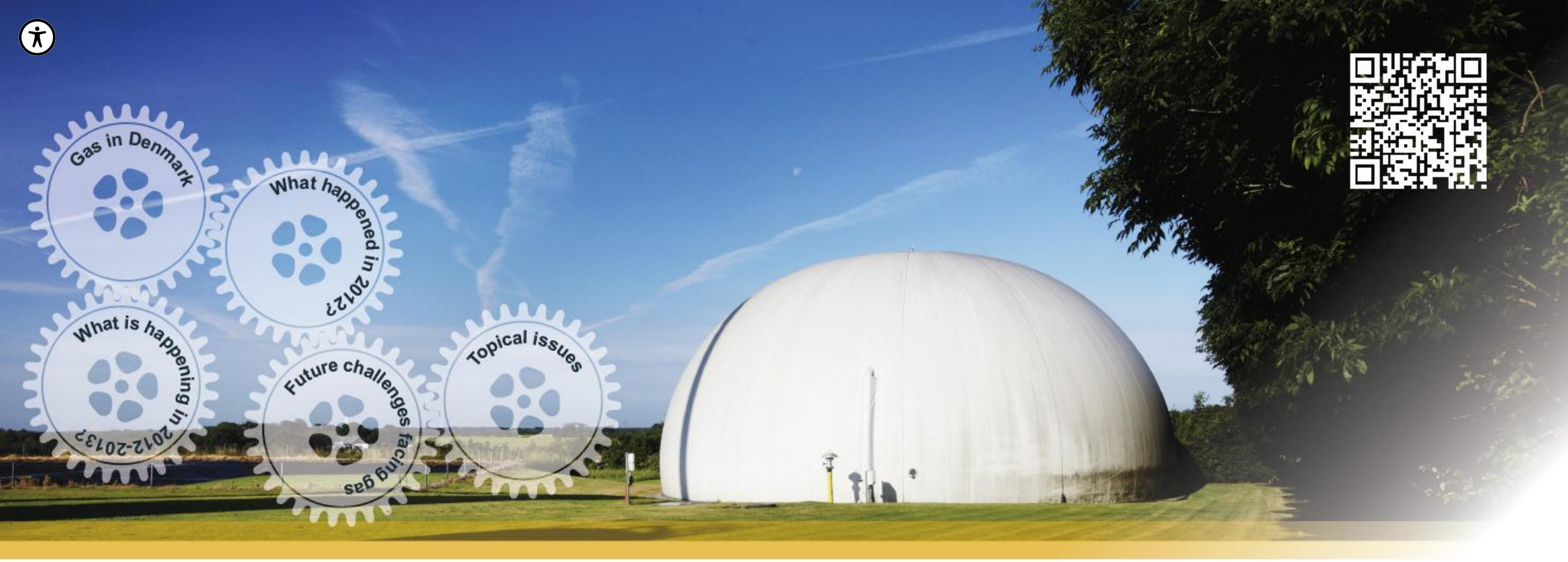


# Gas in Denmark 2013

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# Gas in Denmark 2013

*Gas in Denmark is available for the first time in a web version. This version is made especially for the Danish Energy Authority as a part copy of the web-version. Thus it has not been lay-outed and is full of links that only work on the web.*

**Facts**

- 'Gas in Denmark' is Energinet.dk's annual report to the Danish Energy Agency.
- The report 'Gas in Denmark' meets the following requirements:
- Yearly reporting on security of supply, pursuant to Executive Order on the management of security of supply of natural gas, section 3.
- Yearly coordinated, coherent planning of the development of the transmission grid, pursuant to Executive Order on the use of the natural gas supply grid and plans for the future need for gas transmission capacity, section 7.

# What happened in 2012?

*It has been a year without any major challenges to security of supply. A single major event was handled by an efficient market.*

A warm winter and stable gas prices meant that 2012 was a relatively calm year for the gas market. No major security of supply challenges to the operation of the transmission system were encountered in 2012 either.

In September 2012, there was an event in the North Sea which led to a five-day production outage. In the past, such a situation would have led to Energinet.dk taking steps to maintain supply. This was not necessary, however, as a well-functioning market responded efficiently to the information which was distributed. The situation was thus handled without a risk of disruption to security of supply, and without Energinet.dk having to intervene in the market.

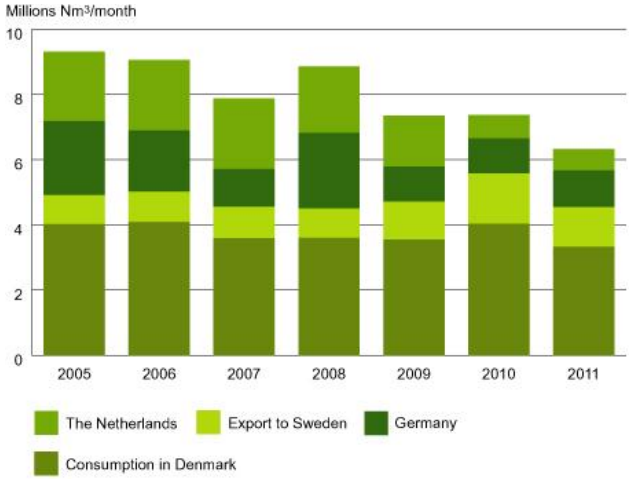
## Gas supply situation in 2011-2012

*Approximately 10% of natural gas production in 2011 was exported to the Netherlands, while 18% was exported to Sweden and 17% to Germany.*

The majority of natural gas transported via Energinet.dk's transmission system 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 transported via the Tyra and Syd Arne pipelines to Denmark, where it is sold in the Danish exit zone or exported to Germany or Sweden. Quite substantial quantities of gas are also exported to the Netherlands via the NOGAT pipeline.

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




*Net production (excluding own consumption) brought onshore to Denmark or the Netherlands. Source: the Danish Energy Agency and Energinet.dk.*

### Utilisation of entry and exit capacities

This table shows capacities at the entry and exit points of the transmission system and storage withdrawal capacity compared to the actual maximum daily quantities during the past three winters.

| Point | Capasity Millions Nm³/d | | Max. flow Millions Nm³/d 2009/2010 | 2010/2011 | 2011/2012 |
|---|---|---|---|---|---|
| Nybro | Entry | 32,4 (note 2) | 23,1 | 22,5 | 18,8 |
| Lille Torup storage | Withdrawal | 8,0 (note 3) | 4,5 | 7,3 | 7,4 |
| Stenlille storage | Withdrawal | 12 | 6,5 | 9,6 | 10,8 |
| The danish exitzone | Exit | 25,5 | 21,5 | 22,2 | 22,2 |
| Ellund | Entry og Exit | 4,8 (note 4)/ 8,3 | 0/7,1 | 4,7/8,5 | 4,0/7,6 |
| Dragør Border | Exit | 8,6 (note 1) | 7,2 | 7,8 | 6,8 |

*Capacities at the entry and exit points of the transmission system compared to actual maximum daily quantities.*

Please note:

- Note 1: The Swedish system is unable to receive these volumes at the assumed minimum pressure in Dragør of 45 bar. The firm capacity is stated at 6 million Nm³/day.
- Note 2: Total capacity of the receiving terminals in Nybro. The potential supplies are smaller today as the Tyra-Nybro pipeline is subject to a capacity constraint of approximately 26 million Nm³/day and large quantities cannot be supplied from the Syd Arne pipeline.
- Note 3: Guaranteed capacity.

Facts

- The maximum daily supply from the North Sea during last winter was 18.8 million Nm³/day.
- Between July 2011 and July 2012, gas was physically imported from Germany on a total of 69 days.

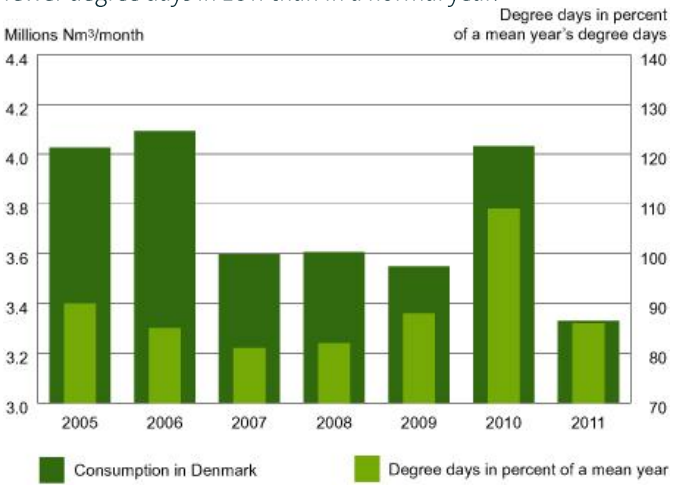
## Gas consumption 2011-2012

*Gas consumption in Denmark is declining. 2011 was a warm year, further reducing consumption.*

Gas consumption in Denmark has been slowly declining since 2006, when compensation is made for annual fluctuations in temperature (normal years). This can be seen in the figure below, which shows natural gas consumption for 2005-2011.

Prior to 2007, consumption in a normal year was approximately 4 billion Nm³. During the three years from 2007 to 2009, which were all close to a normal year, consumption declined to approximately 3.6 billion Nm³, before rising again in 2010 to 4 billion Nm³. The increase in 2010 was due to several factors. 2010 was a cold year, with 9% more degree days than a normal year, and consumption at the big CHP plants was also high.

In 2011, consumption in Denmark was approximately 3.4 billion Nm³. There were 13% fewer degree days in 2011 than in a normal year.

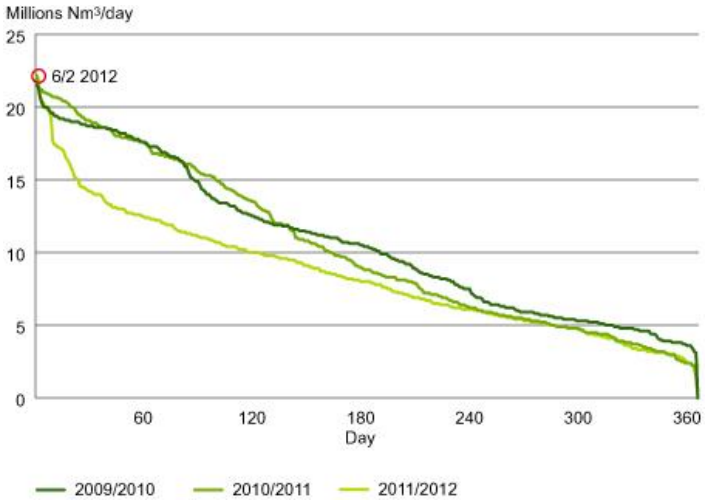



*Natural gas consumption for 2005-2011.*

### Maximum daily consumption

The last winters had periods of very cold weather. This has a major impact on the maximum daily consumption and hence on the load on the transmission systems. The figure below shows the duration curves for daily consumption, compared for the 2009-2012 period. In a duration curve, the daily consumption for the 365 days of the year has been sorted based on size.

Last winter, the maximum daily consumption was 22.2 million $Nm^3$. This was on 6 February 2012, where the daily mean temperature was -9.5° C. In a normal year, a daily mean temperature of -8° C is assumed. For comparison, Energinet.dk assumes a maximum daily consumption of approximately 23 million $Nm^3$/day at a daily mean temperature of -13° C.




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

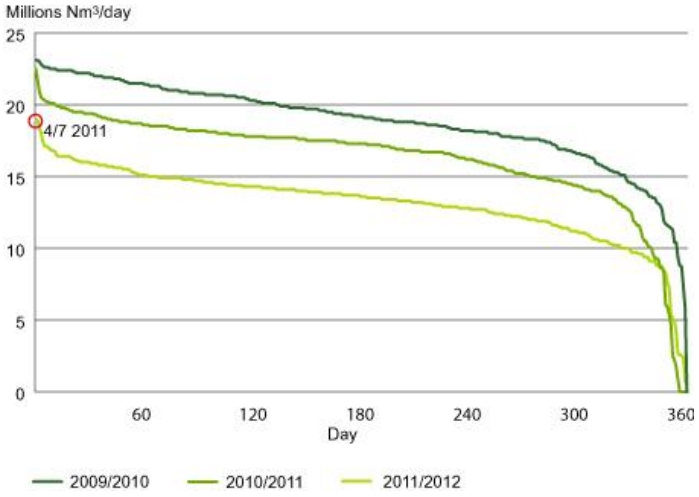
**Facts**

- The Danish Energy Agency sees the financial crisis as the reason for the decline in gas consumption.

## Gas supplies 2011-2012

*Most gas is supplied from the North Sea. At times, the flow reverses such that we import gas, but Denmark continues to be a net exporter of gas.*

Between July 2011 and July 2012, the maximum supply at Nybro was 18.8 million $Nm^3$/day. This happened on 4 July 2011. The duration curves for the annual supplies are shown in the figure below.




*Duration curves for annual supplies between July 2011 and July 2012.*

### Entry Ellund

The transmission system has been physically capable of importing gas from Germany since 1 October 2010. Up to 200,000 $Nm^3/h$ can be supplied, corresponding to 4.8 million $Nm^3/d$.

The figure below shows the imports and exports at the Ellund border point between July 2011 and July 2012.


*Imports and exports at the Danish-German border point between July 2011 and July 2012.*

## Gas storage utilisation 2011-2012

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

Gas consumption varies in step with the seasons. Consumption also varies throughout the day. These variations are far greater than the fluctuations in supplies from the North Sea. Utility companies use the two Danish underground storage facilities in 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. In winter, when supplies from the North Sea can no longer meet Danish consumption and exports to Sweden and Germany, gas is withdrawn from the storage facility again.

If supplies from the North Sea or Germany are disrupted, the two gas storage facilities serve as emergency supply storage facilities.


The figure shows the distribution of withdrawals from and injections into the storage facilities by month between July 2011 and July 2012.

*Monthly distribution of withdrawals from and injections into the storage facilities between July 2011 and July 2012.*

## Gas transmission system events 2012

*In August, gas production from the North Sea closed down for five days. The situation was handled by the market without Energinet.dk having to resort to any of its tools.*

A leak was discovered at Tyra West on Friday, 31 August 2012. Mærsk shut down gas production and reported that they expected the outage to last approximately five days.

### Three intact supply sources

Energinet.dk therefore assessed the supply situation. Domestic consumption was very low, approx. 450,000 $Nm^3/h$ including injection into both gas storage facilities (180,000 $Nm^3/h$). Exports to Sweden were running at 65,000 $Nm^3/h$, and 82,000 $Nm^3/h$ to Germany.

There were three intact supply sources – two of which were able to meet the entire consumption. Given the low consumption and access to storage facilities and imports from Germany, Energinet.dk decided not to take any further steps.

Energinet.dk informed the adjacent systems of the situation and paid close attention throughout the event to whether the market managed the situation by securing the balance via nominations. This can be seen in the figure below.


*The graph shows the gas supply during the extended disruption to gas supplies from Tyra.*

### Safe restart

Energinet.dk's Control Centre Gas closely monitored the supply situation over the following days, and there was no critically low pressure in the system at any time. The pressure at Egtved ranged between 68.3 and 75.5 bar, which is perfectly normal for the time of the year.

- On 4 September, the flow changed direction at the German border point, such that this supply source was also activated. Withdrawal from the storage facilities was thereby reduced.
- On 6 September, gas production at Tyra was slowly restarted. However, after a few hours of production there was a compressor shutdown at Tyra.
- On 7 September, gas production restarted. Production was stable and rising that evening, and the supply situation had thereby returned to normal.

### Handled well by the market

The situation was thus handled in an exemplary manner by the market, without requiring activation of Energinet.dk's system tools.

**Facts**

- Energinet.dk is responsible for securing the supply of gas to the Danish market in emergency supply situations. These situations can arise if the supplies of gas to Denmark are seriously disrupted. If this happens, Energinet.dk takes over responsibility for supplying gas to all Danish

## Gas market 2012

*The number of shippers in Energinet.dk's transmission system plateaued in 2012. However, there was increased market activity.*

For many years, the Danish gas market has seen a continual inflow of new shippers into the transmission system. However, in 2012 Energinet.dk saw the number plateau. New shippers continue to join the system, but there are others who have abandoned the market.

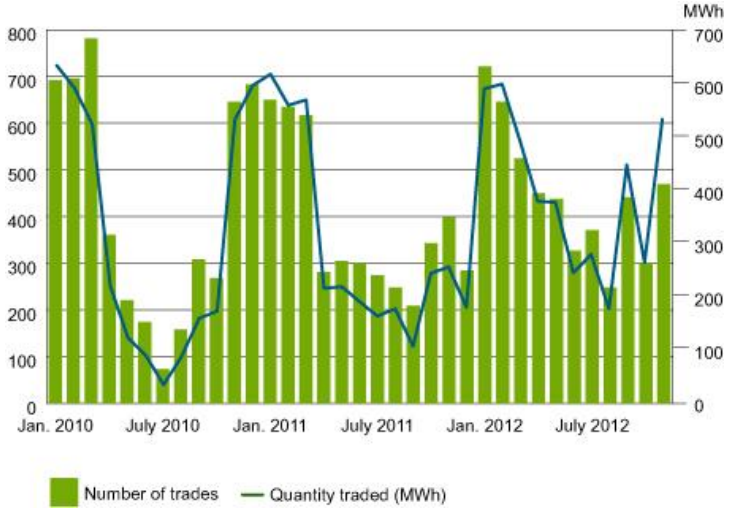
The number of active shippers has been stable at 15-17 over the last two or three years, but there have been changes among the active players on the market. There is also a continually increasing number of latent shippers, who are expected to become

active in the future. Latent shippers are shippers who are registered in the system but not currently active.

### Same number of players – but more activity on the gas exchange

In both 2010 and 2011, gas corresponding to approx. 10% of Danish gas consumption was traded via the Danish gas exchange, Nord Pool Gas.

In 2012, there was an increase in both the number of trades and the quantities traded on Nord Pool Gas, such that the gas traded up to the end of September corresponds to approx. 17% of gas consumption. The gas exchange did not experience the same low level of trades and quantities during this summer as in previous years.




*Number of trades and quantities traded on the Nord Pool Gas exchange per month since January 2012.*

By August 2012, Energinet.dk had achieved the same traded quantity as for all of 2011. Part of the explanation is that there is generally greater faith in the gas exchange than there was before. This is particularly true of the day-ahead trade, which is used by most players on the market. The signals from the market have played a role in Energinet.dk's decision as of 1 October to settle the shippers' imbalances at the daily price on Nord Pool Gas rather than the monthly average, as was previously used.

### Gas Transfer Facility also setting records this year

As the end of 2012 approaches, the Gas Transfer Facility bilateral trading point in the gas system looks set to have experienced yet another record year. The end result may be that more gas is traded at the Gas Transfer Facility than is consumed in Denmark, for the first time ever. Up to 1 September, gas traded at the Gas Transfer Facility corresponded to approx. 115% of the consumption in Denmark for the period.

Since its introduction in 2004, the Gas Transfer Facility has set a new record each year for the amount of gas traded and transferred at the facility. In 2011, gas corresponding to approx. 90% of consumption in Denmark was traded.

However, the physical amount of gas that changes hands at the Gas Transfer Facility is much smaller, as the gas is normally 're-traded' 1.5-2 times. Trades are thus common whereby a shipper purchases from one party and sells direct to another party.

**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 at GTF; today the figure is almost 100%.
- The point functions such that two shippers have a bilateral agreement about delivery at GTF. Actual delivery takes place via nominations of quantities to and from each other.

**Nord Pool Gas (NPG)**

- NPG is the Danish gas exchange.
- NPG was introduced in March 2008.
  In 2009, 3% of total Danish consumption was traded on NPG.
- In 2012, it is expected that 15% of total Danish consumption will have been traded on NPG.
- 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.

## Challenges for the gas market in 2012

*A warm winter and stable gas prices made 2012 a relatively calm year. At the same time, there was more information for the market than ever before.*

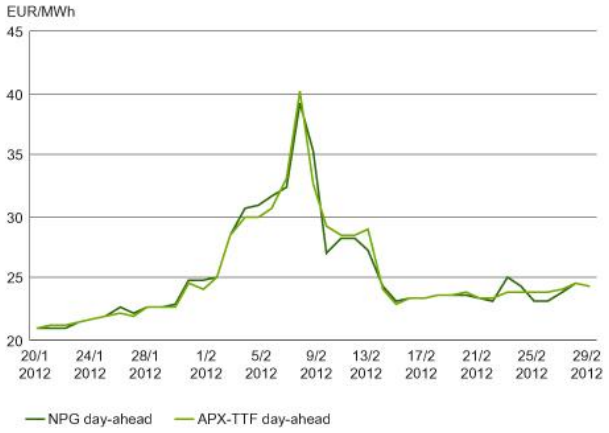
2012 was relatively undramatic for the market. For example, the market did not experience disruption to gas supplies from Germany as it did in the previous year, and it has been a very mild winter, historically. There was therefore plenty of gas on the market.

The Danish gas price is generally higher than in the neighbouring Central European countries. Last winter, the price was practically the same, and was even lower in Denmark for brief periods.

### February 2012 was cold

Although the winter was generally mild, the temperature in late January and early February was very low in Denmark and north-west Europe.

This led to high prices on the trade of gas day-ahead in Germany and the Netherlands. Since the price in Denmark is strongly linked to the prices in neighbouring markets, the Nord Pool Gas prices also rose.




*Day-ahead gas prices on NPG and GTF in January/February 2012*

However, despite the cold weather, there was no shortage of gas in Denmark. The market experienced bigger problems in Germany, which actually resulted in gas being exported to the south during the period.

### REMIT enters into force

The REMIT regulation entered into force in December 2011. The regulation involves more stringent requirements on market participants, and greater responsibility in relation to insider trading.

Under the regulation, if a market participant has knowledge which might influence the price of gas on the wholesale market which they are able to exploit, the market participant may only act once the entire market has received the same information. In Denmark, for example, the entire Danish gas market receives a message each time there is a significant production outage in the North Sea.

At the beginning of 2012, communication of this information was managed by Energinet.dk via email. In April, Energinet.dk launched the Gas Market Message portal, in which these messages are more schematically arranged. Furthermore, players can feed in information and communicate messages direct without the delay of involving Energinet.dk.

**Facts REMIT**

- REMIT stands for 'Regulation on Energy Market Integrity and Transparency'.
- The REMIT regulation officially entered into force between Christmas and New Year in 2011.
- The regulation on integrity and transparency on the wholesale markets aims to prevent market abuse on European energy markets for electricity and gas and thereby promote fair competition on the wholesale energy markets, to the benefit of final energy consumers.

### Gas Market Message (GMM)

- GMM is the website Energinet.dk has made available to ensure greater transparency on the gas market.
- GMM was launched in April 2012
- The website is used by gas market players to communicate information which it is believed may impact on gas prices in the wholesale market.
- GMM is being developed in ongoing cooperation with the Danish Energy Regulatory Authority.

## Gas market development 2012

*In 2012, Energinet.dk took a major step towards the development of the future gas market design. This development will continue in 2013.*

In 2011, Energinet.dk began selling capacity to and from the border points via auctions – although only on the monthly products. In 2012, yearly products also began to be sold via auction.

Energinet.dk also launched a new quarterly product, which is tendered and sold before the beginning of the gas year in four separate auctions. In parallel with this change, the weekly product was removed.

These changes to tendering and sale are a step towards fulfilling the new common EU regulations for capacity allocation. The next step will be taken in 2013, when Energinet.dk begins to sell capacity on a capacity platform together with capacity in adjacent systems.

### A year without annual capacity

Energinet.dk decided to suspend the trade of yearly products at the Ellund and Dragør border points in 2011. We did this because an undesirable capacity situation had arisen during 2010-2011, whereby shippers had to book annual capacity month by month in order to achieve the best possible capacity as far ahead as possible. The reason for this situation was that the market had experienced a bottleneck at the Ellund entry point on several occasions.

Energinet.dk has to fulfil requirements in relation to bundled capacity, which means that capacity going out of one system has to match the capacity going into the next system as a total bundled product. The sale of yearly products was temporarily suspended to free up capacity for bundled products and to group capacity for the yearly products, which in future will only be sold once a year.

### Balance also coming soon

As transmission system operator, Energinet.dk naturally has a focus on system balance. The balance margin was narrowed for shippers in 2011, at the same time as balancing fees were reduced.

A small but significant change has happened in 2012. In future, imbalances will not be settled on the basis of the monthly average, but based on the Nord Pool Gas day price for gas. This has the effect that balance settlement is based on the gas price at the actual time the imbalance arises.

The next step towards more efficient system balancing is to give shippers more data on their individual status in the system. This will help shippers to be able to take steps to avoid imbalances. Access to more data will make it possible for Energinet.dk to narrow shippers' balance margin even more in future, and thereby reduce the joint purchase of system balancing.

The aim is for shippers to bear a greater responsibility than they do today for ensuring system balance. Energinet.dk will thus play a more secondary role in relation to system balance.

**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.
- This change was necessary in order to match the European product range. In the future, multi-year products and within-day products will also be introduced.
- Changes are also being made to when and how products are tendered and sold.
  A number of changes have already been made at the border points, such that products are now sold at fixed times via auctions, whereas they used to be sold on a first-come-first-served basis at particular times.

# What is happening in 2012-2013?

*A new model for security of supply gives market players a bigger role, but Energinet.dk is still responsible for security of supply.*

A new model for security of supply came into force in the Danish gas market on 1 October 2012. The changes are due to a number of new EU regulations, and Energinet.dk has overseen their implementation. The new model operates with four states: Normal operation, Early Warning, Alert and Emergency.

Energinet.dk continues to be responsible for security of supply in Denmark under the new model. However, market players now have a greater responsibility for keeping in balance in relation to the capacities they have ordered in the system. Market players have to keep in balance during normal operation and at the Early Warning and Alert crisis levels. Energinet.dk assumes responsibility for supply in the Emergency crisis level.

If the largest supply source in the system is disrupted, emergency supply covers the protected Danish gas market for a period of three days during an extreme winter, and 60 days during a normal winter.

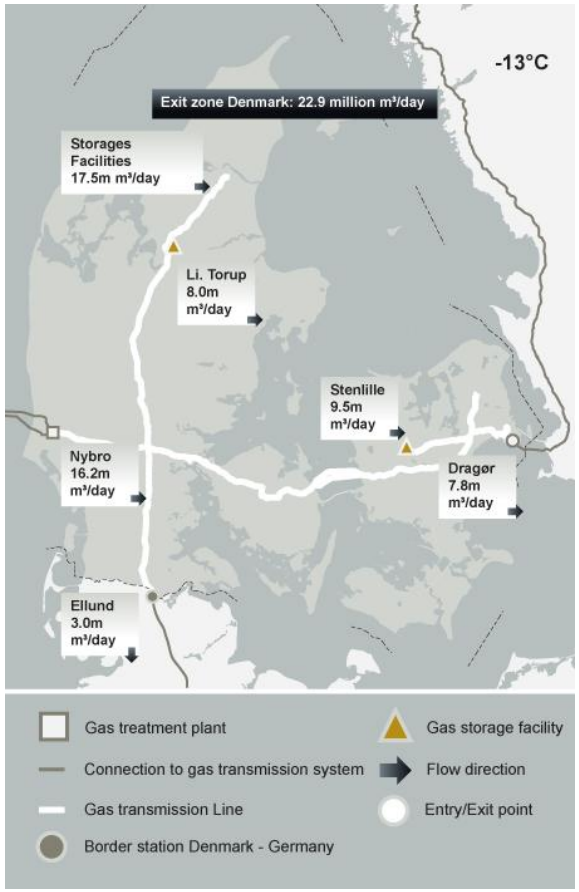
**Facts**

- Security of supply refers to the energy system's physical ability to always provide the energy being demanded.
- Security of supply is very high in the Danish gas system. This is because the system is generally robust and very flexible, and plans have been made to handle major events such as serious breakdowns in the technical systems.

## Winter outlook 2012-2013

*Energinet.dk's calculation of the emergency supply requirement for the coming winter has been based on a temperature of -13° C.*

The calculations include the offtake in Denmark (exit zone) and transit as well as supplies to entry points and from storage facilities on a winter day with a temperature of -13° C. The calculations for the 2012-13 winter are shown in this figure:




- Total transport: Total net transport has been estimated at 33.7 million $Nm^3$/day
- Exit Denmark: Consumption in Denmark is 22.9 million $Nm^3$/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 exports of 3.0 million $Nm^3$/day, corresponding to 125,000 $Nm^3$/hour
- Dragør: Dragør has net exports of 7.8 million $Nm^3$/day, corresponding to 325,000 $Nm^3$/hour
- Storage facilities: Total withdrawal of gas from the storage facilities is estimated at 17.5 million $Nm^3$/day, with 9.5 million $Nm^3$/day coming from Stenlille and 8.0 million $Nm^3$/day from Lille Torup. The distribution of withdrawals is optimised to achieve the highest possible pressure in the gas system
- Nybro: Supplies in Nybro are estimated at 16.2 million $Nm^3$/day.

**Facts**

- Since winter is the time when consumption is at the highest level, the EU legislation requires all TSOs to prepare a forecast for the supply in the coming winter. This is called the winter outlook.
- ENTSOG prepares an overall winter outlook based on the reports from each TSO, including data from Energinet.dk

## Capacity orders 2012-2013

*Leading up to the new gas year, most of the capacity was offered for sale at the border point in long-term contracts. The rest will be sold in monthly and daily contracts.*

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 through the Danish gas system in the coming year.

During the latest gas year, Energinet.dk only held auctions at the border points on a monthly basis, but yearly and quarterly auctions have now been introduced. Both these types are only run prior to the commencement of the gas year.

At the Ellund entry point, where only interruptible capacity is available, almost 1.9 million kWh/h of the available 2.4 million kWh/h were sold. This leaves over 0.5 million kWh/h available for monthly and daily products. This capacity will be of particular interest to the market at times where production in the North Sea is low.

In the opposite direction (Ellund exit), only a very small quantity was sold (approx. 2,000 kWh/h). It suggests that this may be the first gas year in which Ellund is primarily used to import gas.

At the exit to Sweden, most of the firm capacity offered for sale was sold as yearly products, and capacity was actually sold out for the fourth quarter (approx. 2.8 million kWh/h). However, 10% of the total firm capacity was reserved for daily products.

### Nybro follows the same order calendar

Capacity at Nybro continues to be sold on a first-come-first-served basis. However, capacity is only offered for sale on the days where it is also offered at the border points. This means that the yearly capacity is only offered for sale on one occasion prior to the gas year, as is the case at Ellund and Dragør.

The result was that a total of approx. 4 million kWh/h were sold at Nybro – around half of the quantity sold in yearly products during the previous gas year. This is worth noting, as two years ago normal sales at Nybro were over 10 million kWh/h.

### Exit zone and BNG entry unchanged

The booking principle continues to be 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. Given that many contracts run from 1 January, capacity has not yet been ordered this far into the future. The situation for the new gas year is therefore not yet known.

**Facts**

- The situation following the first gas year with yearly auctions is that we have not experienced excess demand. However, much of the capacity has been sold at Ellund entry and Dragør exit.

## Emergency supply options

*The new emergency supply model uses the same emergency supply tools as before. However, the framework for Energinet.dk's purchase and use of the emergency gas has changed.*

A new model for security of supply came into force in the Danish gas market on 1 October 2012. The new model was developed as a result of new EU regulations, which increase the solidarity obligations between member states in the event of a European supply crisis. The regulations have been changed as a result of crises like the one in Ukraine, where the supply through Ukraine was disrupted for an extended period.

The regulations also aim to promote the use of market-based tools to manage emergency situations. Under the new model, Energinet.dk can decide to disconnect the commercially interruptible gas customers even before an emergency supply situation is declared.

This also means that commercial market players have been given a greater role in situations where the supply is under pressure. This has been done to ensure that they actively contribute to balancing the system in pre-emergency situations, ie at the Early Warning and Alert stages.

The development of an event is illustrated in this figure:


*Escalation of the crisis structure before and after 1 October 2012.*

### Protected and non-protected consumers

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

In practice, this means that all industrial companies with an annual gas consumption of less than 2 million $m^3$ and most gas-fired CHP plants will be protected. Energinet.dk is responsible each year for identifying, based on the Danish Energy Agency's executive order, which customers will be non-protected in the coming year.

Under the EU regulations, it must be possible to supply all protected Danish consumers in situations where demand is unusually high, such as in cold winters, and in situations where the largest supply source has been disrupted.

### Forecast for the cubic metre limit

Each year, the Danish Energy Agency fixes and announces a limit based on consumed quantity (the 'cubic metre limit'), which determines which companies will be classified as protected customers. They do this based on a recommendation from Energinet.dk.

Energinet.dk does not currently expect any change in the cubic metre limit for the 2013-2014 gas year.

### In an emergency supply situation

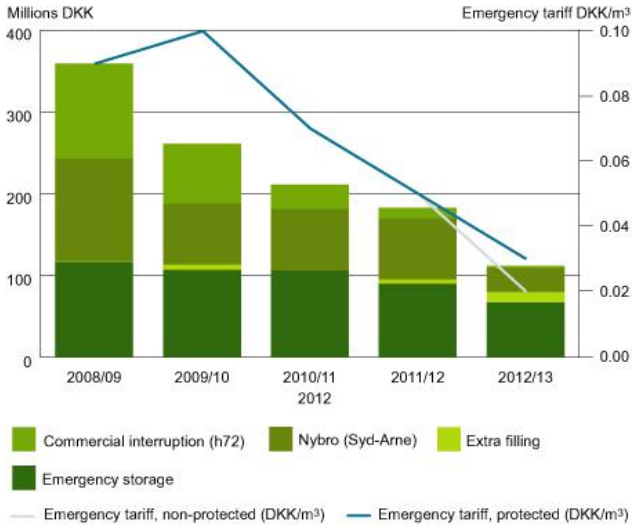
If, at any time, the market and market-based initiatives are no longer able to maintain supply to the market, Energinet.dk assumes responsibility for supplying the market. This is nothing new, and happens when the system is declared to be in Emergency state. In such cases, Energinet.dk is allowed to use its emergency stores and can begin the procedure of disconnecting non-protected consumers.

In the special situation where there is damage to the offshore pipeline from Tyra to Nybro, Energinet.dk still has an agreement with certain operators in the North Sea to redirect the flow from the Tyra platform via the Harald platform through the Syd-Arne pipeline.

Disconnecting the commercially interruptible consumers in Denmark and non-protected consumers in Sweden during the hours just after Energinet.dk has declared an Emergency will help relieve pressure on the system until the non-protected industrial customers can be disconnected.

### Purchase of services

The costs of purchasing emergency supply services have been reduced dramatically in recent years. This can be seen in the following figure:




The dramatic reduction in costs is due to two things. Firstly, the need to purchase the services is declining, due in part to import options from Germany and new regulations. Secondly, Energinet.dk purchases emergency supply services in a new manner.

Energinet.dk introduced a change to the concept of commercial interruptibility in 2012, which led to a change in the service being purchased. The agreement on emergency supply via the Syd Arne pipeline was also renegotiated in 2012. The result is also reflected in the figure.

**Facts**

- The aim of the new model is to use market-based tools as far as possible and reduce the probability of having to declare an actual Emergency in the system.
- Under the new supply standards, the approximately 90 largest industrial companies will be disconnected with 72 hours' notice in an emergency supply situation (the non-protected market)
- In the event of a disruption to the supply infrastructure (N-1), the emergency supply covers the protected Danish gas market for a period of three days during an extreme winter, and 60 days during a normal winter.

## 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 identify any congestion in the system. These analyses are deemed to also apply to Gas in Denmark 2013.

When evaluating consumption, especially at very low daily mean temperatures, it is important to take into account the simultaneity of various types of consumption. This allows realistic M/R station capacity requirements to be set.

Evaluation of the offtake at very low temperatures is made difficult by the fact that no relevant measured data exist for mean daily temperatures lower than approx. -7° C. Ring connections also make it difficult to evaluate individual M/R stations.

**Facts**

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

## Capacity of the distribution companies

*Energinet.dk performs regular analyses of the changes in gas consumption and the effects of changes in gas quality. These data are for the 2012-2013 winter.*

### 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 2012-2013 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 cover DONG Energy's requirements for the coming 2012/2013 winter.

However, capacity increases have been planned for the Egtved, Frøslev and Terkelsbøl stations due to the relationship between the capacity limit, the metered maximum offtake and the peak hour expectation.

The need for such an increase is made even more likely by the expected introduction of German gas with a lower calorific value.

### HMN Distribution

The M/R stations and distribution systems in the HMN Naturgas licence area are estimated to have sufficient capacity during the 2012/2013 winter.

The capacities specified in the Capacity of stations connected to HMN distribution table show the company's forecasts for 2012 to 2013. Changes in gas consumption and the effects of changes in gas quality are regularly analysed.

In 2013, HMN Naturgas expects to receive the first upgraded biogas from biogas plants, where biogas production is based on livestock manure and energy crops.

This may marginally impact on the capacities at Energinet.dk's M/R stations. From 2013 to 2015, it is expected that an upgraded biogas capacity corresponding to 6-8,000 $m^3$/h natural gas will be connected.

### Københavns Energi

Inadequate gas supplies to Københavns Energi's city gas system could have significant socio-economic impacts, as it would be very difficult to re-establish the supply.

In 2010, Energinet.dk established a new remote-controlled valve at Torslunde M/R station to help send gas from Stenlille direct to the Lynge pipeline in the event of a disruption to the main transmission pipeline between Torslunde and Dragør. As a supplement, Københavns Energi decided in 2012 to establish a new city gas production plant in Mørkhøj. This is expected to be operational in 2013.

## Capacity of stations connected to Naturgas Fyn's system

Station capacities are listed in the table, 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.

| 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 setpoint | M/R-station calculated capacity (-13 C) | Expected capacity requirements of distribution companies | Measured peak hour 01-05-2011 to 04-30-2012 |
|---|---|---|---|---|---|---|---|---|
| | | Nm³/d | Nm³/h | Barg | Barg | Nm³/h | Nm³/h | Nm³/h |
| | Fyn | 1,317,320 | | | | | | |
| 551 | Middelfart | 80,828 | 3792 | 61.9 | 17.1 | 9,440 | 3,800 | 4,793 |
| 553 | Billesbølle | 103,611 | 4857 | 60.9 | 17.1 | 9,291 | 5,500 | 5,530 |
| 554 | Koelbjerg | 454,458 | 21334 | 60.6 | 17.1 | 39,709 | 38,000 | 28,896 |
| 557 | Højby | 508,547 | 24997 | 59.3 | 15.0 | 104,212 | 4,000 | 34,911 |
| 559 | Ullerslev | 122,602 | 5780 | 58.9 | 17.1 | 8,985 | 7,500 | 6,024 |
| 560 | Nyborg | 47,274 | 2412 | 58.5 | 17.1 | 8,928 | 4,000 | 2,893 |

*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.*

There are a few examples in the table 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 2010 and 2011

The maximum capacity utilisation for each M/R station during the 2010/2011 and 2011/2012 winters is shown in the table, 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

| M/R-station | | PERIOD: 01/05/2010 - 30/04/2011 | | PERIOD: 01/05/2011 - 30/04/2012 | |
|---|---|---|---|---|---|
| | | Daily volume | Max Hour | Daily volume | Max Hour |
| | | $Nm^3/d$ | $Nm^3/h$ | $Nm^3/d$ | $Nm^3/h$ |
| | Fyn | 1,389,366 | 88,187 | 1,503,467 | 83,047 |
| 551 | Middelfart | 59,299 | 6,171 | 95,684 | 4,793 |
| 553 | Billesbølle | 96,676 | 5,103 | 109,367 | 5,530 |
| 554 | Koelbjerg | 506,680 | 36,024 | 498,860 | 28,896 |
| 557 | Højby | 546,553 | 31,829 | 649,010 | 34,911 |
| 559 | Ullerslev | 122,096 | 6,090 | 96,997 | 6,024 |
| 560 | Nyborg | 58,062 | 2,970 | 53,549 | 2,893 |

*The figure shows the registered peak day and peak hour consumption at individual M/R stations*

## Capacity of stations connected to HMN Gas Distribution's system

Station capacities are listed in the table, 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.

*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.*

| 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 setpoint | M/R-station calculated capacity (-13 C) | Expected capacity requirements of distribution companies | Measured peak hour 01-05-2011 to 04-30-2012 |
|---|---|---|---|---|---|---|---|---|
| | | Nm³/d | Nm³/h | Barg | Barg | Nm³/h | Nm³/h | Nm³/h |
| | HMN | 6,695,530 | | | | | | |
| 663 | Køge | 553,490 | 25752 | 56.0 | 17.9 | 37,660 | 40,000 | 27,009 |
| 664 | Karlslunde | 545,990 | 25323 | 55.7 | 17.9 | 85,907 | 30,000 | 26,228 |
| 665 | Torslunde | 263,677 | 12226 | 55.5 | 17.9 | 31,495 | 20,000 | 13,832 |
| 667 | Vallensbæk | 478,582 | 20125 | 54.7 | 17.9 | 32,272 | 25,000 | 25,746 |
| 668 | Brøndby | 1,698,068 | 71619 | 54.4 | 31 | 125,968 | 90,000 | 81,284 |
| 672 | Dragør | 201,868 | 8712 | 53.5 | 16.6 | 23,039 | 12,000 | 9,725 |
| 682 | Lynge | 1,598,119 | 67050 | 53.1 | 31 | 136,246 | 90,000 | 78,552 |
| 684 | Måløv | 1,355,736 | 56505 | 53.5 | 17.9 | 106,000 | 70,000 | 63,188 |
| | HMN Vest | 5,827,577 | | | | | | |
| 464 | Viborg | 1,481,664 | 62909 | 68.4 | 35.4 | 94,199 | 100,000 | 76,912 |
| 473 | Haverslev | 312,571 | 15254 | 69.3 | 35.4 | 26,327 | 34,000 | 17,072 |
| 474 | Ellidshøj | 185,325 | 8092 | 68.0 | 35.4 | 10,793 | 12,000 | 9,629 |
| 476 | Aalborg | 1,422,447 | 64539 | 67.0 | 44.3 | 155,699 | 90,000 | 76,848 |
| 482 | Brande | 90,572 | 4595 | 64.9 | 35.4 | 10,789 | 6,000 | 5,359 |
| 483 | Herning | 1,990,062 | 85193 | 65.4 | 47.4 | 153,419 | 120,000 | 101,624 |
| 484 | Karup | 282,524 | 12774 | 66.9 | 35.4 | 17,502 | 18,000 | 14,503 |
| 486 | Ll. Torup MR | 62,413 | 2787 | 71.5 | 35.4 | 8,806 | 5,000 | 3,491 |

There are a few examples in the table 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 2010 and 2011

The maximum capacity utilisation for each M/R station during the 2010/2011 and 2011/2012 winters is shown in the table, 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

| M/R-station | | PERIOD: 01/05/2010 - 30/04/2011 | | PERIOD: 01/05/2011 - 30/04/2012 | |
|---|---|---|---|---|---|
| | | Daily volume | Max Hour | Daily volume | Max Hour |
| | | Nm³/d | Nm³/h | Nm³/d | Nm³/h |
| | HMN | 6,908,381 | 326,383 | 6,968,634 | 325,564 |
| 663 | Køge | 510,137 | 26,230 | 526,613 | 27,009 |
| 664 | Karlslunde | 700,560 | 33,968 | 538,018 | 26,228 |
| 665 | Torslunde | 235,726 | 13,030 | 283,936 | 13,832 |
| 667 | Vallensbæk | 504,279 | 23,290 | 523,174 | 25,746 |
| 668 | Brøndby | 1,743,792 | 79,648 | 1,808,904 | 81,284 |
| 672 | Dragør | 198,383 | 9,753 | 206,177 | 9,725 |
| 682 | Lynge | 1,579,088 | 75,824 | 1,686,144 | 78,552 |
| 684 | Måløv | 1,436,416 | 64,640 | 1,395,668 | 63,188 |
| | HMN Vest | 6,288,866 | 297,002 | 6,054,257 | 305,438 |
| 464 | Viborg | 1,562,714 | 69,996 | 1,592,336 | 76,912 |
| 473 | Haverslev | 429,560 | 21,158 | 306,848 | 17,072 |
| 474 | Ellidshøj | 204,678 | 9,607 | 202,306 | 9,629 |
| 476 | Aalborg | 1,516,700 | 75,592 | 1,405,456 | 76,848 |
| 482 | Brande | 92,139 | 4,950 | 102,935 | 5,359 |
| 483 | Herning | 2,110,656 | 97,600 | 2,084,072 | 101,624 |
| 484 | Karup | 309,388 | 14,815 | 294,061 | 14,503 |
| 486 | Ll. Torup | 63,031 | 3,284 | 66,243 | 3,491 |

*The figure shows the registered peak day and peak hour consumption at individual M/R stations between 1 May 2010 and 30 April 2011 and between 1 May 2011 and 30 April 2012.*

## Capacity of stations connected to Dong Gas Distribution's system

Station capacities are listed in the table, 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

*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.*

| 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 setpoint | M/R-station calculated capacity (-13 C) | Expected capacity requirements of distribution companies | Measured peak hour 01-05-2011 to 04-30-2012 |
|---|---|---|---|---|---|---|---|---|
| | | Nm³/d | Nm³/h | Barg | Barg | Nm³/h | Nm³/h | Nm³/h |
| Regi | Dong SYD | 3,607,573 | | | | | | |
| 451 | Frøslev | 634,734 | 28962 | 61.5 | 35.4 | 40,021 | 42,000 | 30,774 |
| 452 | Nybro | 53,116 | 2348 | 65.9 | 17.1 | 4,026 | 3,000 | 2,674 |
| 453 | Terkelsbøl | 305,166 | 13779 | 61.9 | 35.4 | 23,309 | 19,000 | 19,230 |
| 457 | Ll. Selskær | 434,120 | 20153 | 63.0 | 35.4 | 40,525 | 29,000 | 23,400 |
| 458 | Pottehuse | 182,096 | 8907 | 63.5 | 35.4 | 31,795 | 12,000 | 8,904 |
| 459 | St.Andst | 396,739 | 18581 | 63.7 | 35.4 | 40,772 | 27,000 | 22,039 |
| 460 | Egtved | 1,043,125 | 45710 | 64.2 | 35.4 | 61,507 | 65,000 | 59,434 |
| 462 | Varde | 164,260 | 8102 | 65.5 | 35.4 | 40,061 | 14,000 | 8,509 |
| 467 | Helle | 12,978 | 551 | 65.1 | 16.0 | 8,543 | - | 48 |
| 468 | Taulov | 70,488 | 3756 | 62.3 | 35.4 | 33,201 | 7,000 | 5,334 |
| 481 | Nørskov | 310,752 | 14155 | 64.5 | 35.4 | 24,416 | 22,000 | 15,770 |
| 496 | Lillballe | - | 0 | 62.9 | 3.6 | 8,911 | 2,500 | 1,984 |
| | Dong ØST | 1,663,329 | | | | | | |
| 646 | Amager | 42,159 | 2811 | 53.3 | 16.6 | 14,513 | 5,700 | 3,399 |
| 653 | Slagelse | 304,365 | 14519 | 57.9 | 16.7 | 27,757 | 21,000 | 16,084 |
| 658 | Sorø | - | 0 | 57.3 | 17.7 | 38,542 | - | 10,377 |
| 661 | Ringsted | 673,662 | 30622 | 56.6 | 25.0 | 38,309 | 42,000 | 30,888 |
| 687 | Sydhavnen | 16,943 | 780 | 53.2 | 3.6 | 5,792 | 3,000 | 845 |
| 691 | Stenlille MR | 626,199 | 27638 | 61.7 | 15.0 | 32,065 | 40,000 | 31,092 |

There are a few examples in the table 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 2010 and 2011

The maximum capacity utilisation for each M/R station during the 2010/2011 and 2011/2012 winters is shown in the table, 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

| M/R-station | | PERIOD: 01/05/2010 - 30/04/2011 | | PERIOD: 01/05/2011 - 30/04/2012 | |
|---|---|---|---|---|---|
| | | Daily volume | Max Hour | Daily volume | Max Hour |
| | | Nm³/d | Nm³/h | Nm³/d | Nm³/h |
| | DONG ØST | 1,853,377 | 95,226 | 1,812,833 | 92,685 |
| 646 | Amager | 51,109 | 4,083 | 40,773 | 3,399 |
| 653 | Slagelse | 309,458 | 16,469 | 318,490 | 16,084 |
| 658 | Sorø | 198,384 | 12,745 | 153,435 | 10,377 |
| 661 | Ringsted | 668,720 | 31,432 | 631,820 | 30,888 |
| 687 | Sydhavnen | 19,866 | 1,745 | 15,705 | 845 |
| 691 | Stenlille MR | 605,840 | 28,752 | 652,610 | 31,092 |
| | DONG SYD | 3,800,061 | 188,508 | 3,552,455 | 170,949 |
| 45 | Frøslev | 699,828 | 39,968 | 558,330 | 30,774 |
| 452 | Nybro | 56,328 | 2,562 | 50,192 | 2,674 |
| 453 | Terkelsbøl | 356,288 | 17,584 | 327,022 | 19,230 |
| 457 | Ll. Selskær | 473,680 | 24,096 | 451,404 | 23,400 |
| 458 | Pottehuse | 171,640 | 8,296 | 169,508 | 8,904 |
| 459 | St.Andst | 453,056 | 21,912 | 422,104 | 22,039 |
| 460 | Egtved | 1,125,248 | 56,788 | 1,079,392 | 59,434 |
| 462 | Varde | 184,502 | 14,980 | 151,474 | 8,509 |
| 467 | Helle | 5,725 | 407 | 60 | 48 |
| 468 | Taulov | 106,162 | 5,362 | 114,416 | 5,334 |
| 481 | Nørskov | 340,187 | 16,511 | 282,351 | 15,770 |
| 496 | Lilballe | 44,438 | 2,163 | 37,348 | 1,984 |

*The figure shows the registered peak day and peak hour consumption at individual M/R stations*

## Gas quality during the coming winter

*Energinet.dk is responsible for ensuring that the gas in the transmission system always fulfils the given quality and composition requirements.*

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 in Stenlille and Lille Torup.


*Gas quality is measured at measuring stations in Nybro, Egtved, Dragør Border, Ellund, Lille Torup and Stenlille.*

### Variation in gas quality in 2011-2012

In 2011, the Danish market was supplied with Danish North Sea gas as well as European gas imported via Ellund.

Between 1 October 2011 and 1 October 2012, the gas quality varied as follows:

- The Wobbe index for natural gas ranged between 14.28 kWh/Nm$^3$ and 15.36 kWh/Nm$^3$, with an average of 15.20 kWh/Nm$^3$
- The relative density ranged from 0.601 to 0.664
- The upper calorific value ranged between 11.15 kWh/Nm$^3$ and 12.42 kWh/Nm$^3$, with an average of 12.16 kWh/Nm$^3$.

### Gas quality 2012-2013

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

The gas quality forecast for the coming winter is as follows:

- The Wobbe index of the Danish North Sea gas is expected to continue to vary between 15.0 kWh/Nm$^3$ and 15.5 kWh/Nm$^3$.
- Gas imported from Germany is expected to have a lower Wobbe index than that of Danish North Sea gas.
- Energinet.dk expects the average Wobbe index to be 14.4 kWh/Nm$^3$, ranging from 13.9 kWh/Nm$^3$ to 15.5 kWh/Nm$^3$.

### What does the future hold?

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

In the longer term, when new supply routes have been established, the natural gas will continue to belong to group H. This will be true irrespective of whether future supplies come from Norway, Germany, the Netherlands or Russia, as LNG or as a mixture of these 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 Regulations.

In connection with future updates to the Danish Gas Regulations, the Danish Safety Technology Authority will stipulate gas quality requirements for upgraded biogas being fed into the gas system. This will ensure 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 the Rules for Gas Transport.
- Gas distributed to Danish consumers must comply with the quality specifications set out in the Danish Safety Technology Authority's Danish Gas Regulation.
- The Danish market is always supplied with gas complying with the requirements set out in Rules for Gas Transport and in the Danish Gas Regulations.

# Future challenges facing gas

*Expansion towards Germany will secure the gas supply to Denmark until 2020. The Danish Government's vision of fossil-free energy in 2050 entails challenges.*

### Gas consumption and supplies 2013-2050

Natural gas supplies from the North Sea have been declining dramatically in recent years, but production will increase again in 2015 for a few years. New gas fields are beginning to produce, while existing fields are seeing a continual decline in production. Combined with supplies from the North Sea, the expected expansion towards Germany will secure the gas supply to Denmark and Sweden until 2020, as sufficient import capacity will be established to cover the expected demand. The supply situation is more uncertain after 2020.

### Gas supply situation 2013-2015

The supply situation is expected to be tight between 2013 and 2015. However, Energinet.dk expects the existing options for physical supplies from Germany are adequate to handle the critical supply situations for Denmark and Sweden that may arise during the period.

### Alternative supply situation

It is not certain that all the necessary expansion will be carried out in Germany. It may therefore be necessary to connect the infrastructure to alternative supply routes.

### Gas transmission tariffs

Transport tariffs have fallen during the period Energinet.dk has operated the transmission system. However, transport costs are expected to rise in the longer term due to declining quantities. Leading up to 2030, transmission system costs are expected to increase by 20%, while quantities will decline by 40%.

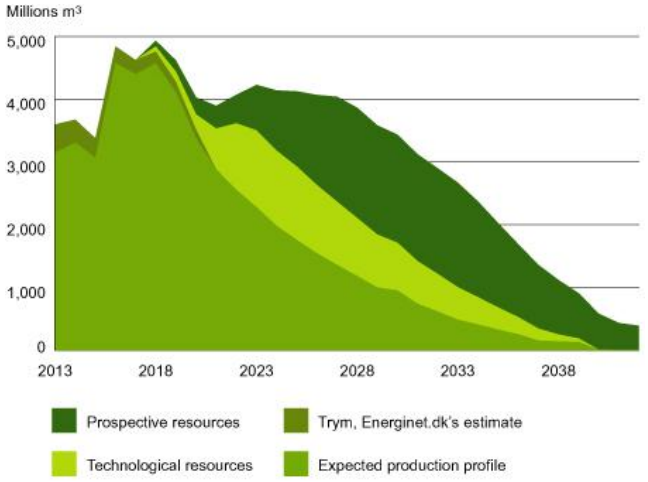
## Gas consumption and supplies 2013-2050

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

Denmark was self-sufficient until 2010 using gas from the North Sea, which 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.

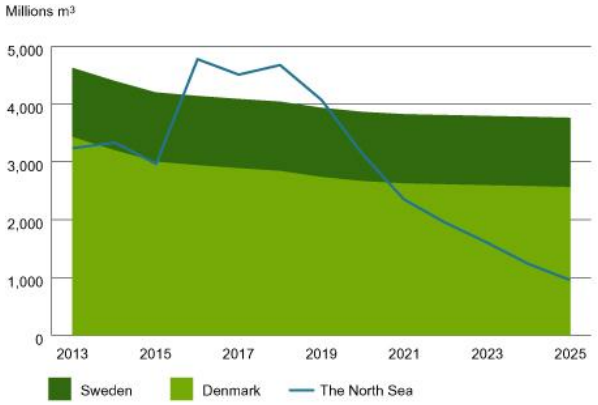
The Danish Energy Agency estimates that gas supplies from the North Sea will decline steadily between 2013 and 2042. There is a risk that supplies will be phased out in 2040, as shown below.




*Gas supplies from the North Sea 2013-2042. Danish Energy Agency and Energinet.dk 2012.*

### North Sea production and Danish and Swedish gas consumption

It is expected that there will not be sufficient gas from the North Sea to supply the entire Danish and Swedish gas markets between 2013 and 2015, as illustrated in the figure below.



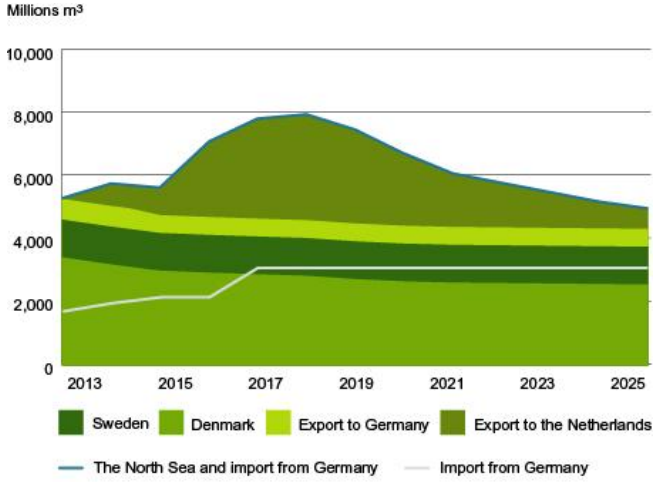

*Danish and Swedish gas consumption and expected gas supplies from the North Sea 2013-2025. Danish Energy Agency and Energinet.dk 2012.*

There is much uncertainty about the extent to which production can be increased via technological resources (new extraction technologies) and prospective resources (new fields). Energinet.dk has an obligation to provide the necessary transport capacity. We therefore rely 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 2013-2025

In 2012, Energinet.dk made a projection of gas consumption in Denmark and Sweden up to 2025. The supply situation assumes that the Danish expansion towards Germany in 2013 is accompanied by the first stage of expansion in Germany in 2014. It is also assumed that the Danish Hejre gas field commences production in 2015.

Further expansion of the system in Northern Germany is assumed in 2017, such that the Danish and Swedish markets can be supplied from the North Sea and Germany up until 2025. Energinet.dk's projection of gas consumption is shown in the figure below.




*Projection of gas production, supplies and consumption 2013-2025. Danish Energy Agency and Energinet.dk 2012*

If sufficient expansion of the export capacity towards Denmark is not implemented in the transmission system in Northern Germany before 2017, the flexibility of the Danish system will be limited. The supply situation will depend on production in the Danish region of the North Sea, and on whether the Danish offshore system is connected to the Norwegian offshore system.

No estimate is presented above of the supply situation after 2020 as a consequence of the Danish Government's vision of a fossil-free energy supply in 2050.

**Facts**

- Denmark was self-sufficient in gas from 1984-2010.
- The supply situation is under more pressure in 2013-2014.
- Gas reserves in the North Sea are expected to be exhausted before 2050.
- The expected expansion towards Germany will secure the gas supply to Denmark and Sweden until 2020.

## Gas storage capacity

*The limited options for acquiring gas for the Danish and Swedish markets over the next few years mean 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, capacity, security of supply and daily operation.

The majority of the storage facilities' capacity of approx. 1 billion $Nm^3$ is used by commercial players, but Energinet.dk has reserved 100-200 million $Nm^3$ of gas storage capacity for extended emergency supplies, and withdrawal capacity of approx. 16 million $Nm^3$/day for emergency supply situations.

### Greater importance of the storage facilities between 2013 and 2015

Until adequate import capacity has been established at the border with Germany, 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 great need to utilise the existing storage facilities, which cannot be easily expanded to any significant extent. The storage needs of commercial players are expected to be at least 500 million $Nm^3$ in 2013.

It is important that shippers and storage customers carefully consider their need for flexibility over the next few years, and Energinet.dk will continue to give the market the best possible information about the expected transport and storage need.

The need to purchase security of supply instruments is expected to decline in 2014 once there is greater security for the supply from Germany.

Demand for withdrawal capacity is expected in normal situations to vary between 10 million $Nm^3$/day and the current capacity of 18 million $Nm^3$/day. The volume required in 2014 is still estimated to be more than 500 million $Nm^3$, and once supplies from the North Sea are phased out, the need for storage volume and capacity may rise.

### Storage need in the medium and long term

It has been planned that the transmission system will be expanded towards Germany in 2014, and the Danish Hejre field in the North Sea is expected to become operational in 2015. Although production from the existing North Sea fields will be declining at the same time, the total supply sources for the Danish and Swedish markets, which are expected to see declining demand, will be sufficient for a number of years. Pressure on existing storage facilities is therefore expected to be reduced in the short term.

However, there are a number of other factors that can increase the storage needed in the medium (2015-2020) and longer term (2020-2050). Energinet.dk has estimated the potential supply situation for the 2013-2025 period on the assumption of supplies coming from Germany and the Danish part of the North Sea.

The longer-term storage need will in part be determined by the tools chosen by Energinet.dk to cover our security of supply obligations to the Danish market and the security of supply need on the Swedish market.

The new EU security of supply regulation requires security of supply to be viewed from a regional perspective. This means that security of supply in Sweden must also be included in the assessment.

If the gas system is to be used longer term as a reserve and peak load source to ensure security of supply in a greatly expanded electricity system based on wind power, additional storage requirements may arise.

**Facts**

- The Stenlille and Lille Torup gas storage facilities have a storage volume of approx. 1 billion $Nm^3$
- The gas storage facilities have withdrawal capacity of 17.5 million $Nm^3$ day in normal situations and approx. 25 million $Nm^3$/day in emergency situations
- The storage for load balancing between 2013 and 2025 is expected to range between 300 and 800 million $Nm^3$
- The EU security of supply regulation may increase the storage requirement for emergency supply in 2020
- Further storage needs may arise given a greatly expanded electricity system based on wind power.

## Consumption trends in Denmark and Sweden

The total consumption of natural gas and biogas in Denmark and Sweden will decline in the years ahead, despite increasing biogas production.

The total natural gas and biogas consumption in Denmark, excluding field consumption in the North Sea, is expected to decline from approx. 150 PJ/year in 2012 to approx. 118 PJ/year in 2021. Natural gas consumption is expected to decline from approx. 145 PJ/year to approx. 100 PJ/year over the period, whereas biogas consumption will rise from 5 PJ/year to approx. 18 PJ/year.

### Natural gas consumption in Denmark

The expected decline in natural gas consumption from approx. 145 PJ/year to approx. 100 PJ/year up until 2021 corresponds to a natural gas quantity of approx. 3.3 billion $Nm^3$/year in 2012 and approx. 2.3 billion $Nm^3$/year in 2021, at a calorific value of 12.1 kWh/$Nm^3$.

This estimate is based on Energinet.dk's annual projection of Danish gas consumption for a 10-year period. This year's projection covers the 2012-2021 period.

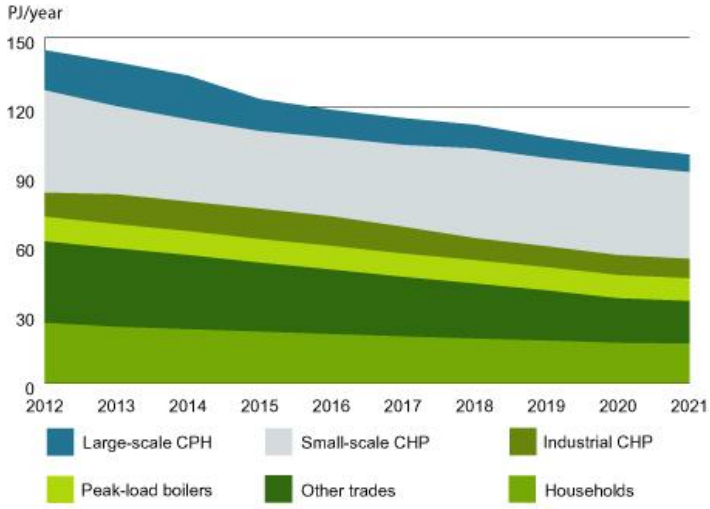
The projection of natural gas consumption covers the existing consumption segments: large-scale, small-scale and industrial CHP plants, district heating boilers, other sectors and households. However, the projection does not include gas used for transport.

### Biogas consumption in Denmark

Up until 2021, production of RE gases is expected to only cover biogas. The Danish Energy Agency (September 2012) estimates that the production of biogas will grow from the current level of approx. 5 PJ/year to approx. 18 PJ in 2021.

### Consumption projection for Denmark

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




*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 source of supply.

Sweden is seeing continued development in areas such as biogas and gasification gas in the grid, 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 Malmö becoming operational. Consumption in 2012 is expected to be approx. 1.1 billion $Nm^3$/year.

There is much uncertainty involved in the projection of Swedish natural gas consumption, but the existing level of consumption is expected to decline slightly. This expectation is based in part on announcements from the Swedish Energy Agency and Swedegas. Energinet.dk therefore expects natural gas consumption in Sweden to be approx. 1.2 billion $Nm^3$/year over the next few years.

Facts

- Projections are based on the energy policy agreements from 2008 and 2012 and 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 2012.
- Fuel prices have been taken from the IEA fuel price forecast from 2011.
- 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.
- The model includes natural gas consumption by large-scale, small-scale and industrial CHP plants and peak-load boilers.

## Supply situation 2013-2015

*The supply situation is expected to be tight between 2013 and 2015. However, 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 between 2013 and 2015. This is because gas supplies from the Danish region of the North Sea are declining rapidly.

Energinet.dk estimates that there is sufficient gas to secure the gas supply for Denmark and Sweden between 2013 and 2014. This is due both to supplies from the Danish gas storage facilities and the fact that it has been possible since October 2010 to receive physical supplies of interruptible capacity from Germany.

During the summer, when large quantities of gas are injected into the storage facilities, it may be necessary to interrupt or reduce this injection and/or the interruptible capacity at the Dragør exit or Ellund entry points. This is done to maintain the necessary pressure in the transmission system.

Energinet.dk will keep market players regularly informed of the expected trends between 2013 and 2015. We will do this until the expansions of the transmission system towards Germany have been established in October 2014, in order to give market players a common information base. This will allow market players to take the necessary precautions to avoid critical supply situations.

### New North Sea and gas consumption forecasts

The Danish Energy Agency annually produces a new forecast estimating 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 2013-2016.

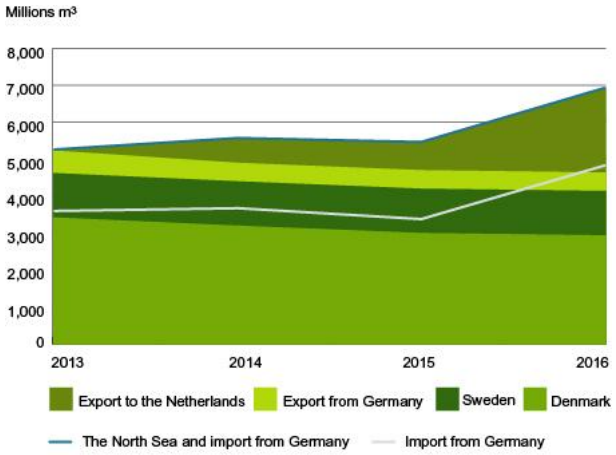
In the short term, it is expected that the interruptible physical supplies from Germany of 200,000 $Nm^3/h$ will help meet any shortfall that may arise in the supply of gas to Denmark and Sweden.

New import facilities in Denmark become operational at the end of 2013. The expansions on Germany's part towards Denmark will become operational by October 2014.

The tight supply situation expected in 2013 and 2014 makes it necessary for shippers and storage customers to carefully assess how they can secure adequate supplies during these years.

### Expected supply situation 2013-2016

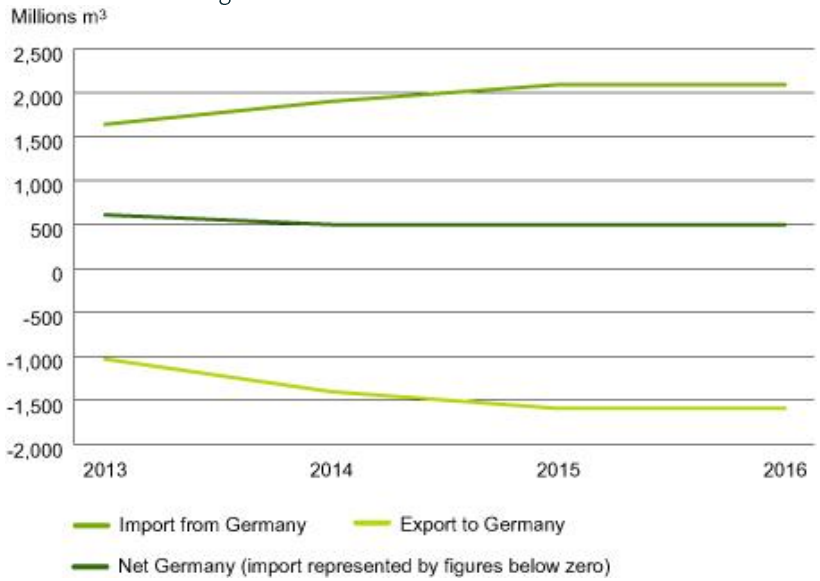
The new Danish Hejre gas field is expected to commence operations in 2015. Combined with import options from Germany, this will ensure adequate supplies. If Hejre commences operations as planned and there is further expansion in Germany in 2017, opportunities will be created for plentiful supplies to Denmark and Sweden, as has been assumed below.




*Expected supply situation 2013-2016*

| | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|
| Export from the Netherlands | 0 | 671 | 763 | 2,288 |
| Export from Germany | 610 | 500 | 500 | 500 |
| Sweden | 1,200 | 1,200 | 1,200 | 1,200 |
| Denmark | 3,428 | 3,204 | 3,004 | 2,942 |
| The North Sea and import from Germany | 1,640 | 1,901 | 2,091 | 2,091 |
| The North Sea | 3,598 | 3,674 | 3,376 | 4,839 |

As a supplement to supplies from the North Sea, it will be necessary in 2013-2014 to import gas from Germany to meet demand on the Danish and Swedish markets. This is illustrated in the figure below.




*Supplies Ellund 2013-2016.*

| | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|
| Import from Germany | 1,640 | 1,901 | 2,091 | 2,091 |
| Export from Germany | 610 | 500 | 500 | 500 |
| Netto Germany (- for import) | -1,030 | -1,401 | -1,591 | -1,591 |

### Important supply issues

The following issues are important to consider:

- The quantities of gas supplied from the Danish part of the North Sea are expected to be insufficient to meet demand on the Danish and Swedish gas markets in 2013. Net imports from Germany of around 1 billion $m^3$ will be required. It is assumed that a physical maximum of 200,000 $Nm^3/h$ can be supplied from Germany – as seen in 2012. The gas will be supplied on an interruptible basis
- The compressor station in Egtved, which was originally planned to be commissioned in October 2013, is now expected to begin operating in June 2013
- From 1 October 2013, it is expected that interruptible capacity of 310,000 $Nm^3/h$ can be supplied from Germany to Denmark
- Expansions in both Germany and Denmark are expected to be operational in 2014, leading to firm capacity of 310,000 $Nm^3$/hour. This will provide security that there are adequate quantities of gas to supply the Danish and Swedish gas markets
- The Hejre gas field is expected to become operational in 2015. This will allow larger quantities of gas from the North Sea to be supplied to the Danish, Swedish, Dutch and German markets.

**Facts**

- The supply situation will be tight between 2013 and 2015, and interruptions may be necessary
- It will be necessary to import 1 billion $m^3$ gas from Germany in 2013 and 1.4 billion $m^3$ in 2014
- The interruptible capacity from Germany of 200,000 $m^3/h$ is expected to be increased to 310,000 $m^3/h$ on 1 October 2013
- Firm capacity from Germany of 310,000 $m^3/h$ is expected from October 2014
- The Danish Hejre gas field is expected to commence operations in 2015.

## Alternative supply situation in 2020

*If the planned expansions of the German gas system are delayed, it may be necessary to carry out other expansions.*

Compared to most of our neighbours, Denmark has been in the privileged situation of being self-sufficient in terms of oil and gas. For example, it has not been necessary to be connected to the Northern European gas infrastructure, which in addition to its own declining production has received supplies from Norway, Russia and LNG.

### More gas from Germany in the future

As North Sea production decreases, Denmark will become more dependent on gas imported through Germany. The Danish gas market has access to extensive gas reserves for many years to come via the connection to the European gas network in 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, while 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. DONG Energy, for example, has entered into agreements with Russian Gazprom for long-term supplies of gas in North Germany.

Energinet.dk's investments in import capacity from Germany are a great improvement in the long-term security of supply, but it may still be necessary to evaluate other alternatives.

### Prospective expansions, including a connection to Norway

In May 2010, the Danish Energy Agency published the '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 optimally used in conjunction with the onshore infrastructure.

The Danish Minister for Climate and Energy also approved Energinet.dk's expansion towards Germany. The expansion involved establishing a compressor station and looping the pipeline between Ellund and Egtved. Energinet.dk decided that capacity in Denmark should be expanded to 700,000 $m^3$/h. The German system will initially be expanded to a capacity of approx. 310,000 $m^3$/h, but further expansion is expected by 2017.

The Danish Energy Agency notes in the report 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 a direct connection to the shore. The decision depends on whether the necessary market is likely to arise at some point in time.

### Security of supply for Northern Europe

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

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

### Security of supply regulation

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

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

### Denmark's energy resources

The Danish Government has the objective that the energy supply in Denmark should be met by renewable energy in 2050, but conversion will take time. Oil and natural gas will continue to play a key role in the Danish energy supply during the transition period.

The Government is pursuing two objectives. As much of the oil that has been discovered as possible should be extracted. Investment should also be made in locating new discoveries.

Preliminary studies are currently being conducted in North Zealand and North 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 quantities of shale gas and if the Government grants permission to extract it, this could radically change the supply situation in Denmark.

Facts

- It is not certain that there will be full expansion in Germany before 2017
- A connection to the Norwegian offshore gas system could help secure the supply to the Danish and Swedish gas markets
- The European Commission supports both a Norway-Denmark and Denmark-Poland gas connection via the Baltic Energy Market Interconnection Plan (BEMIP)
- Subterranean shale gas in Denmark could radically change the supply situation
- The Danish Government's vision of a fossil-free energy supply in 2050 will change the supply situation after 2020.

## Expansion in Denmark and Germany

*Together with the Danish expansion in 2013, the German stage 1 in 2014 ensures security of supply in the short term. A second stage is also planned in North Germany.*

### Expansion towards Germany in 2013

Denmark was self-sufficient in gas from supplies in the Danish part of the North Sea from 1983 to 2010. However, gas production is now rapidly declining, making it necessary to expand the gas system in both Denmark and Germany. The Danish expansion will be completed in 2013, and stage 1 of the German expansion will follow in 2014.

### German expansions towards Denmark after 2014

Further expansion of the system in Northern Germany is expected in 2017, such that the Danish and Swedish markets can be supplied from the North Sea and Germany for a number of years.

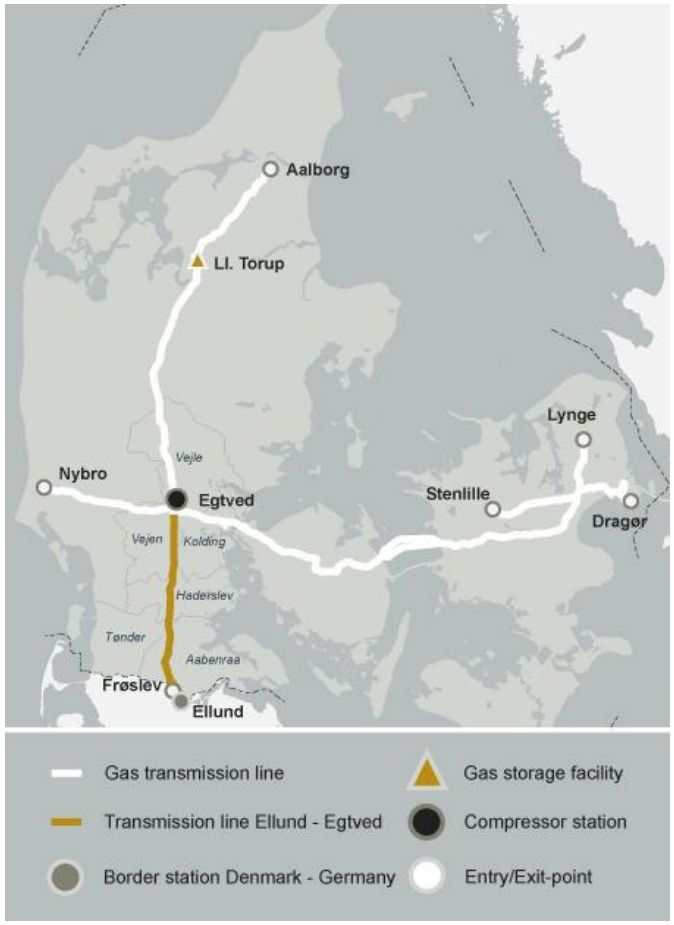
## Expansion towards Germany in 2013

*The new compressor station in Egtved and the 94 km long pipeline to Germany will ensure security of supply for the Danish and Swedish gas markets.*

A new pipeline and a new compressor station will be commissioned in autumn 2013.

In 2011, the Danish Minister for Climate and Energy approved the establishment of plants to expand transport capacity from the Danish-German border to Egtved, from where gas can be transported throughout Denmark. The approval covers a compressor station and a pipeline looping.

Once the compressor station in Egtved is complete, it can raise the gas pressure from the level at the border to the higher level required in the rest of the Danish gas transmission system. A 94 km gas transmission pipeline is also being constructed from the German border at Frøslev to Egtved, looping the existing pipeline. The two parallel pipelines increase the import capacity at the border point.




*The Danish main transmission system for natural gas with a compressor station in Egtved and an Ellund-Egtved looping.*

### Compressor station in Egtved

The pressure in the Danish gas system is currently provided by a compressor station in the North Sea. As gas becomes increasingly supplied from Germany instead of from the North Sea, we will need to be able to maintain a sufficiently high pressure in the gas system ourselves. Energinet.dk has therefore decided to establish a

compressor station in Egtved. The station is being established so that it can pressurise gas in all four directions from Egtved.

A contract was entered into with a turnkey contractor in 2010. The final design concept for the compressor station was completed in 2011, and the plant was planned in detail. Preparation work was carried out in 2011, and construction work began in earnest in 2012.

Two large service buildings, four buildings for compressor units and a transformer station have been built. The first compressor unit is currently being installed.

### 94 km pipeline from Ellund to Egtved

When greatly increasing quantities of gas need to be supplied from Germany to Denmark, the existing pipeline is not large enough. Energinet.dk therefore decided to build a new pipeline parallel to the existing pipeline.

The gas pipeline from Frøslev to Egtved was planned in 2010-11. At the end of 2011, an agreement covering the construction work was entered into with a primary contractor. The gas pipeline was laid in 2012.

In 2013, the pipeline will be integrated with the existing gas transmission grid at selected valve stations, allowing it to come into service at the same time as the compressor station in autumn 2013.

The Danish Working Environment Authority has to approve construction of the plant and ensure that the requirements in the Danish executive order on safety provisions for natural gas installations are complied with. The Danish Working Environment Authority also issues the operating licence.

The other approvals have already been obtained from the building authority in Vejle Municipality and from municipal and national environment, road and rail authorities.

*Compressor site in Egtved*

### Construction project status

At the end of 2012, work on the compressor station has reached the point that two large service buildings, four buildings for compressor units and a transformer station have been built.

The first compressor unit has arrived and is being installed, and installation work is being done in the service buildings. Work is being done outdoors to establish pipe systems, run cables and construct roads, etc.

*Laying the new gas pipeline.*

The work of laying the new gas pipes began in March 2012. The pipeline was laid from north to south, as a sequence of activities, the most important of which were:

- Topsoil removal
- Pipe laying
- Pipe join welding
- Inspection of welds
- Excavation and laying of the pipeline
- Re-establishment of pipes and drains on the pipeline route
- Filling of pipeline trench
- Replacement of topsoil and finishing.

This was in addition to more specialised activities such as crossing roads, railway lines and watercourses. The pipeline has also been drilled under a motorway and under various natural areas.
The entire pipeline has been pressure-tested and is ready to be connected to the German network and the compressor station in Egtved.

Facts

- The Ellund-Egtved pipeline is 94 km long and 30 inches in diameter
- The compressor station in Egtved consists of four identical 5.4 MW units
- The expansion makes it possible to supply up to 700,000 $m^3$/h from Germany
- The plants in Denmark will commence operation on 1 October 2013
- The plant in Germany will commence operation on 1 October 2014.

## German expansions towards Denmark after 2014

*Capacity in North Germany will be extended, depending on demand.*

Energinet.dk has sketched out a supply situation for gas consumption and supplies between 2013 and 2050. The analysis assumes that the first stage of expansion in Germany is completed in 2014, and that the Danish Hejre gas field commences production in 2015.

A further stage in the expansion of the system in Northern Germany is expected by 2017, such that the Danish and Swedish markets can be supplied from the North Sea and Germany for a number of years.

### Stage 1 expansion

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

The existing German Ellund-exit interruptible capacity of 200,000 $m^3$/h will hereby be expanded to 310,000 $m^3$/h under firm conditions. Energinet.dk expects Germany to be able to supply a further 40,000 $m^3$/h as interruptible capacity.

### Stage 2 expansion

Dutch-owned Gasunie Deutschland has reported that they have further expansion plans to increase the capacity and flexibility in the North German system to match the increased demand in Schleswig-Holstein and the Danish and Swedish markets.

If the investment decision is confirmed in 2012, the stage 2 expansions could be operational from 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.

Stage 2 is expected to meet Swedish and Danish demand after 2015 in the short term, and can be further expanded at a later time.

**Facts**

- The interruptible capacity from Germany of 200,000 $m^3$/h is expected to be increased to 310,000 $m^3$/h on 1 October 2013
- Firm capacity from Germany of 310,000 $m^3$/h and a further approx. 40,000 $m^3$/h of interruptible capacity is expected from October 2014
- German investment decisions are being planned in dialogue between the system operators and the German regulator, Federal Network Agency.
- The www.netzentwicklungsplan-gas.de website provides information about the common German transmission system expansion.
- The European system operators plan and publish joint 10-year plans for grid development.

## Tariffs

*Transport tariffs have been reduced during the time Energinet.dk has operated the transmission system.*

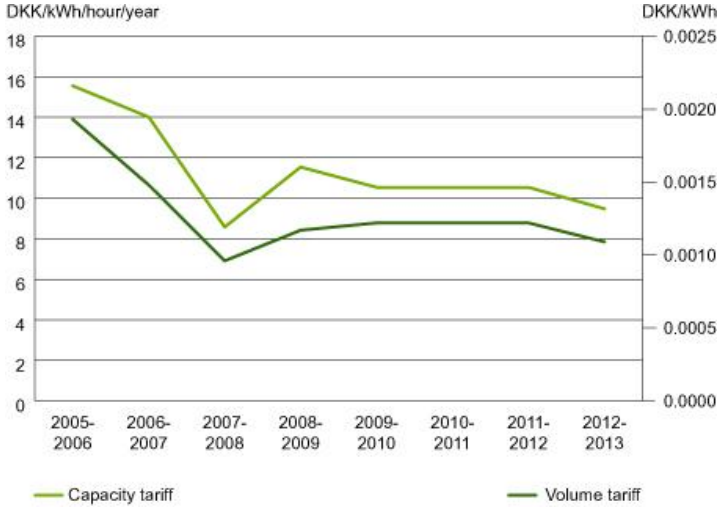
Transport costs are expected to rise in the longer term due to declining quantities. Leading up to 2030, transmission system costs are expected to increase by 20%, while quantities decline by 40%.

## Transport tariffs

*The gas transport tariff has declined since 2005. Differentiated capacity tariffs are being introduced in October 2013, and costs are expected to rise.*

From October 2012, transport tariffs were reduced by 10% compared to the previous year.

The price of transport services has declined in the time Energinet.dk has operated the transmission system. This can be clearly seen in the following model.




*Transport prices 2005-2012*

### Tariffs have fallen

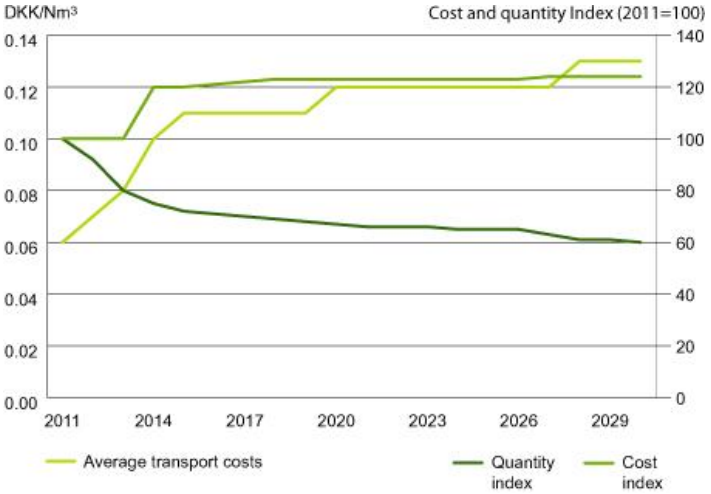
Tariffs have fallen. This is primarily because a surplus accumulated in previous years is extraordinarily being repaid to consumers over a three-year period. The restructuring of capital costs, extended depreciation periods and efficiency gains in operations are also helping to further reduce the costs.

The latest price drop goes against market trends, with declining domestic consumption, warm weather and reduced transit from the North Sea to Germany all leading to declining transport quantities. Capacity reservations and transported quantities are expected to be 15% lower in 2013 than 2012, which is already showing lower transport activity than previous years.

### Transport costs over the next 20 years

Transport costs are expected to rise in the longer term due to declining quantities and rising costs.

The figure shows the average unit cost per $m^3$ transported in the period up to 2030. The costs in the transmission system (here shown as an index) are expected to increase by approx. 20% due to the establishment of new plants, fuel costs for compressors, ageing technical systems and write-downs for decommissioned assets. Transport quantities will decline by 40% during the period.




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

### Differentiated capacity tariffs

Energinet.dk has previously used the same capacity prices in and out of all entry and exit points in the system.

From October 2013, Energinet.dk expects to differentiate the capacity tariffs in order to better distribute system costs to individual points.

Several neighbouring markets use differentiated tariffs. This sends cost signals and prevents cross-subsidisation. Energinet.dk deliberately limits the price range as a reflection of the relatively small and homogeneous market. However, Energinet.dk does distribute the costs of dedicated investments to the customer groups that have requested changes to the system.

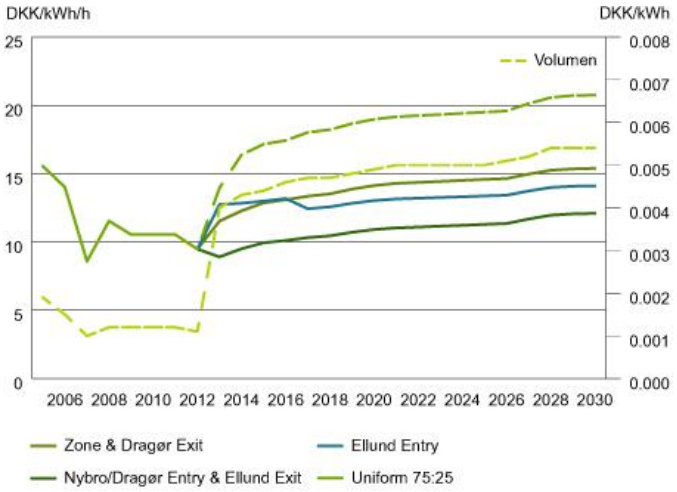
### Relative increase in variable payment

Energinet.dk previously set capacity tariffs so that they accounted for at least 75% of total income, while volume payments accounted for the remaining 25%. In future, capacity tariffs will be linked to the fixed capital costs (depreciation and interest payments). Volume payments will be defined based on the variable operating and maintenance costs.

Given that operation and maintenance 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.

The price of capacity is thereby falling despite the fact that the transport quantities are declining. 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.

The graph shows the effect of restructuring the tariff method, differentiated tariffs and the change to the capacity and volume tariff proportions.




*The effect of restructuring the tariff method, differentiated tariffs and the change to the capacity and volume tariff proportions.*

The figure above shows the two changes in methodology. The three new capacity tariffs are shown using solid lines. Each line shows a point-specific capacity payment.

Capacity tariffs used to be identical (uniform) at all points for each product type. The upper dotted curve shows what the uniform capacity tariff might have been if the proportion between the capacity and volume payment was not changed.

The aim is to increase the volume payment in proportion to the capacity payment. This will be achieved by defining the volume payment (the dotted green line) based on variable costs rather than a fixed percentage of the total cost base. The volume payment is being increased significantly.

Facts

- Tariffs are being reduced in 2013 but must increase in the longer term
- Danish transport costs are expected to increase as consumption declines and costs rise or remain constant
- The tariff method is being amended in line with European harmonisation and adaptation to changed conditions in the Danish gas market, where consumption declines and demand for flexibility rises
- Changes to the emergency supply model are leading to lower prices.

## Emergency supply tariffs

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

The existing emergency supply tariff was restructured effective from 1 October 2012. It is now end users and not shippers (as was previously the case) who settle the emergency supply tariff with Energinet.dk. Consumers ultimately pay in both models, but the chain of settlement has been changed.

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

- Non-protected consumers are approx. 90 industrial companies, which together account for around one-third of the annual gas consumption in Denmark

- Protected consumers are the district heating plants and approximately 400,000 private companies that consume less than 2 million $Nm^3$ per year. These companies and the district heating plants together account for around two-thirds of consumption.

### Difficult to compare prices

The modified emergency supply model and division into new customer categories make it difficult to compare the price level.

The previous common emergency supply tariff of DKK 0.00360/kWh in 2011/2012 has fallen to a new weighted average emergency supply tariff of DKK 0.00201/kWh in 2012/2013. This corresponds to a drop of 44%. One of the primary reasons for the price decline is that the costs of effectively covering a smaller market have been reduced and optimised.

### Sales of extra 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 2011, Energinet.dk sold 40% 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 128 million. This profit was added to the accumulated surplus and has to be repaid to consumers in the form of tariff reductions over three years, starting this year.

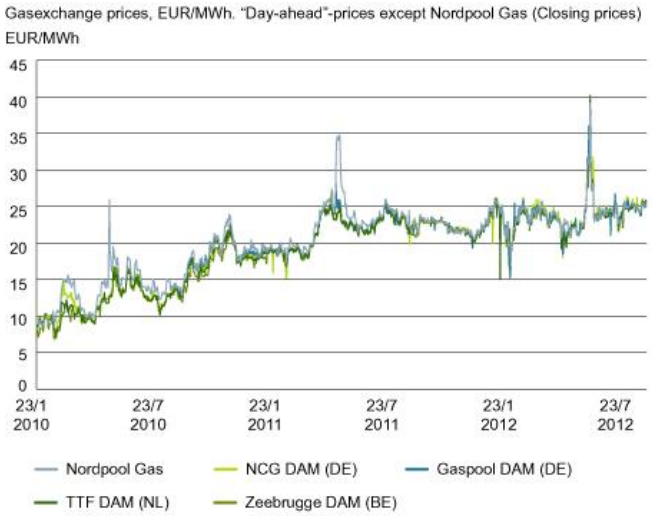
There has also been significant optimisation in relation to the purchase of emergency supply services.

## 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 grid in a tight market. They are also intended to contribute to a greater degree of harmonisation and integration with neighbouring markets. Comparing the prices on the exchanges provides a simple indicator of whether the project has been successful.

The figure shows that the gas exchange prices are already demonstrating a high degree of correlation, as well as periodic fluctuations, where local prices are significantly higher than the prices on other exchanges. Prices are higher than during the worst financial crisis in 2009. However, they are also relatively stable when there is sufficient transport capacity between the markets.




*Gas exchange prices 2008-2012.*

### New marketplaces

The European gas markets have to become more effective and cohesive in the competition with new fuels and adaptation to less polluting fuels. New marketplaces are arising in Europe, and they are being merged into increasingly large market areas with common exchanges and common electronic capacity platforms. These capacity platforms allow shippers to buy bundled capacity in several systems.

Energinet.dk has already introduced capacity auctions at those border points where bottlenecks can force prices to higher levels than the previously regulated tariffs. However, the aim of the capacity expansions and new flexible products is to reduce the risk of bottlenecks. The objective is for capacity at the border points to match capacity in the adjacent systems, and to be sold as a bundled product. Capacity at the Ellund border point will in future be offered for sale on a common Northern European platform, as a common product with German operators.

### Thorough review of prices

Over the next few years, the Danish Energy Regulatory Authority will conduct a thorough review of our product composition, ie prices and advanced 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.

New, modified price structures will be set in close dialogue with shippers and the Danish Energy Regulatory Authority. These must be in place by spring 2013, when Energinet.dk will auction the next year's capacity products.

### Common European regulations in 2012-2013

Capacity bundled at the border points and the joint income from sales have to be shared between two independent operators. This encourages a higher degree of harmonisation of transport-system price structures and product composition, across national markets.

The common European regulations for tariff structures will be negotiated in 2012-2013 and implemented over the next few years. Although the changes are only required at the border points, it is assumed they will impact on the distribution between income and transport streams throughout the system.

Energinet.dk has previously used the same capacity prices in and out of all entry and exit points in the system. From October 2013, it is expected that the costs will be distributed across the individual points to a greater degree, due to the differentiated capacity tariffs.

Several neighbouring markets use differentiated tariffs. This sends cost signals and prevents cross-subsidisation. The price range is deliberately limited as a reflection of the relatively small and homogeneous market. However, the costs of dedicated investments are distributed to the customer groups that request the changes.

# Future of the gas system

*The use of RE in Denmark must be dramatically increased by 2020. The political vision for 2050 is complete conversion to RE.*

In order for Denmark to become independent of fossil energy sources, wind power, solar energy and biomass will become the most important energy sources. The electricity system is therefore expected to play a greater role in energy supply in the future. However, fuel is also needed by consumers that cannot be supplied electricity and appliances that do not run on electricity, and as a backup and strategic store, for example when there is no wind or the sun is not shining. A green gas system could provide the necessary foundation for this.

The gas system was built in the 1980s and currently covers most of Denmark – except for the islands of Lolland, Falster, Bornholm and the smaller islands. The gas system transports large quantities of energy, as gas consumption is approx. 25% greater than Danish electricity consumption.

The two underground gas storage facilities in Lille Torup and Stenlille are the cornerstones of the gas system, as they have extensive energy storage capacity, which the other major energy systems, electricity and district heating, do not have.

### Extensive restructuring expected

The March 2012 energy agreement stipulates that 50% of traditional electricity consumption (ie excluding electricity for transport and heating) must be supplied from wind power in 2020. The agreement also stipulates greater support for biogas production and better conditions for supplying this biogas to the gas network.

The agreement thus promotes a relatively comprehensive restructuring of the energy system in the near future. It is therefore important that the framework for the role of the gas system in the future energy system be defined.

### Role of the green gas system

The role of the gas system must be defined for the energy system – up until 2020, in the longer term and in the intervening period. This leads to a number of challenges which must be dealt with and which are presented in Gas in Denmark 2013:

- The vision of Denmark being independent of fossil energy sources places great demands on all energy systems – electricity, gas, transport and district heating
- A green gas system will be an important part of the solution for integrating renewable energy if this is handled correctly
- The interplay between the green gas system and the existing gas system must continue to work well, even as the quality of green gas increases
- There will be major changes in the consumption and production of gas leading up to 2050
- There will be a number of technical challenges in relation to managing gas of different quality within the system
- In the medium term, ie the transition phase, there will be dramatic changes to supply and consumption
- The option of future applications in the areas of RE integration, transport and micro-CHP and the economy of the gas system must be taken into account.

**Facts**

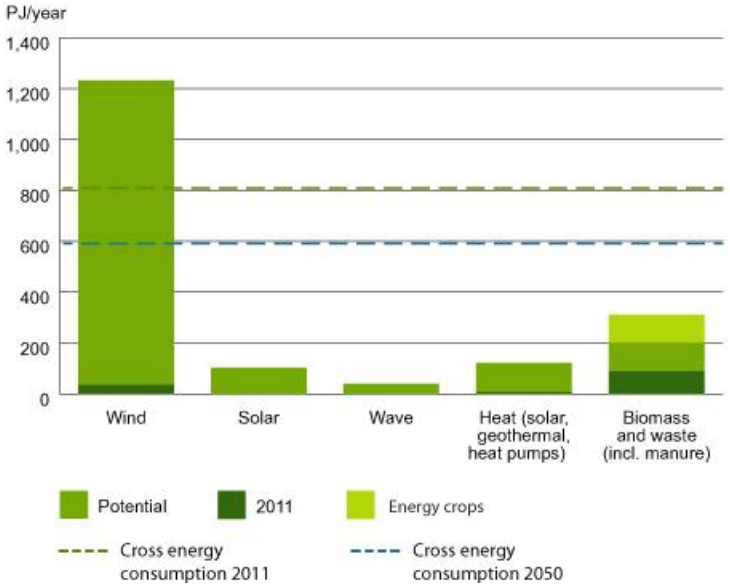
RE is renewable energy, ie energy derived from sources that do not have limited stores, but are continually regenerated or replenished over a relatively short interval. For example:

- Wind power
- Solar power
- Biomass for energy generation.

## Vision of Denmark being independent of fossil energy sources

*Danish politicians have a vision of Denmark being independent of fossil energy sources. Wind and gas will play a major role.*

Denmark has large RE resources, but these are particularly available as fluctuating electricity production in the form of wind power, solar power and possibly wave energy in the longer term. In relation to the total Danish energy consumption, the quantity of biomass and waste that can be used for energy production is limited. The potential and the quantities currently being exploited are shown in the figure below.




*Denmark's renewable energy resources according to the Danish Commission on Climate Change Policy's Green Energy report (2010) and the Danish Energy Agency's Energy Statistics (2011).*

There is therefore a need to develop an energy system that allows wind and solar power, biomass and waste resources to be flexibly integrated. There is also a need to produce fuels for energy services that cannot be efficiently supplied using electricity, such as heavy transport and a number of industrial processes.

Facts

- 'Energy service' refers to the end consumption of energy or the service the consumer receives from the energy consumption, such as light above the dining table, heating in the home or one kilometre of transport in a

## Green gas – part of the solution

*Gas will be an important element of the future energy system because it can be produced flexibly from renewable resources, used flexibly and stored.*

Gas from renewable energy (green gas or RE gas) may be an important element of the future energy system because gas can be produced flexibly from biomass and waste, and even from electricity based on renewable energy in the longer term.

Relatively large quantities of energy can be stored in gas storage facilities, and gas can be used direct for transport, in industrial processes and to produce electricity in peak-load situations. Gas can also be converted into liquid fuels.

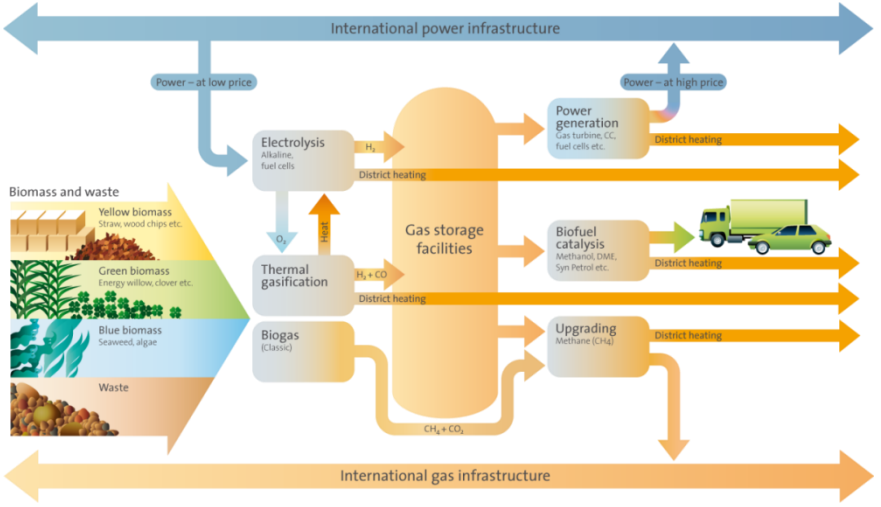
Gas can be transported and stored without energy loss and using minimal energy consumption for compression and temperature equalisation. If the potential losses associated with conversion to and from gas can be minimised by integration with electricity and heat, gas can offer the most energy-efficient transport and storage in the integrated energy system.

### Gas as a bridge

RE gas can work together with natural gas and build a bridge to the gradual conversion from fossil to RE-based energy sources.

Natural gas can thereby serve as a buffer in periods and during years where production of renewable energy from wind and hydroelectric power is low – 'dry years' and 'light wind years'. From a transition perspective, natural gas is a better alternative to coal and oil in terms of $CO_2$ and $NO_x$ .

Some of these perspectives are illustrated in the figure:



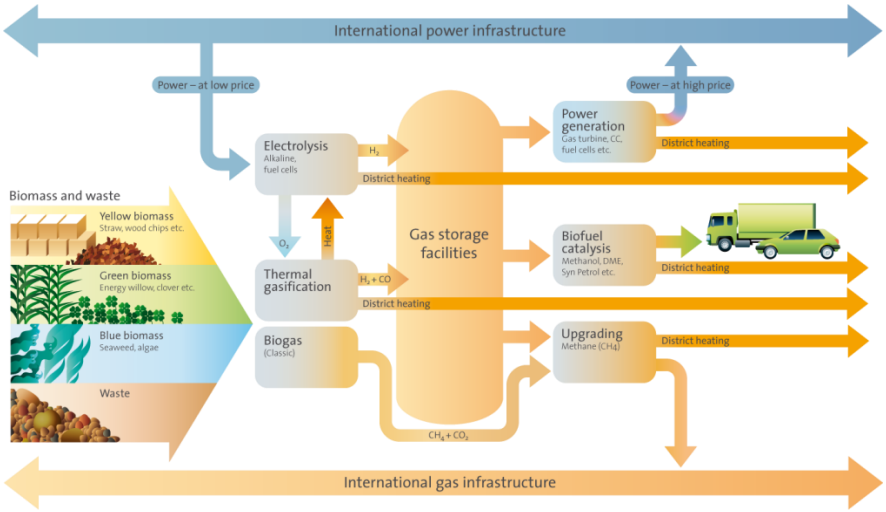

*Perspectives where gas from renewable energy is integrated with electricity, district heating and liquid fuels*

In order for this integration to work, a number of technologies have to be developed.

## Perspectives on the integration of electricity, gas and heat

*In order to achieve a flexible energy system with high energy efficiency, there is a need to integrate electricity, gas, heat and transport.*

The figure shows the conversion of biomass to fuel using different processes, such as anaerobic conversion (biogas), thermal gasification (synthesis gas) and fermentation (ethanol).



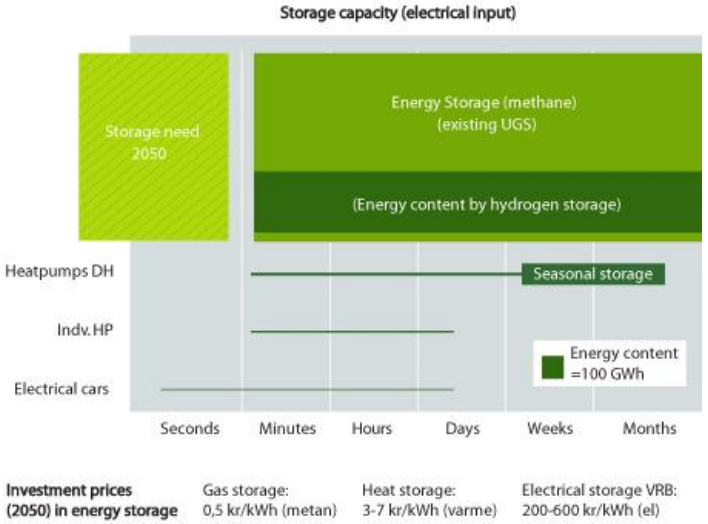

*Perspectives where gas from renewable energy is integrated with electricity, district heating and liquid fuels.*

The figure also shows that electricity from renewable energy can potentially be used in the future for the production of gas (electrolysis). This would allow RE electricity to supplement fuel production from biomass and waste, which is a relatively limited resource.

The gas produced may be used for peak-load electricity production and the production of liquid biofuels. The gas can also be upgraded and stored in underground storage facilities or transported using the internationally connected gas system.

### Wind balancing can be done using various technologies

Balancing the electricity system via the internationally connected electricity grid, in cooperation with hydroelectric power stations in Scandinavia, can serve as a cost-effective and energy efficient solution.




*Storage technologies are shown including prices amounts of energy that can be stored and the practical timeframe for usage of the storage.*

However, Energinet.dk's analyses show that there may be a need in the longer term for access to peak-load electricity production, which allows relatively rapid adjustment and can supplement fluctuating production from wind and solar power. This can also lead to greater security of supply for Denmark and its neighbours.

Some of the processes produce heat. It is therefore important to integrate district heating so that this heat can be utilised.

## Technological maturity in various RE gas technologies

*The technologies for the production of gas from renewable energy have various degrees of maturity.*

Production of biogas from manure and other waste products through biological anaerobic (oxygenless) decomposition has been developed over the last few decades and is therefore relatively mature.

Production is currently around 4 PJ, corresponding to a few per cent of gas consumption. However, it is expected to be expanded in the years ahead so that annual production reaches 30 PJ leading up to 2030.

Thermal gasification of biomass still requires much development before it will be ready for large-scale production.

The technology is expected to be used for gasification of wood on a large scale, for example in Sweden, leading up to 2020. In Denmark, where the focus is primarily on gasification of straw and waste products, the technology will require much more development and is not expected to be relevant to large-scale production until after 2020.

### Large-scale electrolysis only after 2030

Although demonstration plants now exist in Germany, the use of electricity from renewable energy to produce gas is only expected to be viable many years from now, ie after 2030.

Commercial plants used for the industrial production of hydrogen also currently exist on the market. However, these systems need to be developed to have higher efficiency and lower system costs before the technology will be suitable for more general energy purposes.

The figure sketches the relative maturity of the technologies. A number of technologies require further research, development and demonstration.


*Maturity of technologies for the production of gas from renewable energy.*

A number of research projects are underway in relation to refining biomass and waste, hydrogen/fuel cells/electrolysis and the conversion of gas to liquid fuels etc. This table lists a number of key projects.

| Navn | Periode | Budget (mio) | Program |
|---|---|---|---|
| HYCON - HYdrogen CONtrol for optimization of methane production from livestock waste | 1/2011 - 12/2014 | 20,26 | The Danish Council for Strategic Research |
| High efficiency, low cost electrode surfaces for next generation alkaline electrolysis | 2011 - 6/2013 | 24,00 | The Advanced Technology Foundation |
| Maabjerg Energy Concept | 1/2012 - 6/2013 | 35,12 | EUDP |
| Methane from carbon dioxide - System integration | 1/2012 - 6/2013 | 11,91 | EUDP |
| Biogas transmission grid | 4/2011 - 3/2013 | 23,53 | EUDP |
| Development of a new membrane concept for biogas upgrading | 1/2011 - 6/2013 | 2,24 | ForskNG |
| Green Gas Test Center | 10/2011-12/2013 | 4,50 | Green Labs DK |
| Biogas-SOEC | 1/2011 - 6/2012 | 1,36 | ForskNG |
| Pilot plant for cost effective removal of CO2 from biogas | 4/2010 - 8/2011 | 1,35 | ForskEL |
| Framework for interaction between biogas and natural gas grids | 1/2010 - 1/2011 | 2,35 | ForskNG |
| Biogas to the grid - phase 1 | 2/2008 - 12/2009 | 2,80 | ForskNG |
| Green natural gas | 10/2011 - 9/2014 | 24,14 | EUDP |
| Synthetic natural gas potential and efficiency | 8/2009 - 3/2011 | 0,64 | ForskEL |
| Suitability of the natural gas grid for pure hydrogen distribution | 1/2001 - 3/2004 | 2,39 | EFP |
| Detailed analysis of bio-SNG technologies and other RE-gasses | 1/2011 - 12/2012 | 2,39 | ForskNG |

*List of a number of key research, development and demonstration projects.*

## Integration between green gas and the existing gas system

*The traditional role of the gas system in carrying natural gas from the North Sea to consumers must work together with the future role of integrating RE.*

The Danish gas system was established to transport natural gas from the North Sea to natural gas consumers. This applies primarily within Denmark, but also to export supplies to Sweden and Germany.

As the opportunities for the production of gas from renewable energy are expanded in the decades ahead, the gas system will have to handle this gas in addition to natural gas.

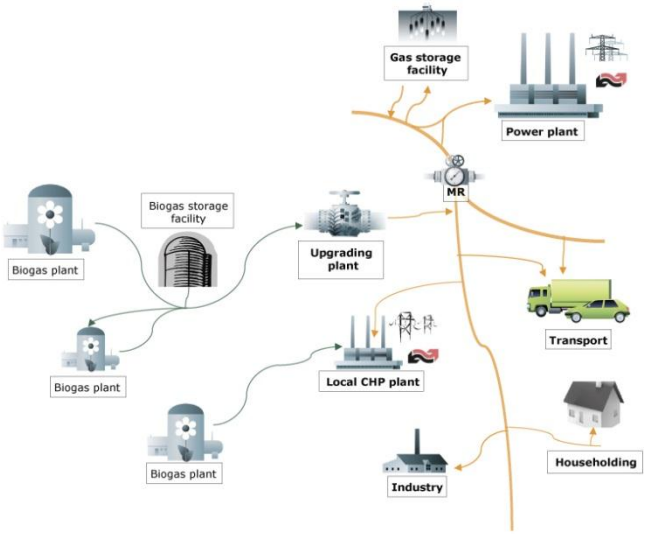
The production of gas from renewable energy, such as biogas, will be highly decentralised within the distribution networks.

Whether it will be necessary to bring the RE gas up to transmission level will depend on the local situation, such as how much gas is consumed locally.

### Integration of various RE gases needs to be planned

The various distribution networks need to be efficiently planned. This applies already, for example in relation to integrating the expansion of biogas production with the transmission system. In the future, it will also apply to the production of other types of gas from renewable energy.

In the even longer term, as the production of other types of gas from renewable energy such as synthesis gas and gas from electrolysis becomes viable, there will be a further need to handle local clusters of gas of deviating quality in the main transmission system.




*Local RE gas networks integrated with the general gas system.*

### RE gases – expensive but good

The production of gas using renewable energy is currently more expensive than natural gas. However, gas produced using renewable energy can be expected to have a greater market value than natural gas, in step with a greater focus on RE-based fuels for the transport sector etc.

There will not necessarily be demand in proximity to the local network where the RE gas is produced. Energinet.dk has therefore developed certificates for RE gas – like those used in the electricity market – which can be issued and traded for gas fed into the gas grid.

This will allow the market value of RE gas to be exploited in other locations in the internationally connected gas system.

There will be a need to further fine-tune the market in the future so it can handle both RE gas and natural gas. Enhanced use of gas to provide flexibility and balancing may also lead to a need to adapt market solutions to the future role of gas.

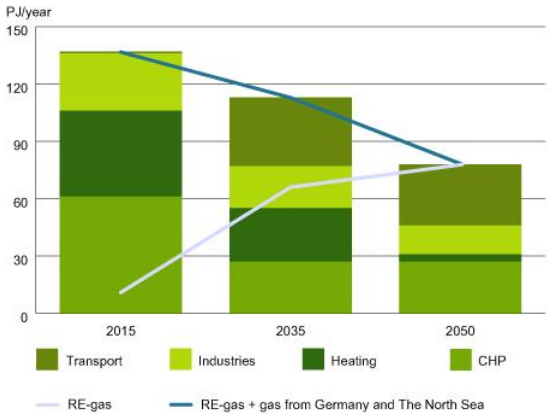
## Analyses of gas production and consumption up to 2050

*There is much uncertainty in relation to gas production and consumption up to 2050.*

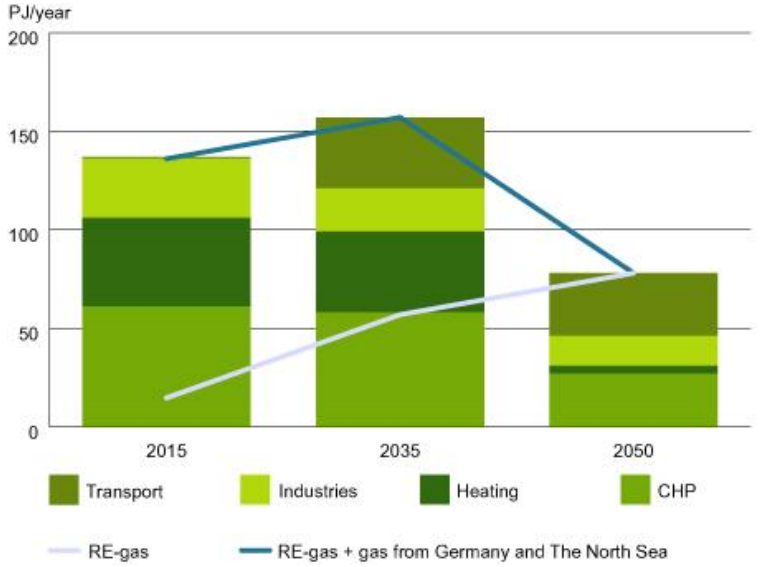
Energinet.dk has analysed prognoses with varying degrees of RE gas development. This has been based on the assumption that the political vision of Denmark being free of fossil fuels in 2050 has to be fulfilled.

The analysis is based on a possible projection of the need for energy services up to 2050, with an expected maximum RE gas production of 80 PJ (and corresponding consumption), fuel and $CO_2$ prices as predicted in IEA WEO 2011 and technology data from 'Technology Data 2012' and 'Alternative fuels 2012'.

The bars in this figure show the consumption of gas in Denmark given a relatively fast conversion process. The gray line shows the production of RE gas. The data for supplies to Denmark from Germany and the North Sea have been included for comparison in the blue line. The figure does not take into account transit deliveries to Sweden, which are completely dependent on the Danish gas supply, or the export of Danish North Sea gas or shale gas to Sweden, Germany, the Netherlands or other countries.




The next figure shows a slightly slower conversion process. The gas price is assumed to be lower, and a greater consumption of natural gas is maintained in 2035 for CHP.




The consumption of gas is expected to gradually decline at the same time as the production of gas from renewable energy is increased. The gas produced can either be supplied as gas to end consumers or converted to liquid fuel.

**Facts**

- 'Energy service' refers to the end consumption of energy or the service the consumer receives from the energy consumption, such as light above the dining table, heating in the home or one kilometre of transport in a vehicle.

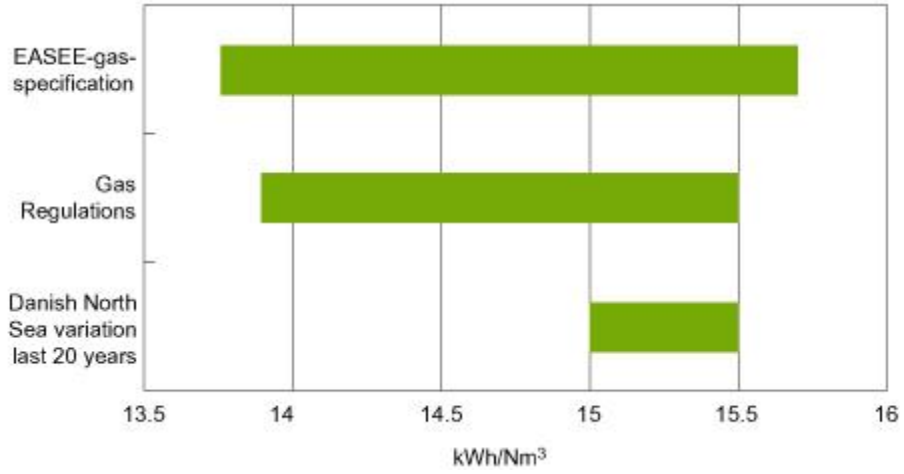
## Technical challenges associated with gas of different quality

*Historically, Denmark has had gas of a very uniform quality, but in recent years, we have experienced great variations in gas quality.*

Denmark had a relatively uniform gas quality up until 2010. This is primarily because we received natural gas with a uniform composition from the Danish part of the North Sea.

As Denmark has opened its gas market to supply and competition from Germany, greater variations in gas quality have been experienced.

Energinet.dk is also involved in harmonising gas quality at the European level. One of the aims is a common European specification in line with the EASEE specification. This specification permits the Wobbe index to vary more, as shown in the figure.




*Wobbe index for Danish North Sea gas compared with the Danish Gas Regulation and the EASEE gas specification.*

In the long term, the best way of incorporating RE gas needs to be assessed, for example as hydrogen production becomes more mature (after 2030).

Greenpeace and Gasunie in the Netherlands are already testing the addition of hydrogen to the transmission system. Such a process will require a number of adaptations to the gas system and the plants that consume gas. The varying gas quality impacts on different elements of the system in different ways.

## The impact of gas quality on different elements of the gas system

*Varying gas quality places demands on the different elements of the gas system. There will be changes to the gas system in the years ahead.*

Corrosion is not a problem in plastic distribution networks (4 bar). It is therefore possible to downgrade the distribution network to biogas quality if appliances, metering and settlement are improved to handle this gas quality.

The addition of hydrogen to methane gas can potentially lead to hydrogen embrittlement in steel pipes.

Greenpeace and Gasunie in the Netherlands are currently conducting a number of research and development studies into how hydrogen impacts on the transmission system, the steel distribution network and the plastic low-pressure distribution network (PE80/PE100). To date, the analyses have shown that the plastic network is suited to handling a relatively high proportion of hydrogen.

Steel pipes are more sensitive to parameters such as pressure variation where there is a greater proportion of hydrogen. It is therefore necessary to test different types of operation and load over an extended period. Energinet.dk is maintaining a focus on accumulating knowledge with the aim of handling hydrogen fed into the gas network.

### Household appliances

A number of household appliances are sensitive to changes in the gas Wobbe index. Variations in the $CO_2$ or hydrogen levels change the Wobbe index of the gas, and the appliances must therefore be designed and configured to handle this.

For example, adding 10% hydrogen to natural gas with a Wobbe index of 15.3 kWh/Nm$^3$ reduces the index by approx. 0.5 kWh/Nm$^3$. Supplying natural gas at the lower end of the allowed Wobbe index may therefore - locally and for a period of time - limit the hydrogen injection capacity in the network.

### Metering and settlement

The calorific value is reduced compared to natural gas where there is hydrogen or $CO_2$ from RE gas that has not been fully upgraded. This necessitates more advanced methods for metering and settlement.

Energinet.dk has developed methods to manage the variations in calorific value that arise due to variations in different natural gases and future bio-natural gas qualities. We will continue to work to ensure the robust handling of gas with variations in calorific value.

## Gas system during transition phase

*Declining consumption, changes in consumption patterns and greater fixed costs may present economic challenges to the gas system during the transition phase.*

Gas is currently used primarily for CHP production, heating and process energy in industry. However, there is great uncertainty about how gas consumption may change leading up to 2020.

All distribution companies have experienced a steady decline in gas consumption during the last decade, and expect this trend to continue towards 2020.

### Room heating, CHP and process energy declining

The many initiatives being taken to save energy will generally impact on all areas, but distribution companies particularly expect the proportion of energy being used for heating to be reduced. Combined with the conversion of natural gas to district heating, this reduction will be significant.

The conversion of natural gas-fired CHP to biomass district heating and solar heating is being driven by low electricity prices during certain hours and the uncertainty about conditions for gas-fired CHP plants after 2018.

In relation to industry, there are also a number of initiatives which are reducing gas consumption, such as the Danish Government's pool for the conversion of heavy industry from fossil fuels to renewable energy. However, this is partially offset by the large price difference between oil and gas, which means it is often worth converting from oil to gas supply.

### Gas for transport is increasing, but still minor

Gas for transport is an area where gas consumption can spread to a new sector, but there is great uncertainty about the ultimate scope, and it will also take time to phase in the new form of consumption. Despite strong growth, the transport sector therefore expects its gas consumption to only account for a few per cent of the total gas consumption in 2020.

### General decline in consumption of 20-30% expected

Overall, gas companies expect gas consumption to decline by 20-30% between 2012 and 2020.

Energinet.dk sees great uncertainty about the level of gas consumption in 2035, and that a major decline in consumption between 2020 and 2035 is possible.

### Costs not dependent on the quantity of gas

The total gas system, including storage facilities and the transmission and distribution components, is generally large and efficient. It also has a high degree of built-in flexibility.

This means that the system has very efficient daily operations. However, it also means that the system has many fixed costs, and that only a small proportion of the costs is linked to how much gas is being transported in the system.

All other things being equal, declining gas consumption will therefore mean higher costs for the other consumers. However, this will be offset to some extent by a significant reduction in debt during the period.

The expected reduction in income and the opportunities for reducing costs will be quite different depending on how the decline in gas consumption takes place. In general, however, the opportunities to reduce costs as consumption declines will be limited.

## Gas system to become greener

*Energinet.dk is working to introduce RE gases into the gas system. Biogas from manure will make the gas system greener now, with other RE gases to be added later.*

Biogas and other RE gases are renewable energy, ie energy from sources that are not exhausted through use, but are replenished continually or over a relatively short time period.

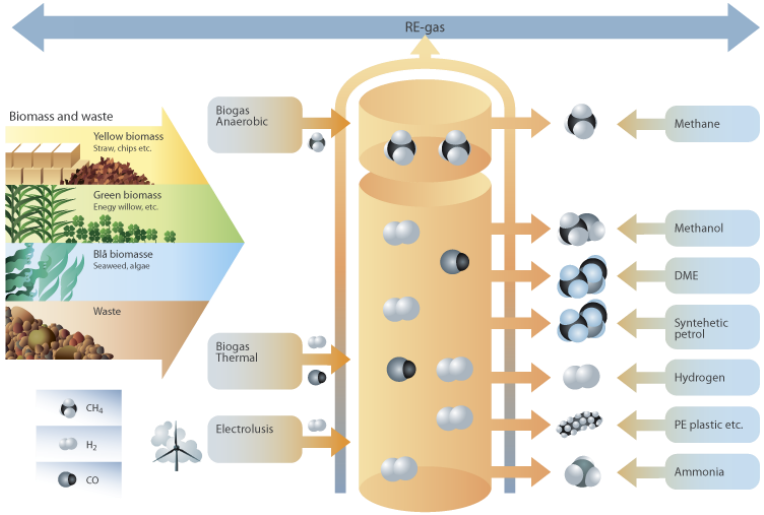
### How is biogas produced?

Biogas can be produced through the anaerobic decomposition of manure and plant matter to produce a gas containing 60-70% methane and 30-40% $CO_2$. Since the biomass has absorbed the same quantity of $CO_2$ during its growth as ends up in the gas, this form of biogas is fossil free.

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

biomass has absorbed the same quantity of $CO_2$ as is converted to CO, this form of biogas is fossil free.

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. These processes are shown in the figure below.




*Biomass can be converted to methane or synthesis gas. Synthesis gas, in particular, can be used as a building block in a wide variety of products.*

Biogas from decomposition is already transported in the gas system in small quantities. Energinet.dk expects these quantities to increase dramatically in the years ahead.

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 RE gas is therefore balanced by the quantity of $CO_2$ used to produce the RE gas
- Thus, the consumption of RE gas does not contribute to the accumulation of $CO_2$ in the atmosphere. RE gas is therefore climate neutral
- Energinet.dk expects biogas to simply be the first of a number of RE gases to be produced in the longer term.

## Biogas on the way

*The Danish energy agreement dated March 2012 will promote the development of biogas and ensure that biogas is added to the gas system.*

The energy agreement made in March 2012 contains a number of elements that will have a major impact on the expansion of biogas production:

- Increased subsidy rates
- Harmonisation between subsidies for biogas for CHP and biogas for other applications
  - Biogas upgraded and added to the gas system
  - Biogasfor industrial production
  - Biogas for transport
- Sustainability criteria for biogas.

Energinet.dk expects the energy agreement to lead to a dramatic expansion in biogas production in the coming years.

Increased biogas production will have a major impact on the gas system – either because biogas is added to the gas system, or because biogas replaces natural gas in an existing application.

The biogas will be traded throughout the entire gas system through the use of RE gas certificates.

**Facts**

The Danish energy agreement contains a number of other initiatives aimed at promoting the development of biogas in Denmark:

- New settlement rates
- CHP plants running on pure biogas can change from fixed electricity settlement to a price premium based on market prices
- Municipal gas companies may invest in the production of biogas
- A Biogas Task Force will be appointed to investigate and support specific projects
- If no progress has been observed in the biogas sector in 2014, the option of making it compulsory for CHP plants to purchase biogas will be considered
- The biogas promotion team will be continued
- The start-up support (opportunity to apply for a loan with a municipal guarantee) is being increased from 20% to 30%, and a construction pool of DKK 243 million was established in 2012. The construction pool had an application deadline in September 2012, and more than 50 construction projects applied for over DKK 800 million in funding.

## Harmonisation of biogas subsidies for various applications

*The Danish Government's energy agreement dated March 2012 contained a decision to harmonise biogas subsidies for various applications.*

A key element of the Government's energy agreement is to ensure equality in the subsidies paid for biogas used for CHP and biogas upgraded for sale via the gas system.

The harmonisation of subsidies will be financed via a PSO scheme to be managed by Energinet.dk. Energinet.dk has decided to let the distribution companies collect the PSO.

A subsidy scheme has also been established, which offers a subsidy on biogas used for processing, transport and other energy utilisation. Energinet.dk will also be responsible for managing payment of this subsidy.

### Energinet.dk will be ready when the EU approves

Energinet.dk is in the process of implementing the necessary administrative systems, which are expected to be ready when the EU approves the subsidy schemes.

The Danish Energy Agency submitted a request for approval of the subsidy schemes in late September 2012, and it is expected to take at least six months for the request to be processed.

**Facts**

- PSO stands for Public Service Obligation
- The biogas PSO scheme is a subsidy scheme whereby an amount is collected from all natural gas and city gas consumers via their gas bill
- This amount is collected by the gas distribution and city gas companies
- Energinet.dk then pays out the money to all parties entitled to a subsidy.

## Demand for biogas sustainability

The sustainability of biogas depends on how it is produced. Biogas produced from waste is more sustainable than biogas produced from corn.

The disadvantages of supplanting food production from agricultural soil and producing energy crops instead have received attention. Adding corn to a biogas plant would significantly increase biogas production, but also have the effect that the biogas is no longer based on waste products, but on agricultural crops which supplant food production.

In September 2012, the parties to the energy agreement therefore agreed to phase in limits on the use of energy crops for the production of biogas eligible for a subsidy. This will ensure that biogas production is primarily based on livestock manure and residual waste products.

The utilisation of livestock manure via biogas plants achieves a particularly high reduction in greenhouse gas emissions. This is because, in addition to replacing a fossil fuel, it also achieves a reduction in methane and nitrous oxide emissions from agriculture.

### Resource input requirements for biogas production

The agreement places the following resource input conditions on biogas production eligible for a subsidy:

- Between 2015 and 2017, the proportion of energy crops used must not exceed 25%, measured as a weight input. This is in line with the requirements for applications to the Danish Ministry of Food, Agriculture and Fisheries for start-up grants for biogas plants
- Between 2018 and 2020, this proportion will be reduced to 12%.

Work needs to be done on formulating regulations and monitoring biogas production eligible for a subsidy.

## Biogas production to see tremendous growth

*Once the details of the Danish energy agreement are in place, the biogas sector is ready for dramatic expansion. Existing plants are being expanded and many new plants will follow.*

The biogas sector is preparing for dramatic expansion once the final details of the energy agreement have been clarified. The specific way the biogas subsidy regulations are implemented is important to the economics of individual projects.

However, the expectation is that the new higher subsidies mean that many biogas projects are well on their way to the construction phase.

### Biogas production will have a major impact on the gas system

The biogas sector expects that significant expansion of production capacity will be combined with sale of the gas via the existing gas system.

Even the biogas plants that are not planning to inject biogas production direct into the system will have a major impact on the gas system. Production from the biogas plants will replace natural gas used by existing gas consumers in the vast majority of cases. The biogas plants will therefore have the same effect on consumption as if they injected the gas direct into the gas system. Biogas plants generally have a 1:1 effect on the existing gas system.

It is up to the owners of each plant to decide whether to connect the plant to the gas system. The decision will largely focus on ensuring effective utilisation of the energy in the biomass, without unnecessary expense. In many cases, it will not be possible to consume large quantities of biogas locally, and it will therefore be a better solution to sell the gas via the gas grid, despite the costs associated with upgrading and pressurising.

## RE gas certificates

*Energinet.dk has established a certificate system for biogas which can ensure that the gas is effectively utilised and allow biogas producers to reach many consumers.*

At the request of gas market players, Energinet.dk established a certificate system to document the trade of biogas via the gas grid in 2011. This means that natural gas consumers who purchase gas with an associated biogas certificate are guaranteed that a corresponding quantity of biogas has been produced, injected and specifically allocated.

Trading biogas via the nationwide gas system gives biogas producers the opportunity to reach a significantly larger market segment through the established natural gas system.

However, the greatest socio-economic benefit from transporting biogas using the natural gas system is that the great potential in biogas can be utilised, even where local district heating consumption is not sufficient to make use of all the biogas. With increasing wind production and declining heating needs, there will also be times when there is no need for electricity production from biogas-based CHP plants. It may therefore become an increasingly prevalent problem that biogas CHP plants operated directly in step with production from a biogas plant produce electricity and heat at times when there is not much need for this production.

## RE gases and hydrogen

*In the longer term, thermal gasification and the production of hydrogen from water using wind power can make the gas system even more sustainable.*

Energinet.dk expects biogas to simply be the first of a number of RE gases to be produced. A lot of research and development is being done at the moment in the necessary technologies.

### Synthesis gas from gasification

Gasification of dry biomass produces synthesis gas. Synthesis gas consists of carbon monoxide (CO), hydrogen (H), carbon dioxide ($CO_2$), methane ($CH_4$) and tar. The most important components are carbon monoxide and hydrogen.

Dry biomass such as straw and wood waste is particularly suitable for processing in a gasification plant, but some energy crops can also be used.

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

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').

### Electrolysis can convert wind power to gas

It is possible to convert wind power to gas via electrolysis. This is done by using electricity to split water into hydrogen and oxygen.

Electrolysis plants may be able to play a vital role in relation to balancing the electricity system, as large quantities of wind power can be stored in the gas system using this type of technology.

There have been a number of investigations into the possibility of mixing hydrogen with the gas transported in the gas system. The Danish Gas Technology Centre has participated in a number of analyses which have shown that:

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

### The best solutions

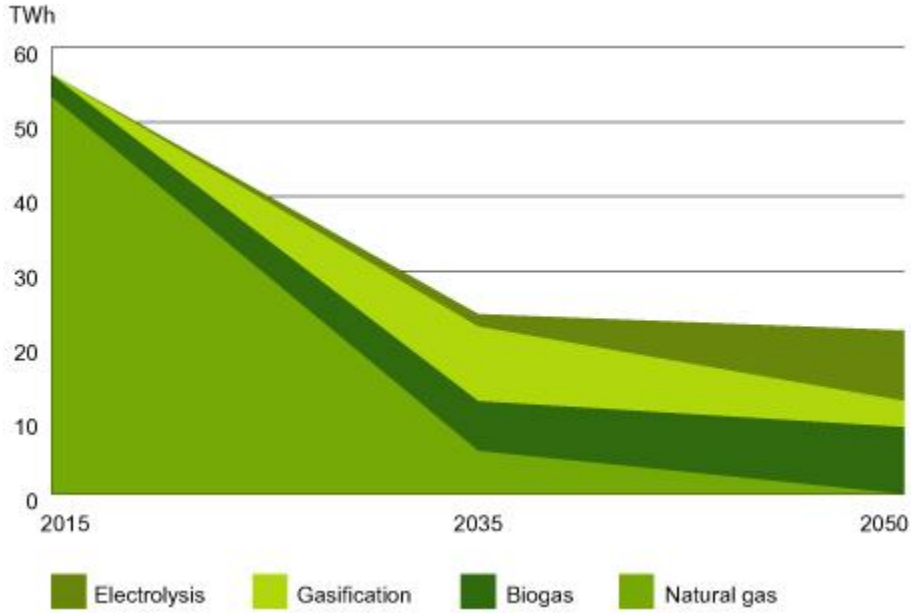
The best solutions need to be identified. Preliminary investigations suggest it is possible to store hydrogen in salt caverns.

If the hydrogen produced can be converted to methane using $CO_2$ (for example from biogas) via a 'methanisation' process, this would allow unlimited quantities to be transported and stored in the existing system. A number of research projects are working on developing methanisation technologies.

### Prerequisites for the future

If electrolysis is ever to be utilised on a large scale, it is essential that technological advances be made in the years up to 2035. There is also a need for better economics via a higher sales price for the gas produced, and a need for access to many hours of cheap electricity.

Electrolysis is only expected to gain a significant market share after 2035, as the technology is still relatively inefficient and capital intensive.




*Prospective development path for the production of RE gases.*

Based on the assumption that Denmark has to be fossil-free in 2050, the figure shows a prospective development path whereby biogas from anaerobic gasification enters the system first, whereas gas from thermal gasification commences from around 2020. Gas from electrolysis enters the picture from around 2030. Based on this analysis, the total production could reach a level of 80 PJ.

**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.

In addition to biogas, the two most important RE gases are:
- Synthesis gas from gasification
- Synthesis gas from electrolysis.

# European gas market gaining speed

*Gas has to be traded across EU borders without impediment in 2014. The infrastructure and market are therefore taking yet another step in terms of European cooperation.*

Energinet.dk is actively helping to develop the European market for gas. This means, for example, changes to Danish market rules and that the Danish gas infrastructure is being harmonised with the rest of the gas infrastructure in Europe.

This demands stronger cooperation with other European transmission companies. This cooperation involves market and infrastructure development and harmonisation of gas quality.

### Common European gas market in 2014

The European heads of government have set 2014 as the deadline for the next step in the development of the European gas market, in which gas can be traded across EU borders unimpeded. However, it has become apparent that the job is so complex that the legislation work and subsequent implementation is expected to go beyond 2014.

Energinet.dk and 40 other European transmission companies are helping to create the set of rules necessary to make it easier to freely trade gas across European borders. This is taking place via ENTSOG, the organisation responsible for developing European market rules and for general planning of European gas infrastructure.

Energinet.dk is represented on the ENTSOG board and participates in a number of working groups, which provide the professional foundation for developing the European gas market.

### Joint responsibility for emergency gas supply

Interconnecting the national gas markets also helps ensure better opportunities for countries to support each other in emergency supply situations, including the fact that gas can flow across the borders to the areas where it is needed.

The collective responsibility is described in more detail in the emergency supply regulation. Denmark was one of the first countries to incorporate this regulation into its national legislation.


*Escalation of the crisis structure before and after 1 October 2012.*

### Gas is a cornerstone of the European energy system

The European Commission published its Energy Roadmap 2050 in December 2011, which describes the Commission's vision for the energy sector.

The Commission made it clear in this report that natural gas will play a key role in reducing the EU's $CO_2$ emissions. This is because, in many countries, natural gas is supplanting coal, which has about twice the $CO_2$ emissions per energy unit. The gas system also provides the opportunity to transport various forms of green gas.

Energinet.dk wants to support and develop these green options via improved cooperation with system operators in the Netherlands and Belgium, with the goal of creating a green gas system by 2050.

Developing the European gas infrastructure is also an element of the Commission's draft regulation on development of energy infrastructure, which creates better opportunities to implement infrastructure investments where there is common European interest.

**Facts ENTSOG**

- The European Network of Transmission System Operators – Gas (ENTSOG) is a compulsory European TSO cooperation organisation with headquarters in Brussels
- ENTSOG was established in 2009 to promote deregulation of the European gas market
- ENTSOG has been charged with providing 10-year investment plans for European gas infrastructure and grid regulations governing gas transport across borders within Europe
- ENTSOG receives input from all gas stakeholders
- Grid regulations are being formulated in the areas of capacity products, congestion management, balancing, transparency and data communication
- Energinet.dk is participating actively in ENTSOG to create the best conditions for the Danish gas market.

## From national to common European gas market development

*The EU train has left the station and is moving rapidly towards a better common European gas market. Energinet.dk is helping to lead the way.*

The ENTSOG grid regulations are not yet complete. However, many TSOs in North-West Europe have taken the lead, by implementing the rules in practice.

In April 2012, Energinet.dk therefore signed a statement of intent regarding cooperation with the 12 German TSOs, Gas Transport Services (the Dutch TSO), Fluxys (the Belgian TSO) and GRTgaz (the largest French TSO).

These 16 TSOs have decided to develop a new common capacity platform on which all capacity at the border points is to be offered for sale, making it easier to trade gas across borders. The platform is intended to replace the three existing trading platforms – Trac-x, Link4Hubs and CAPsquare.

The common capacity platform is a step towards implementing one of the grid regulations which is expected to become compulsory in 2014. Energinet.dk and the other partners expect to be ready to offer the first products in April 2013.

### Common rules are on the way

The first network regulations have been a long time coming. This is due in part to the preliminary work of creating the necessary EU institutions. For example, the ACER regulators' organisation and the ENTSOG TSO organisation both had to be established almost from scratch in terms of organisation and resources.

Both organisations are now almost fully established and can contribute direct to the development of the common European grid regulations.

The next step is that the regulations have to be approved by the member states. They will then become binding and have to be implemented in the TSOs of all member states, including Energinet.dk.

However, a number of regulations have already become binding. This is because the European Commission is able to act without involving ENTSOG if, for instance, they want a rapid regulation change. This was the case, for example, for rules relating to congestion management (CMP), which were already implemented in the regulation in September 2012.

### Markets staying ahead of rule changes

Even though the final rules for capacity allocation are not yet binding, gas markets in the EU are already beginning to adapt to the new situation. For example, in connection with the establishment of a common capacity platform.

This does not apply only to TSOs. Commercial shippers have begun to frequently act in the market in new ways. For example, many are abandoning the very long-term gas contracts in favour of the shorter term spot market where gas is traded on exchanges. This is leading to the establishment of a more efficient market for gas in Europe.

In the past, the long-term contracts helped to ensure a strong foundation for the development of new infrastructure. It is important to ensure that there continues to be an interest in investment in new infrastructure.

### Yet more cooperation across systems

The new platform and future product range are leading to greater demands than ever for cooperation between TSOs.

Energinet.dk has taken up this challenge by getting involved in the development of a common European capacity platform, and bilaterally via coordination with the adjacent gas systems at the border points.

Facts

**Common capacity platform network code**

- Capacity Allocation Mechanisms Network Code (CAM NC)
- The network code stipulates that a common platform must be developed at the border points
- The common platform has to make it possible to offer capacity for sale jointly as 'bundled capacity', making it easier to transfer gas across borders.

**The three existing trading platforms:**

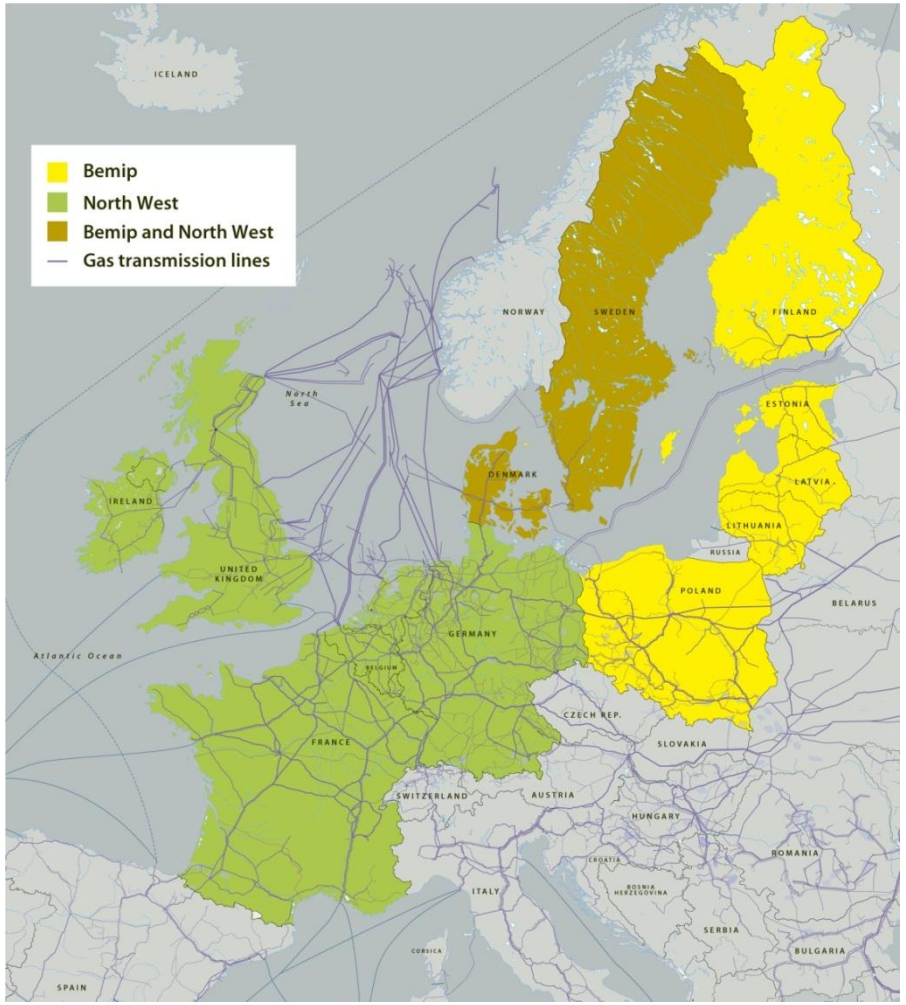
- Trac-x: The German capacity platform, where 12 German TSOs currently offer their capacity for sale
- Link4Hubs: A joint project involving Energinet.dk, the Dutch TSO GTS and the German TSO Gasunie Deutschland, which allows gas to be transferred from one market to another without capacity having to be purchased at the border points
- CAPsquare: A joint capacity project between the French TSO GRTgaz, the Belgian TSO Fluxys and the German TSO Open Grid Europe.

## Common European gas infrastructure development

*There will be an increasing European focus on gas infrastructure development. Investment decisions are increasingly being made jointly.*

Between the end of 2011 and the beginning of 2012, the EU TSOs published a number of regional gas infrastructure plans. The plans were made in response to legal requirements in the latest EU regulation.

Energinet.dk was involved in formulating two of these plans – the North West Gas Regional Investment Plan (the North Sea) and the BEMIP Gas Regional Investment Plan (the Baltic Sea).




*The two Gas Regional Investment Plans cover areas that overlap. Denmark and Sweden are part of both plans.*

### BEMIP – an unconnected region

The primary conclusion in the BEMIP Gas Regional Investment Plan is that the region is characterised by a lack of geographical and market cohesion. At the same time, no final investment decisions have been made for any of the projects capable of integrating the various sub-regions within the region.

The region consists of three sub-regions:

- Finland, which is connected to Russia but isolated from the rest of the region
- Estonia, Latvia and Lithuania, which are connected to each other and to Russia
- Denmark, Sweden and Poland, which are connected via Germany.

Like ENTSOG's Ten-Year Network Development Plan 2011-2020 dated February 2011, in terms of security of supply, the report shows that further investment decisions must be made to secure the supply in Denmark and Sweden when production in the Danish part of the North Sea declines in the coming years.

### North West – a well-integrated gas market

The primary focus in North West GRIP is to inform the gas market about investment projects that will promote market integration at the various border points.

The North West region consists of Belgium, Denmark, France, the Netherlands, Ireland, Luxemburg, Great Britain, Sweden and Germany. The North West region accounts for more than half the total gas consumption in the EU.

The countries have a long tradition of cooperating and supplying gas across the borders. The focus of the plan is therefore on ensuring that the market works efficiently via good transmission connections between the countries.

### TYNDP – third due in 2013

ENTSOG is currently working on its third Ten-Year Network Development Plan, expected to be published in February 2013.

### Common European decisions about gas pipelines between countries

As part of the energy infrastructure package, the European Commission has proposed a regulation on guidelines for trans-European energy infrastructure.

## Great need for investment in EU energy infrastructure

*The EU estimates that EUR 200 billion needs to be invested in energy infrastructure. Work is being done on a regulation for projects of common European interest.*

There is a great need for investment in energy infrastructure in the EU. In Energy Roadmap 2050, the European Commission estimates there is a need for about EUR 200 billion to be invested in electricity and gas infrastructure before 2020, with gas accounting for around EUR 70 billion. The Commission also estimates that about half of these investments are in danger of not being implemented. There is therefore a major focus within the EU on ensuring that the necessary investments in energy infrastructure are made.

In October 2011, the European Commission thus proposed a regulation on guidelines for trans-European energy infrastructure.

### Projects of common interest

The proposed regulation contains a process for identifying Projects of Common Interest (PCIs). This process involves four phases:

- Phase 1: The regulation identifies 12 priority corridors. Four priority corridors are in the electricity system, four in the gas system and one in the oil system, and there are three thematic areas: intelligent electricity grid, electric motorways and $CO_2$ transport.
- Phase 2: The second step in the process is to develop methodologies for evaluating projects in relation to the criteria specified in the draft regulation.
- Phase 3: For each corridor, the European Commission will appoint a regional group charged with preparing a draft list of projects of common interest, to be submitted to the Commission. The list is to be based on a pool of projects gathered from TSOs and other stakeholders. The projects are to be evaluated in relation to the developed methodologies.
- Phase 4: Based on the lists from these groups, the European Commission will produce a combined list of projects of common interest.

The Commission expects the regulation to be adopted. The Commission has therefore already initiated the process and established the regional groups. Energinet.dk is participating with respect to gas in the Baltic Energy Market Integration Plan (BEMIP) regional group.

The Commission is encouraging the regional groups to prepare their first draft list of projects by the end of 2012.

### Priority given to 12 strategic corridors

The proposed regulation gives priority to 12 strategic trans-European energy and infrastructure corridors.

There are four gas corridors:

- North-south gas connections in Western Europe
- North-south gas connections in Eastern Europe
- The southern gas corridor
- The Baltic energy market integration plan (BEMIP).

The BEMIP corridor is the only corridor with direct influence on the gas market in Denmark. Energinet.dk and the Danish Energy Agency and Danish Energy Regulatory Authority are therefore participating in the BEMIP regional group.

### List of priority gas investment projects

The regional BEMIP group must produce a first priority list of possible gas infrastructure projects by the end of 2012. The projects must be selected on the basis of whether they are of common interest to several member countries and fulfil the requirements in the proposed regulation for projects of common interest.

In November 2012, the following projects relating to Denmark had been submitted to the master list.

- Step 2 expansion in Denmark: The German TSO Gasunie Deutschland has registered a project involving German investment, which expands capacity towards Denmark.

- Norway-Denmark: The North Sea producer Mærsk has registered a project whereby the Norwegian offshore system is connected to the Danish offshore system via the Harald platform.

- Baltic Pipe: The Polish TSO Gaz System has registered a project whereby the Danish and Polish systems are linked. The project proposes that the Baltic Pipe be connected to the Danish system in eastern Denmark.

- LNG terminal in Gothenburg: The Swedish TSO Swedegas has registered a project involving establishment of an LNG terminal in Gothenburg, capable of supplying gas to the Swedish transmission system. Sweden currently receives gas via the Danish transmission system. An LNG terminal would increase security of supply and reduce the need to transport gas through Denmark.

The projects have to be evaluated together with the other registered projects, based on cost-benefit analyses.

**Facts**

- ENTSOG is a compulsory European TSO cooperation initiative which works closely with regulators, stakeholders and market players.

## Harmonisation of gas quality

*The increase in gas traded across borders is leading to a need for greater harmonisation of gas quality throughout the EU. Denmark is actively participating in the work.*

A lot of work has been done over a number of years on harmonising natural gas quality in Europe, both in order to promote the free movement of gas and to ensure efficient markets for natural gas. This has in part been at the initiative of the European Commission.

The work has been carried out under the auspices of the CEN standards organisation in the CEN BT WG197 working group, where the GASQUAL project (2009-2011), for example, carried out extensive testing on gas consuming appliances in homes. The work is continuing in 2012 in CEN/TC 234 WG11, with the aim of developing a European standard for distributed natural gas quality. This work is expected to be completed in 2014.

### Greater variations in gas quality expected

In parallel with this work, Denmark has experienced significant changes in the distributed gas quality. This is a natural consequence of Denmark being able to import gas from Germany since 2010, and no longer being supplied exclusively from the North Sea.

Even greater variations in gas quality should be expected in Denmark in the future, for example taking into account the addition of upgraded biogas to the gas system.

### Pilot project underway

As an offshoot of the GASQUAL project, five countries have chosen to run a pilot project to investigate the possibility of harmonising natural gas specifications. The five countries are Spain, France, Germany, Belgium and Denmark. These countries currently have gas quality requirements that are relatively consistent.

Denmark has chosen to participate in the project for various reasons. Firstly, because Denmark will be exposed to greater variations in gas quality as a consequence of the new supply sources. Secondly, because we already have unique experience with the impacts of changes to gas quality, which we can share at the European level.

### Five national working groups

Work on the pilot project will be coordinated through the five countries each establishing a national working group which reports to an international coordination group. This coordination group is anchored in Marcogaz/Easeegas and will involve participation by the European Commission.

The international coordination group will ensure that knowledge sharing takes place between the five national groups.

The aim of the work is to gather further knowledge about the operating ranges of various appliances, including what variation ranges can be achieved under fixed safety conditions, and exchange knowledge and experience of the impacts of variations in gas quality. It is also hoped that the work will demonstrate that harmonisation between these five countries can be implemented safely.

### Risk of difficulties prior to harmonisation

Specific difficulties in relation to gas quality at the border points between transmission companies may arise before harmonisation of gas quality is implemented.

The European Commission has addressed this possibility via the Agency for the Cooperation of Energy Regulators (ACER), which in its Framework Guidelines for Interoperability in 2012 instructs gas transmission companies within the EU to work towards operational solutions to any gas quality barriers.

**Facts**

- The proposal to establish a pilot project for the harmonisation of gas quality was presented by Marcogaz/Easeegas at the Madrid Forum in March 2012.
- The European Commission is very focused on ensuring that the work towards harmonisation of gas quality advances and has encouraged the establishment of this pilot project.

## Technical opportunities and challenges

*Advanced technology is helping Energinet.dk keep an eye on the state of the gas pipes and correctly monitor and measure the quality of the gas.*

### Monitoring the pipes

Energinet.dk has to constantly be aware of the state of the pipes and be able to carry out improvements whenever necessary. This applies to pipes which are buried underground and gas pipes lying on the sea floor. The pipes are therefore regularly inspected, inside and out, in cooperation with experts from the oil and gas industry.

### Precision measurement

Gas does not have a constant uniform composition. The quality varies greatly throughout the year, and it is important that customers pay for the right energy quantity and not only for the quantity transported. Modern technology makes it possible to measure the quality very precisely, almost down to the atomic level.

### Re-laying gas pipes

In connection with the construction of the new motorway between Herning and Aarhus, the Danish Road Directorate asked Energinet.dk to re-lay two sections of the existing 12-inch pipeline near Silkeborg. This was necessary to make room for the motorway.

## Internal inspection and pigging in gas pipelines

*Energinet.dk inspects the gas pipelines according to a fixed schedule to check for damage and corrosion.*

Even though Energinet.dk's gas pipelines are generally located in sparsely populated areas and buried to a depth of approx. one metre, they can still suffer damage. This can be in connection with excavation work or other external activities in proximity to the pipeline.

*Inserting an intelligent pig in a gas pipeline (left) and a cleaning pig with a gauge plate (right).*

Effects from high-voltage lines in the vicinity and material damage to the pipeline can also give rise to early rust formation on our land pipelines – also called corrosion.

Gas pipelines lying on the sea floor are exposed to other impacts associated with sea activities around the pipelines, such as anchor drag from ships in the area or sea currents which impact on the position of the pipe.

### Security is a high priority

Energinet.dk gives high priority to security surrounding the gas pipelines. We therefore perform pigging to evaluate the general condition of the pipes, both inside and out. This applies both to onshore and offshore pipelines. The pipes are primarily checked for:

- Geometric deformations: We look for dents or other changes in diameter (ovalities) in the pipeline.
- Corrosion: We check for rust on the pipes.

### Various forms of pigging

Energinet.dk conducts various forms of pigging in the gas pipelines:

Calliper pigging

- Used to check for dents or other deformations in the pipelines
- Carried out every second year on the submerged pipelines and approximately every 10 years on the land pipelines.

Intelligent pigging

- Used to detect any rust formation on the pipelines
- A technique called MFL (Magnetic Flux Leakage) is used, whereby a magnetic field is applied to the pipe wall. If the pipe has become thinner, this will be reflected in the magnetic circuit, which is detected by the pig and used to estimate the thickness of the metal
- The procedure is carried out about every 10 years on land pipelines and every six years on offshore pipelines.

Cleaning and gauging

- This is done before the calliper pig or the intelligent pig are run through the pipeline
- A cleaning pig is fitted with brushes and a metal plate (gauge plate) corresponding to the diameter of the pipeline being inspected
- The cleaning pig collects dust and other impurities in the pipeline
- The pig is used to ensure there is free passage through the pipeline, which can be seen by checking for damage on the gauge plate.

### How is pigging carried out?

Pigging is done in cooperation between Energinet.dk's technical staff and an external pigging service provider.

Performing pigging has no impacts on operation, but is always timed so as to cause the least possible disruption to operation. This also ensures a gas flow between 1.5-4.0 m/s, which is the ideal range in order to collect good quality data.

Pigging is carried out according to the following procedure:

- The pig is inserted into the pipe and sent with the gas flow
- The pig gathers data along the route
- Field staff maintain regular contact with Energinet.dk's control centre in Egtved in order to estimate the timing of the pig's arrival at the receiver sluice
- The pig is left in the receiver sluice for 12-24 hours to ensure there is no gas in the pipe when the pig is removed
- The collected data are checked, and a decision is made as to whether it is necessary to run the pig through the pipe one more time
- If this is not necessary, the pigging service provider makes a preliminary assessment of the condition of the pipeline
- The collected data are then used to prepare a detailed final report, which is generally available about four weeks after the inspection.

**What happens next?**

The final report provides a detailed list of all signs of damage and defects that could be characterised as corrosion.

The final report is analysed in light of operations data and other events in the vicinity of our pipeline network. The engineers evaluate whether corrective action is required in the form of repairs, or reinforcing the external coating on the pipe in particularly exposed locations.

Preventive maintenance, external inspection via surveys and pigging provide a basis for preparing status reports that describe the general condition of our pipeline network.

*Repair work on a pipeline following pigging.*

**Facts**

- Pigging a gas pipeline involves inserting a pig in the pipeline
- The pig may consist of one or more modules and has a built-in computer and a number of sensors, which make contact with the inside of the pipeline
- The pig is propelled by the pressure in the gas pipe and gathers various data en route, which we can use to assess the condition of our pipeline.

## Surveys of gas pipelines on the sea floor

*Energinet.dk conducts regular surveys of the Danish gas pipes on the sea floor in order to maintain a high level of security.*

Surveys involve inspecting the gas pipelines lying on the sea floor. The aim is to check the external condition of the pipe to ensure the pipe is positioned as it should be. Energinet.dk does this by examining the general condition of the pipe, which includes checking that:

- Sea currents have not removed material around the pipe
- There are no areas where the pipe has insufficient cover
- There are no areas where the pipe is lying without support, ie raised above the sea floor
- Corrosion protection is intact.

The work is done in cooperation with external service providers. Based on these inspections, Energinet.dk's engineers write a report assessing whether the pipes are positioned in a technically correct manner, or if remedial action should be taken.

### How are surveys carried out?

Pipes on the sea floor can be exposed to many effects that impact on security. For example, currents can erode the sea floor, exposing the pipe, which may then become damaged by fishing operations or anchor drag from ships in the area.

Surveys are carried out using a special vessel. The position of the pipe is measured using a remote-controlled mini submarine or visual diver inspection.

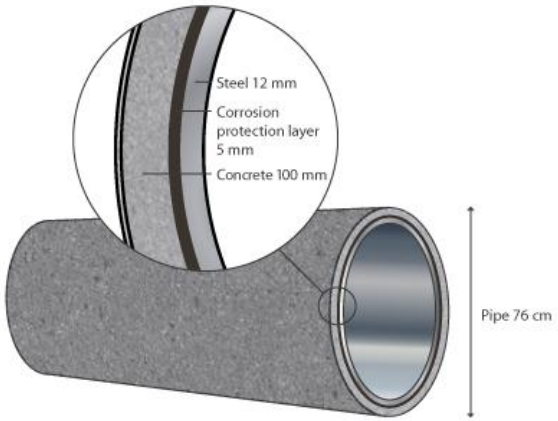
Monitoring offshore pipes is an ongoing process, in which new data are compared with earlier data. The survey is based on:

- Information from the Admiral Danish Fleet (SOK) about any ships which have run aground or been anchored near the gas pipes. Cooperation with SOK is intended to reduce damage and ensure an effective emergency response if the pipes are damaged
- A side scan – sonar imaging of the pipe and surrounding sea floor. This shows if the pipe is visible and to what extent
- A diving inspection, which provides a detailed picture of the condition of the pipe and indicates whether it is positioned correctly
- A subsequent decision about whether remedial action needs to be taken.

### What happens next?

If Energinet.dk discovers that conditions are not ideal, there are various things we can do to protect the gas pipes. For example:

- Add material if the cover is inadequate
- Add stones to reduce erosion of the sea floor
- Support the pipe using cement bags if unsupported spans are too long
- Repair the outer cement pipe protection or other defects.




*The submarine pipelines are made from 12 mm thick steel and have a diameter of 76 cm*

Energinet.dk conducts regular surveys so as to ensure that we are fully aware of the condition of the pipes and future maintenance requirements. The surveys and remedial action are carried out by external service providers.

**Facts**

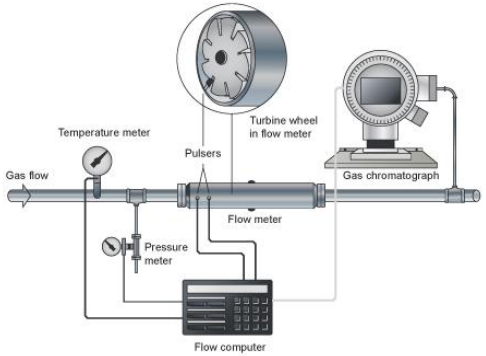
- Danish gas pipes lie on the sea floor in the Little Belt and the Great Belt and at Kalvebod (between the islands of Zealand and Amager)
- The offshore pipes were laid in 1982
- The pipes are made of steel with a wall thickness of at least 12 mm and a diameter of 76 cm
- The exterior of the offshore pipes has a bitumen coating to prevent corrosion. The pipe is also surrounded by a 10 cm layer of concrete to ensure it does not float up to the surface.

## Why do we measure the gas in the transmission system?

*Energinet.dk measures the gas at all system exit and entry points so we can charge for the transport of gas through our transmission system.*

Energinet.dk transports approx. six billion cubic metres of gas per year. Energinet.dk's customers pay for the energy transported on their behalf. Even small errors in the measurement of gas quality and quantity would lead to significant errors in charges to customers.

It is therefore vitally important that we know exactly how much gas is flowing at all points in the system – within the pipe itself, and at entry and exit points in the transmission system.




*A gas meter*

### Gas metering is a complex process

Gas metering records both the amount of gas and its energy content.
There are meters at all entry and exit points in the transmission system. A gas metering system consists of the following components:

- A gas flow meter, which measures the amount of gas in operating cubic metres (before correction is made for pressure, temperature and gas composition)
- A temperature meter

- A pressure meter
- A flow computer, which calculates the energy quantity
- A gas chromatograph, which measures the gas energy content.

Measurements are constantly performed, and the flow computer calculates the quantity of energy supplied by multiplying the gas amount by the energy content.

### Flow meters are difficult to inspect

The flow meter is the largest, most expensive and most important component in a gas metering system.

Energinet.dk uses turbine wheel flow meters. This means that there is a wheel which revolves inside the meter. Each time the wheel has revolved once, a known amount of gas has passed through it.

### External flow meter inspection

Energinet.dk's flow meters are regularly sent to an accredited calibration laboratory for inspection. Force Technology employs high-pressure calibration for the gas flow meters, which is internationally acknowledged. Energinet.dk has worked with Force Technology since 2004.

### Internal flow meter inspection

All Energinet.dk's flow meters are tested each year for friction in the bearings. This provides a good indication of the precision of the meters.

Energinet.dk performs the test itself at the metering station. We do this by sending gas through the turbine flow meter under high pressure. We then note how long it takes before the turbine meter wheel stops revolving. If the wheel stops very quickly, the meter is removed and sent for repair.

### Energinet.dk has its own accredited calibration laboratory

In order to be able to charge customers correctly, the amount of gas must be converted to normal cubic metres. This is done using temperature and pressure meters, which also require calibration.

Energinet.dk has its own accredited calibration laboratory, where we can calibrate pressure and temperature metres. Calibration is performed locally at the metering stations. It is cheaper to perform the calibration internally than to send the equipment away for external calibration.

### Varying gas quality

Over the last few years, Energinet.dk has gained access to natural gas with a different molecular composition to the traditional North Sea gas. The gas, which primarily comes from Germany, has a different energy content.

The varying gas quality means it is now even more important to correctly calculate the energy of the gas. Energinet.dk uses advanced computer simulation to calculate the gas energy content at all entry and exit points in the transmission system.

**Facts**

- The gas quantity measured in gas flow meters is expressed in operating cubic metres. The quantity corresponds to the geometric volume of the gas
- Following correction for gas pressure, temperature and composition, the gas quantity is expressed in normal cubic metres
- Settlement for transport services is based on energy units – kWh
- Pressure and temperature meters are internally calibrated each year
- Flow meters are externally calibrated every eight years.

## Re-laying the natural gas pipeline near Silkeborg

*Construction of the new Herning-Aarhus motorway made it necessary to move the existing pipeline.*

In connection with construction of the new motorway between Herning and Aarhus, the Danish Road Directorate asked Energinet.dk to re-lay two sections of the existing 12-inch pipeline near Silkeborg. This was necessary to make room for the motorway.

Energinet.dk decided to establish a new valve station to supply the Silkeborg Kraftvarmeværk CHP plant at the same time.

The two new pipeline sections are 660 and 1,000 metres long. The pipes were placed in the ground, welded and pressure-tested during summer 2012.

*Welding in a new valve station at Sejling Hedevej.*

### Intense 24-hour final stage

The pipe work was finished in August and ready to be welded onto the existing gas transmission system. The final step of the process was an intense stage just 24 hours in duration.

In order to be able to weld the two new pipe sections and valve station into the system, it was first necessary to empty gas from approx. 11 kilometres of the existing gas pipeline between Herning and Skjoldelev.

Engineers first closed the valves at the metering and control station in Silkeborg and the Voel valve station. Chimneys had been erected in both locations for flaring of the gas. The flames rose about 30 metres into the air and could be seen and heard from a great distance. Flaring of the gas lasted one hour. Neighbours, local authorities and local media were notified in advance. Approx. 50,000 cubic metres of gas was flared.

*Gas flaring at Sinding Hovvej.*

### Minimal disruption to gas consumers

The work was done on a Saturday in August. It was planned that way because gas consumption at that time was so low that the operation resulted in the least possible disruption to gas consumers.

Once gas had been emptied from the pipeline, welders could begin to cut out the old pipes and weld in the new ones.

After 24 hours, the new welds were checked using ultrasound and radiography and approved by an independent inspection company. Energinet.dk's operations staff could then begin filling the pipeline with gas.

Facts

- 12 inches is about 30 cm
- Planning began in early 2011
- Construction work was carried out during the summer of 2012
- The re-laid pipeline was commissioned on 25 August 2012
- Forty staff participated in the operation, at seven different work locations
- The work was paid for by the Danish Road Directorate and carried out in close cooperation with HMN Naturgas.

## Gas for transport

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

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

In connection with negotiations on the Danish Climate Change Act (Klimaloven) in October 2012, the Danish Ministry of Climate, Energy and Building initiated investigations into opportunities to promote natural gas and biogas as fuels in the Danish transport sector.

### 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 reducing the use of oil in transport and $CO_2$ emissions.

The 'Alternative fuels' report, which the Danish Energy Agency published in February 2012, discusses various fuels for passenger vehicles and heavy transport (buses and trucks) up until 2030.

The analysis shows that biogas and natural gas are among the best socio-economic alternatives. This also applies in relation to petrol and diesel for both passenger vehicles and heavy transport throughout the entire 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 opportunities.

Major activity is taking place in Sweden and Germany 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 into the transport sector, and options for transferring this experience to a Danish setting.

### Run on biogas using RE gas certificates

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

For example, when a gas filling station sells biogas to a consumer, the station purchases a corresponding quantity of RE gas certificates. The certificate system thus ensures that the quantity of gas the consumer has withdrawn and purchased as biogas actually corresponds direct to an equivalent quantity of biogas that was produced, upgraded and fed into the nationwide gas grid.

### Liquefied natural gas in sea transport

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

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

## Alternative fuels

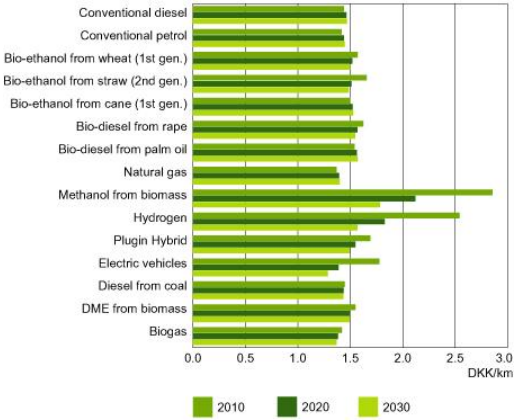
*Biogas is one of the best alternatives to traditional fuels, both for passenger vehicles and heavy transport.*

In February 2012, 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 trucks) up until 2030.

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

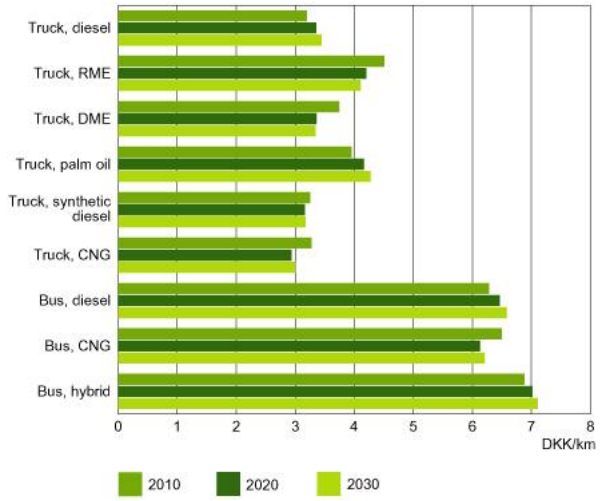
### What about electric vehicles?

Electric vehicles are very energy-efficient, and in terms of the environment and climate, they are a good alternative to petrol and diesel-powered passenger transport. However, from a socio-economic perspective, electric vehicles only become interesting in 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: The Danish Energy Agency.*

In the area of heavy transport, pure electric power is not expected to become an alternative for many years. One of the reasons for this is the limitations of battery technology. In the area of heavy transport, gas is believed to be the best socio-economic alternative for many years ahead, as shown in this figure:




*In the area of heavy transport, gas is believed to be the best socio-economic alternative for many years ahead. Source: The Danish Energy Agency.*

### Biogas best for the climate

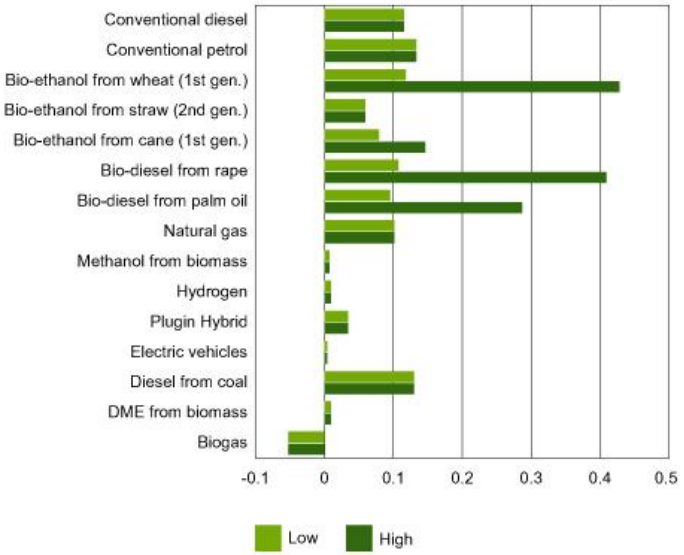
Natural gas is a fossil fuel and therefore has significant $CO_2$ emissions. However, natural gas is better for the climate than either diesel or petrol. Upgraded biogas can directly replace natural gas as fuel in a gas vehicle.

Biogas actually has a positive climate effect as methane from manure etc. is used to generate biogas, instead of it simply evaporating from pasture. Methane has a greenhouse effect about 21 times as great as $CO_2$.

Electric vehicles are also expected to become very climate-friendly as a greater proportion of our electricity is derived from renewable energy and therefore does not emit $CO_2$.

### Contested climate effect of first-generation biofuels

The climate effect of 'first-generation biofuels' produced from biomass, which could alternatively have been used for food products or animal feed, has been contested. The Danish Energy Agency report has therefore analysed the climate effect of various fuels. The analyses take into account land areas used to grow the biomass that is applied in biofuel production, as shown in the figure:



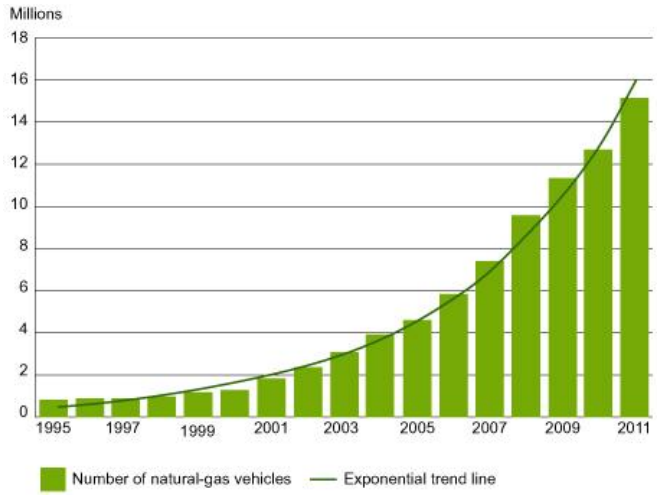

*Climate effect of various fuels, including the use of land to grow the biomass. Source: The Danish Energy Agency.*

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 (grain) and biodiesel produced from oilseed rape or palm oil. The European Commission is also working on more stringent biofuel requirements.

## Gas for transport in Denmark and the neighbouring countries

*The last 10 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-powered vehicles globally in 2011. Approx. 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 10 years have seen a dramatic increase in the use of gas for road transport around the world. Source: Natural Gas Vehicles Association.*

### Trends in Germany and Sweden

Germany had approx. 95,000 gas vehicles in 2011. The tax on gas for transport and environment zones in many German cities is low. Gas vehicles currently have much lower emissions of $NO_x$ and 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 approx. 36,000 gas vehicles in Sweden in 2011.

Several factors have contributed to the large number of gas-powered 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 often 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 driven by bus transport using biogas in southern Sweden. One in every five new buses in Sweden currently runs on gas.

### Denmark has great potential for the use of gas for transport

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

Efficient gas-powered buses and trucks have come onto the market in recent years. Gas-powered passenger vehicles and light trucks are being massproduced, and many standard petrol and diesel models are also available in a gas version.

### Why haven't gas vehicles come to Denmark?

From a socio-economic perspective, gas is already a better fuel than petrol or diesel. This is the conclusion, for example, of the Gas for transport report, which COWI prepared 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 dated August 2012, prepared under 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 that applies to gas vehicles and gas as a fuel and is less favourable than in countries such as Sweden and Germany.

### Growing interest in gas for transport in Denmark

In recent years, both politicians and gas market players have shown an increasing

interest in gas for transport. For example, the broadly backed energy agreement made in spring 2012 has a focus on introducing gas into the heavy transport sector.

Gas market players have also entered the fray. In addition to Naturgas Fyn, HMN Naturgas announced in October 2012 that they plan to establish a public gas filling station in cooperation with Skive Municipality. Several municipalities have also expressed an interest in acquiring gas buses that can run on biogas.

## Market support for gas in transport

*If biogas is to play a significant role as a fuel in the transport sector, this has to be supported by the market, legislation and EU regulations.*

The most efficient solution is if gas is supplied to filling stations from the existing gas system. Certificates can be used to ensure that customers can choose between tanking biogas and natural gas.

The current regulations for calculating the RE share in the transport sector do not support the option of tanking biogas via the gas system.

The Renewable Energy Directive effective from 2009 needs to be amended such that, in future, biogas purchased 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 that the directive be amended to ensure that biofuels used to fulfil the 10% objective are produced sustainably.

The proposed amendment limits the opportunity to fulfil 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 in a stronger relative position. However, the first draft of the proposal does not contain the option of including biogas purchased via certificates.

## LNG: Liquefied natural gas in sea transport

*There are many opportunities and a great potential for introducing liquefied natural gas into 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 and nitrous oxide ($NO_x$) emissions. LNG (Liquefied Natural Gas) is highly pressurised, and an LNG tank therefore contains much more energy than the corresponding quantity 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 also below the equivalent prices of conventional fuel oil for sea transport. A number of Danish shipping companies have expressed 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. Flue gases (emissions) from sea transport currently contain a number of substances that are harmful to human health and the climate, and this has been attracting increasing attention in recent years – particularly the content of $SO_x$ and $NO_x$.

LNG can significantly reduce pollution from sea transport in Denmark because gas emissions contain much less sulphur and $NO_x$ than the oil traditionally used for sea transport.

### More stringent environmental requirements from 2015

The emission requirements in the north European ECA area will become significantly more stringent from 1 January 2015 when the limit for sulphur is reduced to 0.1%. Tolerance will become even more restrictive from 1 January 2016 when new vessels are required to comply with strict $NO_x$ emissions requirements.

Ships powered by LNG can immediately fulfil the stringent new requirements.

### New infrastructure required

In order for shipping companies to convert a proportion of sea transport to LNG as a fuel, the necessary infrastructure to support this must be established, such as gas 'filling stations' at harbours.

Several Danish harbours and shipping companies are expressing interest in establishing LNG bunkering facilities.

### Hirtshals may lead the way

Hirtshals Harbour may become the first Danish harbour to implement infrastructure for bunkering LNG. The harbour has initiated an EIA process to determine the project's environmental impact. The expansion plans involve an LNG tank for ship bunkering.

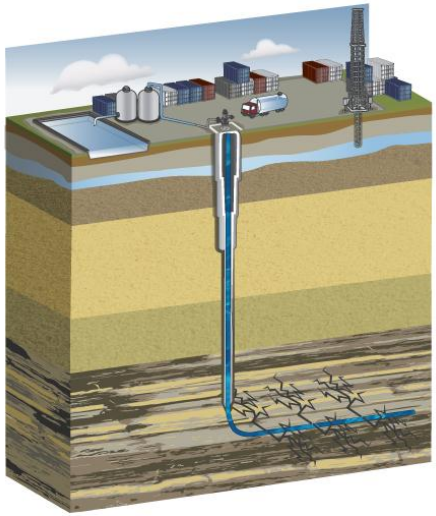
The Norwegian Fjordline shipping company, which sails between Hirtshals and Norway, has ordered two ferries capable of being powered by LNG.

## Shale gas potential in Denmark

*The extraction of shale gas in Denmark may have major impacts – both economically and on the energy sector.*

Total E&P Denmark B.V., of France, is the only company currently permitted to explore for shale gas in Denmark. The company will explore the potential for extracting shale gas in north Jutland and north Zealand and initiate the first exploration drilling in north Jutland in late 2012.

North Jutland and north Zealand are also at the extremities of the transmission system and are hence those parts which have the least capacity.



*Shale gas is extracted by drilling approx. 4 km into the underground formation, then pointing the drill in the horizontal direction to make a fracture in the shale rock, whereby the gas is released.*

### Possible expansion and reinforcement of the natural gas grid

If it is decided that shale gas production should be established in Denmark, it will be necessary to set up new connection points in the Danish gas grid. If significant production is established, it may be necessary to expand the capacity of the transmission system in certain areas in order to transport and export the gas.

It may be necessary to install up to 300-400 kilometres of transmission pipes. The Danish transmission system is currently 930 kilometres long.

### Shale gas potential is five times greater than natural gas reserves

The Danish shale gas potential is not currently known, but the U.S. Energy Information Administration (EIA) roughly estimates the shale gas potential to be up to five times greater than the total Danish natural gas reserves in the North Sea over the years.

Natural gas in the North Sea has been extracted for commercial sale since 1979 and has generated significant income for the Danish state since that time.

The EIA provided a similar estimate of the shale gas potential in Skåne, Sweden, but the first test drilling carried out by Shell showed that the actual potential was too low for commercial extraction. Sweden therefore decided to suspend further exploration.

### Shale gas driving growth in the USA

The global awareness of shale gas is due to what has happened in the USA. Production there began in 2008 and has since increased surprisingly in scope. As a result, the USA will be able to cease importing and begin exporting natural gas in the years ahead.

The impacts of shale gas production on US society have been significant, both economically and generally.

Economic impacts: The production of shale gas has led to a very low gas price in the USA. This has had a major impact on competition in the gas market. Gas is replacing coal in power stations, leading to immediate $CO_2$ reductions. Access to abundant, cheap shale gas has reinforced the trend whereby US industry is recovering jobs and growth in several marginalised local communities.

General impacts: The shale gas potential in the USA is so great that Americans will be self-sufficient in natural gas for many years to come. This has significantly increased security of supply and partially removed the USA's dependence on resources from geopolitically unstable countries.

### Good and bad environmental effects

Gas is cleaner and emits fewer greenhouse gases than the coal and oil it replaces, but there have been environmental impacts in those local areas where shale gas has been extracted. In addition to economic growth, shale gas has also led to serious pollution of local water resources in several cases.

Large quantities of production water with added chemicals are used in the extraction of shale gas. These chemicals may be carcinogenic. Due to insufficient safeguards, this production water has seeped out of gas wells and into local watercourses and wells, and there are several reported cases where the concentration of gas in the local water is far too high.

This pollution has led to major health impacts for the local population and given rise to debate as to whether shale gas resources can be extracted responsibly.

### Shale gas production needs to be closely monitored

As a result of the debate regarding shale gas production, the Danish Minister for Climate, Energy and Building has stopped granting permits for exploratory drilling until the environmental impacts have been identified.

This issue has been handled differently in other EU countries. France has placed a ban on shale gas exploration, while Poland is well advanced in establishing actual shale gas production.

At the EU level, the debate has given rise to a proposed directive, which permits the extraction of shale gas under certain conditions. One of the focal points is that extraction must use the best available technology and be subject to the necessary stringent monitoring to ensure that it takes place in an environmentally and socially responsible manner. The proposal must first be considered by the European Parliament and the Council of Ministers before entering into force. It will be up to each country to decide whether to give specific permission to extract shale gas.