stored at minimal consumption of energy for compression and temperature equalisation.

If the potential losses associated with conversion to and from gas can be minimised by integration with electricity and heat, gas can offer energy-efficient transport and storage in the integrated energy system.

In order for the existing infrastructure to be used for new types of gas, eg hydrogen, both the short and long-term effects on the components in the gas infrastructure must be examined.

Facts

- The Stenlille and Lille Torup gas storage facilities are operated commercially by DONG Energy and Energinet.dk respectively and have a total storage volume of approximately 1 billion Nm^3.
- The gas storage facilities have withdrawal capacity of 17.5 million Nm^3/day in normal situations and approximately 25 million Nm^3/day in emergency situations.
- The total gas transport capacity in Denmark depends on the possibility of obtaining gas from the North Sea, Germany and the storage facilities. The operation is dimensioned for a maximum offtake of 23 million Nm^3/day in the Danish zone and 8 million Nm^3/day for Sweden.

4.4.3.1 Storage of hydrogen

Gaseous hydrogen can be stored in large quantities in underground caverns. The technique has been developed and is known from the natural gas storage facilities and can be used for hydrogen.

Electrolysis is rapidly being developed for use in the energy sector, primarily with focus on scaling up to large units, reducing the price and increasing the efficiency of the process.

Hydrogen is interesting for the energy system because it is possible to store large quantities of energy over a long period of time. Hydrogen can also be a component in methanisation processes, where, for example, CO_2 from biogas or carbon monoxide from thermal gasification can be converted to methane or biofuels. Methane can be injected direct into the natural gas network.

Storing hydrogen in large storage facilities, in the same way as with natural gas, may be a solution for handling large fluctuating volumes of generated electricity in the future.

Lille Torup storage facility. Photo: Lars Holm.

Example: HyUnder

The potential for storing hydrogen in Europe is being examined, for instance, in the EU-funded project HyUnder, which maps the geological potential and provides an outline of the future needs and of a business model for large-scale storage of hydrogen.

The project thus sheds light on investors' potential financial return as well as the physical use of hydrogen storage facilities for both network operators and renewable-energy producers.

The project was launched in summer 2012 and is scheduled to have a duration of 24 months.

Hydrogen for industry

Hydrogen is used for industrial applications worldwide. The consumption in the states along the east coast of the USA is so large that a 965 km hydrogen network, used by 22 hydrogen suppliers, has been constructed. The total system has a production capacity of 1.3 million Nm^3/hour. The hydrogen is used, for example, at oil refineries.

A cavern storage facility has also been constructed in connection with the hydrogen network. Efforts are being made to expand the use of hydrogen in the USA from industrial applications to transport and other energy applications.

Facts

- HyUnder is supported by EU funding.
- Hydrogen can be produced by splitting clean water by means of electricity through electrolysis. This process has been used for more than 100 years, but not for energy applications.
- Hydrogen can be stored and distributed in tanks at 100-800 bar pressure or in liquid form at minus 250°C.

4.4.3.2 Hydrogen in the gas network

Energinet.dk is currently investigating what happens to the gas system when it is exposed to hydrogen over a long period of time.

In order to fulfil the Danish objective of 100% renewable energy in 2050, it is necessary to increase the focus on conversion between various energy sources and on storage of large quantities of energy. Surplus RE electricity can be converted into hydrogen and stored in the gas infrastructure.

Hydrogen is the smallest molecule and therefore a very volatile gas, which is highly flammable when reacted with oxygen. It is therefore important to test how tight the process and measuring equipment is and to discover any changes in the tightness and the materials when exposed to hydrogen over a long period of time.

Pilot projects with hydrogen in the network.

Several projects are currently investigating the possibilities of mixing hydrogen with the gas transported in the network. The Danish Gas Technology Centre has participated in a number of analyses, which show that:

- The steel pipes in the gas system can handle large quantities of hydrogen (approximately 10-15%), but there is limited experience with the impacts over an extended period.
- Other elements of the infrastructure would require modification, and it must be taken into account that hydrogen reduces the calorific value and Wobbe index of the gas.
- A lower Wobbe index may create problems for some gas-powered appliances.

In cooperation with the Danish Gas Technology Centre and GreenHydrogen.dk, Energinet.dk and DONG demonstrate what happens to the gas system when exposed to hydrogen over a long period of time. Energinet.dk's objective is to determine whether the Danish natural gas infrastructure can be operated stably and safely with varying concentrations (up to 20%) of hydrogen.

Helle M/R station (left) and Agerbæk M/R station (right).

Test setup

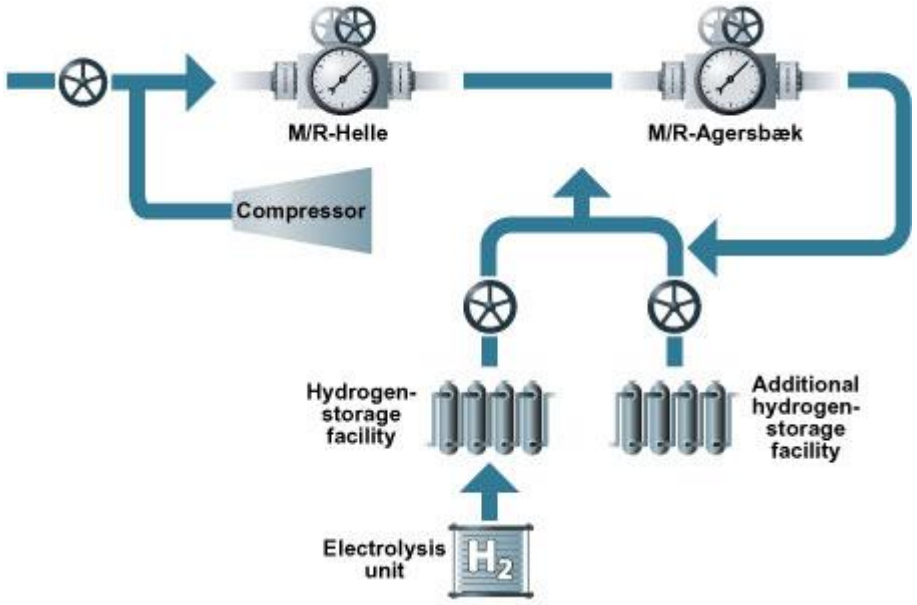
For this purpose, a number of tests are conducted at the Helle M/R station (Energinet.dk) and the Agerbæk M/R station (DONG). Both M/R stations have been decommissioned and are no longer used for natural gas transport. At the same time, they are both standard M/R stations similar to those which are used all over the country. It will therefore be possible to transfer the results direct to all other Danish stations.

How is it done?

A closed system is established between the Helle M/R station and the Agerbæk M/R station which resembles the existing gas network structure.

Today, there is a connection between the two M/R stations, and a new connection is to be established from the Agerbæk M/R station back to the Helle M/R station. Here, the pressure will be increased from about 4 bar to 80 bar by means of a compressor. At the Helle M/R station, the pressure will be reduced to approximately 17 or 40 bar, and further reduced to 4 bar at the Agerbæk M/R station.

This test setup is similar to the existing network with its various process equipment.



Test setup for the Helle M/R station and the Agerbæk M/R station.

Expected results

Through the project, Energinet.dk will gain knowledge on what it will cost to prepare the stations for handling hydrogen.
The past ten years have seen both national and EU projects which have examined infrastructure components such as pipes, meters, process equipment, gas storage facilities and end-user installations to discover their suitability for hydrogen and natural gas operation. However, the Agerbæk/Helle project is the first to test such high hydrogen concentrations over a two-year period.

If the hydrogen impact causes damage to the material, the damage may not be visible until the material has been exposed to hydrogen over a long period of time. On project completion, Energinet.dk will know how the gas system is to be maintained in the future and how a reliable green gas system can still be ensured.

Facts

- The project is divided into three phases:
  - The first phase will be a preliminary study, with the first adaptation measures being recommended on the basis of a review of the M/R stations.
  - The second phase will cover the construction work and the establishment of the test loop.
  - The third phase will be the test phase, with the stations being operated with natural gas and hydrogen mixes containing up to 20% hydrogen.
- When the test installation is established in 2014, the test will run over a 24-month test period with varying natural gas and hydrogen mixes.