NL Agency
Ministry of Economic Affairs, Agriculture and Innovation

Dutch gas sector

Overview of research and collaboration (2006-2009)

>> ***Focus on energy and climate change***

Colophon

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Introduction

Fifty years ago the largest gas field in Europe was discovered in Slochteren (NL). Within a few years, the Netherlands became a big producer and user of natural gas and a strong gas industry was established. The Dutch became a supplier of natural gas for a large part of North Western Europe.

Natural gas accounts for about half of the energy consumption in the Netherlands. In the future the Dutch production of natural gas will decrease because of the slow depletion of the so-called small gas fields and, eventually, the Slochteren gas field.

In order to ensure that the Nethelands continues to fulfil a central role in the European gasmarket, the government of the Netherlands strives for six preconditions to be met: 1) a substantial production of gas from the Dutch fields 2) sufficient transport capacity, 2) storage capacity, 3) diversification of gas sources including biogas, 5) a dynamic gas market and 6) a strong innovative gas industry.

With these conditions in mind, an ambition was formulated by the Dutch government to become the gas hub for North-Western Europe. The government of the Netherlands gave gas and the gas hub strategy a central position in the Energy Report 2011 that was sent to the House of Representatives in June of that year. One of the aims of the energy policy is to realise a "new style" industrial policy through the development of the gas. In the Energy Report 2011, the government accentuates the following:

Important policy actions include:
- investments in regulated infrastructures,
- adaptations of the Gas Act to make possible cross-border investment participation,
- allowing minority privatisation of the grid in order to attract new capital,
- economic diplomacy being an integral part of the energy diplomacy.

With this new policy, gas investments and infrastructure are firmly anchored in present and future energy system of the Netherlands.

Fostering game-changing innovation is an essential part of the Top Sector policy in which the gas industry has been selected as one of the main topics in the 'Energy' top sector. Stimulating cooperation between the gas industry and knowledge institutions and expanding R&D efforts related to the gas hub have been prioritized attention to optimise the benefits of our natural resources.

This report is focussed on the research and developments in the Dutch gas sector (2006-2009) based on the data from the NL Agency project database and the expertise of our colleagues from the NL Patent Office and NL EVD International. The aim of this report is to show the developments and the scale of R&D activities creating a starting point for future scans, monitoring and programme development.

1 Conclusions

1.1 National gas policy

The Dutch gas sector has a large innovative potential. Promoting and supporting relevant new initiatives for cooperation will help develop a stronger sector. Innovation and valorisation are crucial elements in the Gas Hub strategy, the Energy Report 2011 and the new Top Sector policy. Regulatory barriers hindering biogas projects will be removed by the newly developed Green Deal policy.

1.2 The Dutch gas sector: value chain and economic potential

The gas sector is well developed and includes production, transport, storage and trading companies, suppliers, service companies and consumers (industrial and households) as well as universities, special gas institutes and research institutes and further several interest groups. The interaction of the sector could be improved by more collaboration. The newly initiated Topsector policy on Energy can generate a higher level of interaction via the so-called 'Innovation contract' committing the whole chain of the gas sector. In August 2012 the foundation TKI GAS, responsible for the execution of the innovation contract gas, was founded. The first TKI GAS projects will start early september 2012 focussing on: Upstream, Small Scale LNG, Green Gas, Societal Aspects and Power to Gas / Gas to Energy.

Economic potential of the gas sector according to the Brattle report
The Brattle Group estimates that the Dutch gas sector currently supports about 11,600 Full Time Equivalent (FTE) jobs directly, 31,500 indirectly and 23,300 induced jobs. The value of goods and services produced around the Dutch gas sector is about €41 billion or about 7% Dutch GDP (2005). The gas sector contributes a total of €16.7 billion in final demand each year, about 3% of Dutch GDP in 2009.

To estimate the economic potential of the Dutch gas sector, the Brattle Group simulates a Gas Hub scenario involving an additional €7.7 billion of investments. Such scenario generates €1.8 billion in combined additional income from intellectual property royalties and added value from trading. The Gas Hub scenario could create up to 136,000 FTE job-years and €21.4 billion of additional goods.

In 2011 76,4 bcm of natural gas was produced and 21,8 bcm was imported. In total 52,9 bcm was exported and our own consumption of natural gas amounted to 45,3 bcm (industry, powerstations and households).

1.3 R&D, innovation and collaboration

WBSO's (Dutch fiscal scheme promoting research) confidential project database was used to make an overview of relevant gas projects, R&D players, and the technologies and applications in the gas chain. Nearly all companies of the Netherlands use the WBSO to support their R&D activities. The WBSO is easy to access and the database gives a good representation of the R&D being carried out by companies in the gassector.

The number of R&D players has grown substantially: 50% in four years
In the period 2006-2009 the number of R&D players in gas increased by about 50%. In the same period, the number of companies applying for the R&D fiscal support scheme grew from 300 to 460. About 85% of these belong to the SME category while 5% have more than 1,000 employees.

R&D activities grew to 700 FTE in 2009
The R&D volume was about 520 FTE in 2008 and grew by more than 25% to about 700 FTE in 2009. The 700 FTE represents a total of 33.5 million euro in terms of salaries. Total R&D costs (salaries and material costs) will be at least 70 million euro a year. The NL Agency database indicates that the estimation made by the Brattle Group on the number of direct R&D jobs (i.e. 502) is rather conservative.

There is a strong focus and a great deal of interest in Biogas and LNG is emerging
Most of the R&D effort focuses on natural gas or biogas projects, followed by syngas, LNG and LPG. The share of natural gas projects is decreasing while biogas, LNG and syngas projects are increasing in volume and share. The interest in LNG may be explained by the possibility to use LNG as an alternative fuel in road transport and shipping to reduce the emissions of CO_2, NO_x and So_x.

Publicly (partially) funded R&D primarily focuses on gas treatment, engines, fermentation and gasification
The R&D in our databases mainly focuses on gas treatment, gas engines, fermentation and gasification. The volume of R&D in relation to gas treatment and engines (mobility and combined heat and power applications) has remained stable. The volume of R&D on fermentation and gasification has grown. Other relevant R&D concerns pipelines, gas quality and boiler design.

Dutch participation in EU FP7 concentrates on syngas projects
About 44 Dutch organisations applied for funding in the European Framework Programme 7. This funding was primarily for projects focussing on syngas and biogas. The syngas projects were mostly Gas-to-Liquid projects (e.g. large GTL production plant in QATAR by IOC Shell). There are only a few Dutch organisations participating in funded FP projects, including TU Delft, TNO, TU Eindhoven, ECN, Nuon, Universiteit Utrecht and Avantes. They are cooperating mainly with German, Italian and British partners.

Patents: strong position on LNG and Gas-to-Liquid technology
The NL Patent Office conducted a scan of all patents applied for in the period 1999-2007 and also made an international comparison. The Netherlands has a strong position on LNG and Gas-to-Liquid technology and on gas production (third), biogas production (third) and gas quality (fourth). Shell is mainly responsible for these positions, biogas production excluded.

Collaboration
We have used our databases to monitor R&D developments and the level of collaboration. Given the nature of the gas sector, we believe that the number of collaborations and commercially focussed projects is much higher than the projects in our databases. Nonetheless, we did expect to find greater dynamics and higher profile collaborations between institutes and industry, given the economic scale of the sector.

2 Research questions and methodology

This report provides an overview of the gas sector in the Netherlands. The research mainly focuses on gas knowledge, companies and institutions, technology and innovation.

2.1 Research questions

The leading research questions for this report are as follows:

1) What are the main knowledge institutions and companies? (Ch.3)
2) What is our knowledge position in terms of R&D and patents? (Ch.4)
3) How has R&D on gas and biogas production been stimulated by fiscal and subsidiary-based instruments since 2006? (Ch.5)
4) Which (inter)national collaboration networks exist? (Ch.6)
5) Which companies have participated in trade missions? (Ch.7)
6) What are the main topics of Dutch gas policy? (App 1)
7) What are the relevant trends and developments? (App 1)

2.2 Methodology

This report has been written using data derived from subsidised projects and or fiscal benefits programmes. These programmes are generally set up to promote certain technologies and are therefore biassed. NL Agency has little data focussing on commercial activities of the gassaector. We have used newspapers and websites to describe trends in the sector.

The following sources were consulted:

- the project-database of subsidised projects by NL Agency (Datawarehouse);
- EGL-database European Zeventhy Framework projects;
- Infotheek from NL Agency (for relevant literature);
- TWA netwerk (international attachés network) from NL EVD International;
- NL Patent Office (information about Dutch patent position);
- NL EVD International for participants in trade missions;
- experts in the NL Agency organisation;
- reviews by experts from external organisations.

Information gained from the analysis of the different sources has been integrated into this report.

3 The Dutch gas sector and collaboration

The Dutch gas sector consists of different types of players: companies, knowledge institutions, research centres and interest groups. This chapter gives an overview of economic parameters and the main players in the sector.

3.1 Dutch gas production and consumption

The following information has been taken from the report "Energy in The Netherlands 2011" drawn up by EnergieNed and Netbeheer Nederland[1].

In 2009 the Netherlands produced 83.944 million m^3 and imported 24.408 million m^3 of natural gas, while 56.433 million m^3 was exported. Large industry and power stations used 36.721 million m^3 of natural gas. Households and small industry used 15.198 milion m^3 of natural gas.

The entire household market is responsible for 20% of natural gas consumption. The Netherlands has by far the highest proportion of gas-heated homes in Europe. Considering the importance of the household market segment, energy companies keep a close eye on developments in that market. Activities include an annual survey of 3,000 households. An important factor in the development of energy consumption in homes is the increasing demand for comfort. This is responsible for a large proportion of the consumption of both natural gas and electricity.

Over the past 30 years, average household gas consumption has decreased from 3,000 m^3 to 1,617 m^3 in 2010. This reduction is almost entirely the result of a decrease in the amount of gas required for heating space. Two developments have played a major role in this: the introduction of the high-efficiency boiler and improvements in home insulation. Gas consumption for heating water is increasing. For increased comfort, smaller hot water appliances are being replaced by larger ones. Gas consumed for the preparation of food has remained virtually the same for the past 15 years.

3.2 Economic potential gas sector

The Brattle group[2] estimates that the gas sector contributes about 9% of all Dutch central government revenues. The Dutch gas industry invests around €1.5 billion per year in pipelines, offshore platforms and other gas infrastructure, and has operating expenditures of around € 5 billion, a significant amount of which goes on employment, particularly in the downstream sectors. Brattle group estimates that the Dutch gas sector currently supports about 11,600 FTE jobs directly, 31,500 indirectly and 23,300 induced jobs. The added value of goods and services produced around the Dutch gas sector is about € 41 billion (7% Dutch GDP).

The gas sector contributes a total of €16.7 billion in final demand each year, or about 3% of Dutch GDP in 2009. Gas exports had a value of €14 billion and €10 billion in 2008 and 2009 respectively, which represented around 3-4% of the value of all Dutch exports.

3.3 Universities and knowledge institutions on gas

The listings are not exhaustive and there may be more relevant universities, knowledge institutions, companies, suppliers and service companies.

The following universities and knowledge institutions are important in the field of gas.

A. Universities & academies
- Rijksuniversiteit Groningen (RUG)
- Technische Universiteit Delft (TUD)
- Technische Universiteit Eindhoven (TUE)
- Universiteit Twente (UT)
- Hanzehogeschool Groningen

B. Knowledge institutions, research programmes and foundations
- Netherlands Organisation for Applied Scientific Research (TNO)
- Dutch institute for energy innovation (ECN)
- MARIN (Maritime Research Institute)
- KEMA
- Energy Delta Gas Research (EDGaR)
- Energy Delta Institute (EDI)
- CRL Energy
- Stichting Technische Energiekennis Transfer (STET)
- Stichting LNG TR&D (Technology, Research and Development)

1 *"Energy in the Netherlands 2011", Energiezaak, Energie-Nederland and Netbeheer NederlandNetherlands).*

2 *"Economic Impact of the Dutch Gas Hub Strategy on the Netherlands", The Brattle Group, September 2010; aangeboden aan Tweede Kamer met brief van 8 december 2010, kamerstukken II, vergaderjaar 2010/11, 29 023, nr. 79.*

3.4 *Important companies in the gas sector*

The listings are not exhaustive and there may be more relevant universities, knowledge institutions, companies, suppliers and service companies.

The companies are classified into transport, production, suppliers, service companies, market, storage & terminals, and heavy consumers. The listings are not exhaustive and there may be more relevant companies.

A. Transport
- NV Nederlandse GasUnie
- Gas Transport Services B.V. (GTS)
- Noordgastransport B.V.
- NOGAT B.V.
- Ballast Nedam - CNG Net

B. Production
- EBN
- NAM
- Total
- Wintershall
- DANA Petroleum
- Centrica
- GDF SUEZ E&P Nederland B.V.
- Dyas
- Cuadrilla (expected)
- TAQA
- Vermillion
- Northern Petroleum
- Queensland
- DSM Energy

C. Suppliers
- SBM Offshore
- Schlumberger
- Gastreatment Services (GTS)
- Allseas
- Heerema
- Bluewater
- Gutteling
- Cryonorm

D. Service companies
- Gasunie Engineering B.V.
- VSL (Dutch Metrology Institute)
- Vertogas
- KIWA Gastechnology
- GasTec Certification B.V.
- KEMA
- Biomass Technology Group (BTG)
- Imtech
- NMI

E. Whole salers and regional distribution companies
- GasTerra
- GDF SUEZ Gas Supply & Sales The Netherlands B.V.
- SHV Gas

F. Storage & terminals
- Koninklijke VOPAK NV
- GATE terminal

G. Big end-users
- Electrabel
- E.on
- RWE/Essent
- Vattenfall/Nuon
- Eneco
- Dong
- Horticulture sector

The figure below provides a geographical overview of important institutions and companies in the Netherlands. Some stakeholders are active in more than one gastype (natural gas = 'aardgas') in that case a single selection has been made. LNG organisations are mainly found in the western part, biogas organisations in the eastern and natural gas organisations in the northern part of the Netherlands.

3.5 Interest groups on gas

There are also various interest groups and two associations relevant in the area of gas.

- Energy Valley (North-Netherlands)
- Vereniging Gasturbine – Dutch Gas Turbine Association
- Nogepa (Dutch Oil and Gas Exploration and Production Association)
- Industriële Raad voor de Olie en Gas Industrie (IRO) – Association of Dutch suppliers in the oil and gas industries
- CNG Net
- Groen Gas Mobiel
- Vereniging voor Energie, Milieu en Water (VEMW)
- Stichting Groen Gas Nederland
- Royal Dutch Gas Association (KVGN)
- Netbeheer Nederland
- Energie Nederland
- Global Gas Networks Initiative (GGNI)

3.6 Public and private collaboration

In the coming years, the biggest challenge will be to keep Dutch production of natural gas up to acceptable levels. This will require innovative technologies, investments, qualified personnel and a well maintained infrastructure. Continued production will make it easier to retain a competitive position in the field of upstream oil and gas technology and expand thereupon.

The Dutch gas sector is innovative and involves various collaborations with the expertise sector, businesses and the government. The supply industry is very focussed on export. According to some interest groups as Nogepa, IRO and EBN, The Netherlands is one of the worldwide top 5 countries when it comes to gas and offshore technology and is a leading light in cranes and transport vehicles and in drilling and pipe-laying equipment for the exploration of oil and gas at sea.

EBN holds a central position in the Dutch gas industry. By participating on behalf of the Dutch State in exploration, production, storage and sale van Dutch oil and natural gas, EBN is responsible for a major contribution to the Dutch treasury. Dutch society has been benefiting from these natural gas revenues for over 50 years.

EBN executes the so-called “Small Fields Policy” set up by the Dutch government. About 40% of all Dutch gas production stems from these small fields, the other 60% gas production from the big Groningen-gas field (“Slochteren”). In 1974 the Dutch government implemented the so-called “small fields policy” to preserve the Groningen gas field and to stimulate the exploration for and production from other gas fields. Without these small fields the Groningen gas field would almost have been depleted.

3.7 Collaboration in innovation projects

There are few collaborative, funded projects in the period 2006-2010. Several collaborations were submitted but not funded for a variety of different reasons. These projects are also mentioned below because they also provide information about subjects for collaboration.

We have seen collaborative projects funded by the EOS (energy research programme), Maritiem and IS programmes (innovation programmes). We believe that parties are collaborating more than our database shows.

Biogas

Duurzame Energie Nederland (DEN) programme funded two projects on biogas. The first project concerned the odourisation of upgraded biogas and was a collaboration with KEMA and Kiwa Gas Technology. The second project concerned the analysis of the produced biogas with Plant Research International and Praktijkonderzoek Plant en Omgeving.

Treatment

The Innovation Collaboration programme (IS) funded a project on gas treatment with five partners: Twister, FMI Precision, Gasunie Engineering & Technology, NEM, Science and Technology Holding and TNO.

LNG

Two projects were funded by the Maritime Innovation programme (MIP). In one project a LNG ship-to-ship transfer system was developed with partners Gutteling and Exmar. The other project concerned an LNG Floating Production, Storage and Offloading (FPSO) system. BM Offshore, Gas treatment Services and Linde Engineering AG cooperated in this project.

A non-funded LNG collaboration project was Full Scale Testing and Numerical Simulations of LNG Containment Systems, conducted by Shell Global Solutions and the Maritime Research Institute Netherlands (MARIN).

Gasification

Alterra, Amsterdam Fertilizers, ECN and HoSt applied for a project on gasification. The project concerned the development of a whirling bed gasifier. The project was not funded.

3.8 Collaboration in research programmes and initiatives

EDGaR
The Energy Delta Gas Research programme (EDGaR) is an important consortium on gas research. The programme is funded by The Northern Netherlands Provinces (SNN), the European Union (European Fund for Regional Development), the Ministry of Economic Affairs, Agriculture and Innovation and the Province of Groningen.

The consortium executes a public-private strategic research programme on the energy future of the Netherlands. It focuses on positioning Dutch natural gas in an international perspective and, from this position, on achieving a sustainable energy supply. EDGaR's main objective is to carry out research of fundamental, strategic and technological importance on gas. The research programme follows three themes:

- From mono to multi-gas
- Future energy systems
- Changing gas markets

The consortium includes the companies GasUnie, KIWA Gastec, Enexis, Stedin, Liander and GasTerra and the knowledge institutes ECN, RUG, TUD and Hanzehogeschool Groningen.

LNG TR&D foundation
LNG TR&D (LNG Technology, Research & Development) was set up to cluster knowledge and expertise of the whole LNG chain and to get Europe at the forefront of LNG technology and application. The aim of LNG TR&D is to remove innovation barriers and to strengthen the knowledge and competitive position of companies in the energy sector. LNG R&D programs on behalf of the LNG industry

- Lobby for the realisation of a Dutch LNG test center
- Education programs
- R&D programs under a future STW partnership program LNG. STW is a foundation which aims to realise the transfer of knowledge between the technical sciences and users. It does this by funding excellent technical scientific research and by bringing researchers and users together in each project.

LNG TR&D is a collaboration initative of TNO, VSL and 3TU and uses an industrial advisory board with the members Shell, SBM, Vopak, Gasunie, Imtech, VSL, Demaco, Cryonorm for the definition of the leading areas of interest in LNG and a Science Committee with members of TNO, VSL, and 3TU.

Energy Valley
The Energy Valley foundation is a network organisation which supports regional chances for the energy sector. Energy Delta Institute and the University of Groningen constitute the knowlegde cluster of Energy Valley. Energy Valley operates as an intermediair for public and private partners to facilitate energy projects and knowledge exchange in the northern regio. Energy Valley is subsidized on project basis by Samenwerkingsverband Noord-Nederland, the European Union, the Ministry of Economic Affairs, Agriculture & Innovation, regional governments, industry and knowledge institutions.

Gas Hub Consultative Platform
In 2010 the Gas Hub Consultative Platform was initiated by the Minister of Economic Affairs, Agriculture and Innovation and the energy sector. The following organisations participate in the Platform: APX, Clingendael, Delta, Dong Energy, EBN, ECN, EDI, Eneco, Exxon Mobile, Fluxys, GasTerra, GasUnie, GDF-Suez, Nuon, RWE-Essent, Shell, TAQA and TNO. The aim of the Gas Hub Consultative Platform is to serve as the link between government activities and the initiatives of the business community.
The platform's primary objective is to facilitate the development of the Gas Hub. Several of its functions will help it to achieve this objective:

- coordinate activities and discuss strategic issues;
- exchange information;
- engage business community in policy development;
- initiate cooperation;
- implement multi-year action plan together with government.

4 Gas research and patents

We have used the WBSO (fiscal scheme promoting R&D) project database to select relevant gas projects in the period 2006-2009. The WBSO generally supports R&D and is therefore a valuable source for data to estimate R&D developments. Using this data we have determined:

1 the size of the companies that are carrying out research
2 the share of each kind of gas in R&D and development-projects per year
3 the volume of gas R&D in FTE per year per technology
4 the volume of R&D focussing on the different components of the gas chain.

The overview shows the different R&D players, the scale, the different types of gas and the technologies and applications in the gas chain. Knowledge institutes do not submit their proposals to the WBSO.

NL Patent Office has conducted a scan of all the patent applications in the period 1999-2007. The absolute numbers of patents per country and per topic have been analysed. An overview of the Dutch position and an international comparison was then made. A complicating factor was the lack of distinction between the patents on gas and oil production.

4.1 R&D players

Table 1 shows the development of the number of applicants of R&D projects in the WBSO. The number of applicants has increased from 300 to 460. The share of gas applicants in the total population of the WBSO has increased from 2.4% to 3.0%.

In 2009 the growth was the highest with 20.7%. The total number in the WBSO also grew by 23.1% because of the extra budget for software development in ICT services.

Table 1 *Number of applicants of R&D projects per year.*

Number of applicants	2006	2007	2008	2009
# Applicants for gas projects	300	330	380	460
Growth	-	7.9%	17.2%	20.7%
# Applicants in total WBSO population	12,610	12,115	12,545	15,445
Growth	-	-3.9%	3.5%	23.1%
Share of gas applicants in WBSO	**2.4%**	**2.7%**	**3.0%**	**3.0%**

Divided according to size categories, it turns out that 87% of the applicants for R&D projects belong to the SME category; cf. table 2. Generally 96% of the WBSO population belongs to the SME category (<249 employees). It can be concluded that on average in the gas sector more research is carried out by larger companies compared to the other sectors of industry.

Table 2 *Applicants by size category.*

Category	Partition total WBSO	Division of gas project applicants
1-9	54%	38%
10-49	29%	30%
50-249	13%	19%
250-999	3%	8%
> 1000	1%	5%

Table 3 *R&D volume per year.*

FTE for R&D projects	2006	2007	2008	2009
Gas	520	500	540	690
Growth	-	-4.3%	-8.5%	26.9%
WBSO total	57,800	59,680	62,390	67,595
Growth	-	3.3%	4.5%	8.3%
Share of gas projects	**0.9%**	**0.8%**	**0.9%**	**1.0%**

4.2 R&D volume in FTE

Table 3 provides an overview of R&D volume (only labour costs) per year in FTE (1400 R&D hours).

The FTE volume increased in 2006-2009 from 520 to 690 FTE. There were many more applicants in 2009 (+20.7%), but the FTE volume increased even more (+27%). This is a significant increase, far more than the increase in total WBSO volume (8.3%). The percentage of gas R&D in the WBSO increased to 1.0% in 2009, while the share of applicants with gas projects in the WBSO was 3% (cf. table 1). It can be concluded that applicants are applying for relatively small projects.

4.3 R&D on different kinds of gasses

In figure 1, the R&D volume per year is classified into different types of gas such as biogas, syngas, LNG and CNG. In appendix 2, the definitions of the different gasses are given. Figure 1 shows that most R&D concerns natural gas and biogas.

Figure 2 shows the share of each kind of gas per year. It shows that the relative share of natural gas is decreasing, because the R&D volume per year has remained constant (cf. figure 1). The decrease can be explained by the total volume increase of gas R&D. This is also the case for LPG.

Biogas and syngas however have been increasing in volume and in share since 2007. LNG has a constant share meaning a volume increase in line with the total volume of R&D (cf. figure 1).

Figure 1 *R&D volume different kinds of gas per year.*

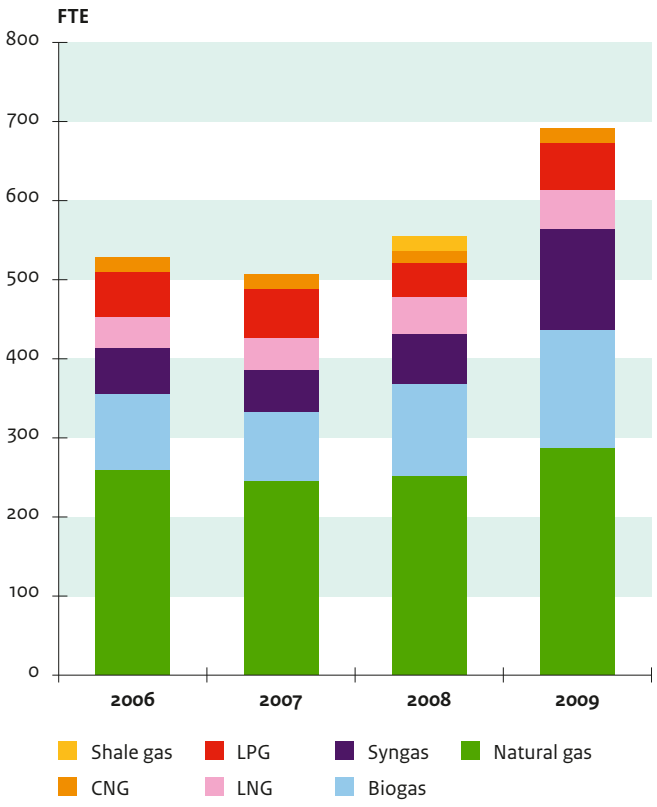
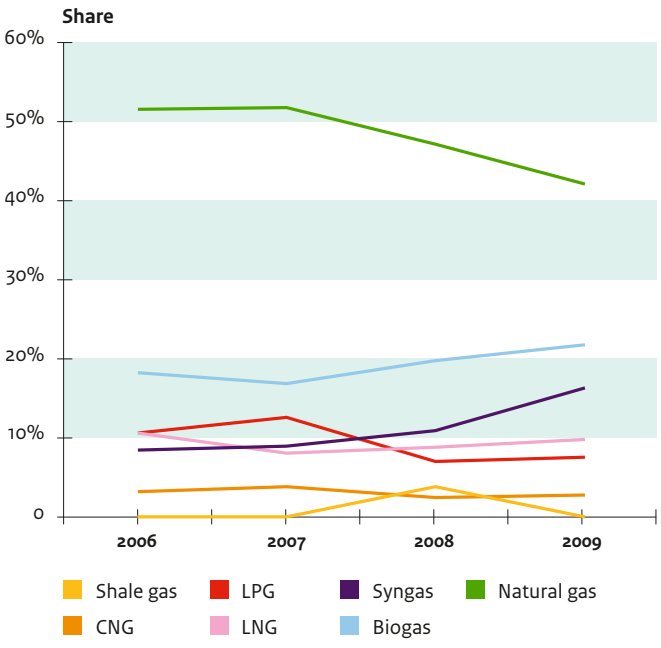


Figure 2 *Share of gas type per year.*



4.4 Gas technologies

Figure 3 shows the volume of gas R&D in FTE per year per technology. Appendix 3 provides the definitions of the different categories. Most R&D activities relate to gas treatment, gas engines, fermentation, gasification and gas pipes.

Figure 3 *R&D volume per technology per year.*

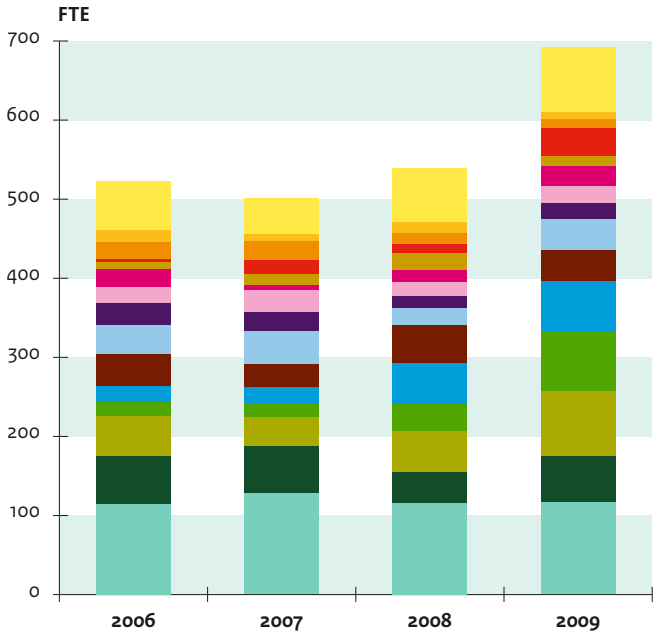
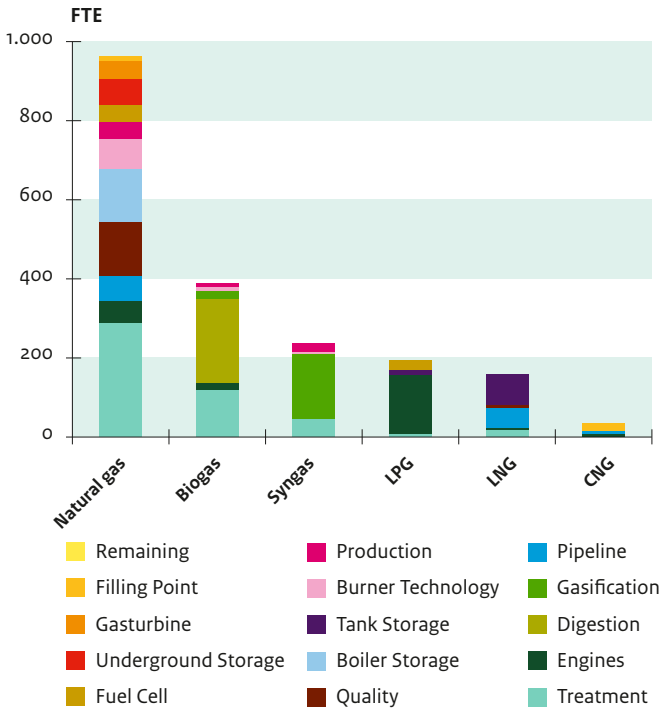


Figure 4 *Gas technologies per type of gas.*

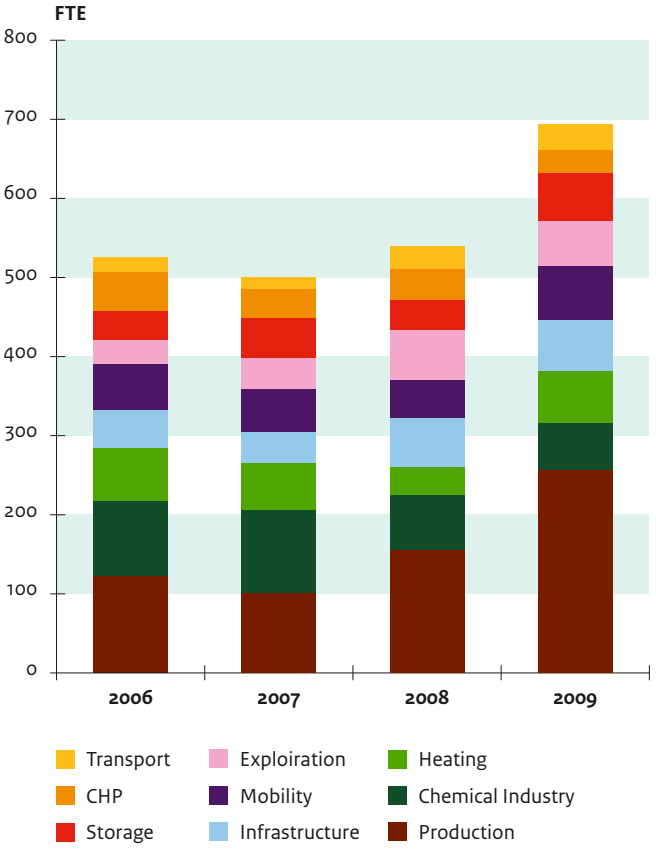


In figure 4 the different technologies are related to types of gas. Fermentation specifically relates to biogas. Gasification relates to syngas. Gas treatment relates to all kinds of gas.

4.5 Focus of R&D on components of the gas chain

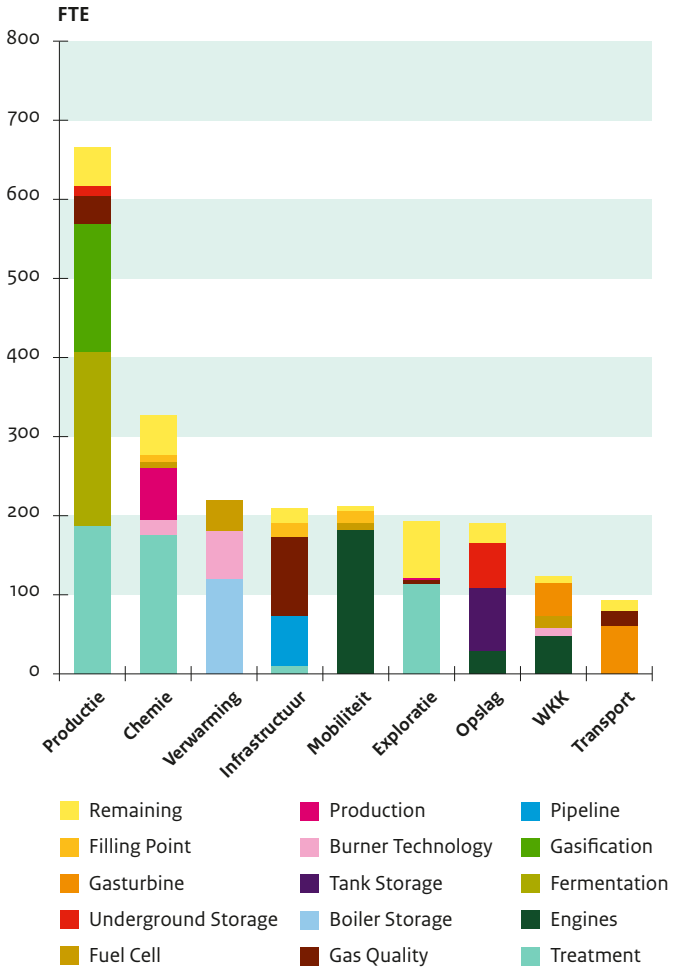
Figure 5 shows the volume of R&D focussing on the different components of the gas chain. The R&D mainly focuses on gas production and this share has almost doubled (from 24% in 2006 to 38% in 2009) and is responsible for the increase in total R&D over the years. This can be explained by the development of biogas and syngas production. R&D into gasses for chemical applications decreased from 19% in 2006 to 8% in 2009.

Figure 5 *R&D volume in the gas chain.*



In figure 6 the technologies for the different categories in the gas chain are shown. For the production of gas, the most relevant technologies are gas treatment, fermentation (biogas) and gasification (syngas).

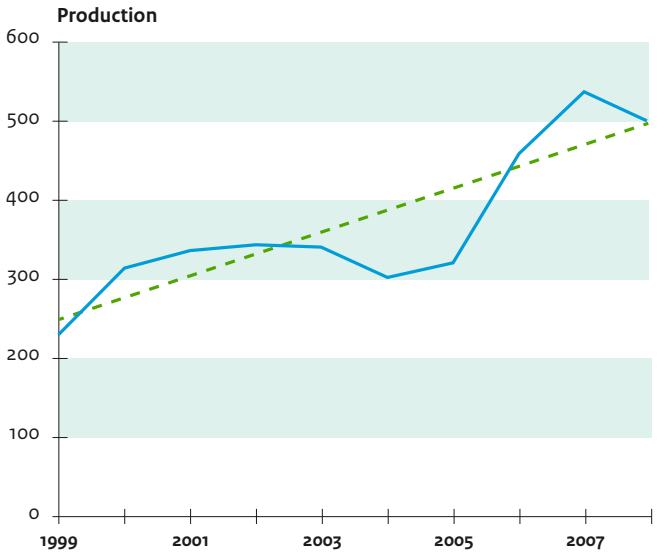
Figure 6 *Relevant technologies in the gas chain.*



The gas infrastructure projects mainly focus on the technology 'gas treatment', pipelines and fuelling stations. The largest R&D efforts focus on the production of gas. The technologies within this category are gas treatment (for example cleaning of biogas and syngas), gasification and fermentation. Gas treatment technology is also found in the category 'chemical', for example, in the development of Fischer Tropsch catalysts using natural gas as a feedstock.

The technology 'engines' is used in the gas infrastructure, mobility and CHP (combined heat and power). An example of a project in mobility is the development of injection systems for a dual fuel engine that runs on LPG or natural gas, and the development of a CHP engine running on biogas.

Figure 7 *Patents in oil & gas production.*



4.6 Dutch Patent position in gas technology

Oil & gas production

In the field of oil & gas production the number of patents slowly increased from 250 to 500 per year (cf. figure 7).
The Netherlands takes the third position behind the US and UK, mainly because of Shell and Schlumberger. Shell is the third applicant in the world in this field. Schlumberger however applies for patents in the Netherlands but conducts its research abroad whereas Shells has a large part of their R&D based in the Netherlands. Other applicants include Prad, LogiNed and Akzo Nobel. The international top players are Schlumberger and the big oil and gas producers.

Figure 8 *Patents biogas.*

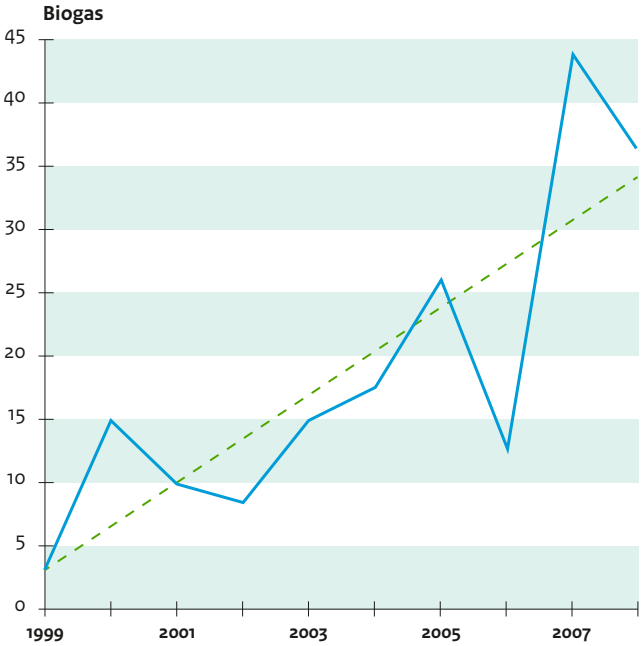


Figure 9 *Patents in gas composition.*

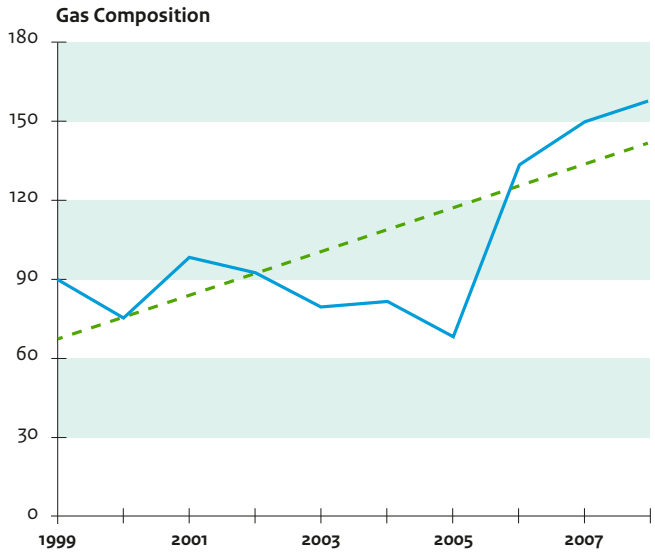
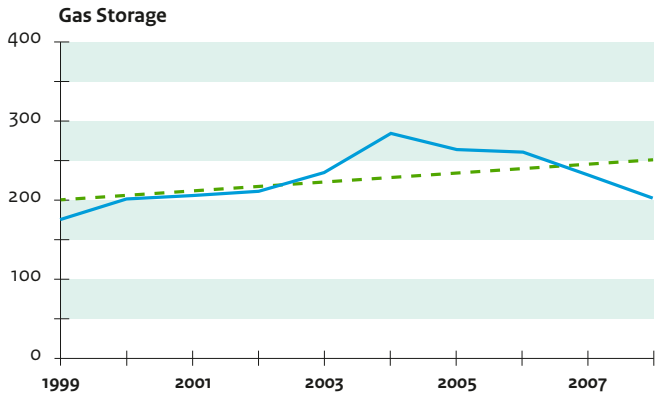


Figure 10 *Patents in gas storage.*



Biogas production
In terms of biogas production, the number of patents has significantly increased from 5 to 35. The Netherlands ranks fourth after Germany, the US and Italy. In the list of applicants, German companies hold the first three positions. Dutch patents were registered by Biothane Systems (#3), TNO (#2), Naco Int (#1), Orgaworld (#1), Pacques (#1) and Wageningen University (#1).

Gas composition
In the field of gas composition the number of patents is much higher. It has increased from 90 to 160 patents yearly.
Shell is mainly responsible for the fourth place of the Netherlands with 70 patents in total. Other Dutch organisations with patents are ECN, Twister, Akzo Nobel and DSM.

Table 4 *Main applicants of patents in gas pipes.*

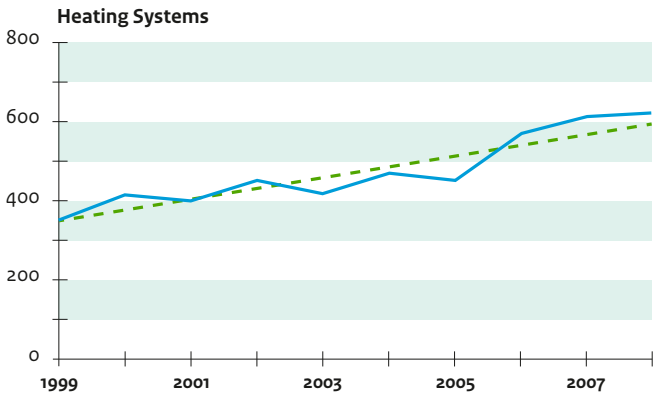
Applicant	Total
Shell	10
Akzo Nobel NV	3
Schlumberger Group	3
Twister BV	2
Biogast Sustainable Energy BV	1
DSM NV	1
Ecoplay Int BV	1
Philips NV	1
Petroleum Research & Development NV	1
Pipelife Nederland BV	1
Prad Research & Development	1
Schlumberger Technology BV	1
TNO	1

(Gas)pipes
The number of patents regarding (gas)pipes has remained constant over the years with about 70 patents per year. The Netherlands has the eighth position. The main applicants were Shell, Akzo Nobel, Schlumberger and Twister. Others are DSM, Prad Research & Development Ltd and TNO.

Gas storage
The number of patents in gas storage technology grew slowly and stays at around 225 patents per year (cf. figure 10). The Netherlands has the 11th position. The most important applicants are Shell, Philips and Blue Water Systems. Others are Avantium and Advanced Lightweight Construction Group. The international top applicants for storage technology are Air Liquide, Linde Ag and Air Production & Chemistry.

Heating systems
In the field of heating systems and water boilers using gas the number of patents grew steadily from 350 in 1999 to 600 in 2007 per year (cf. figure 11).

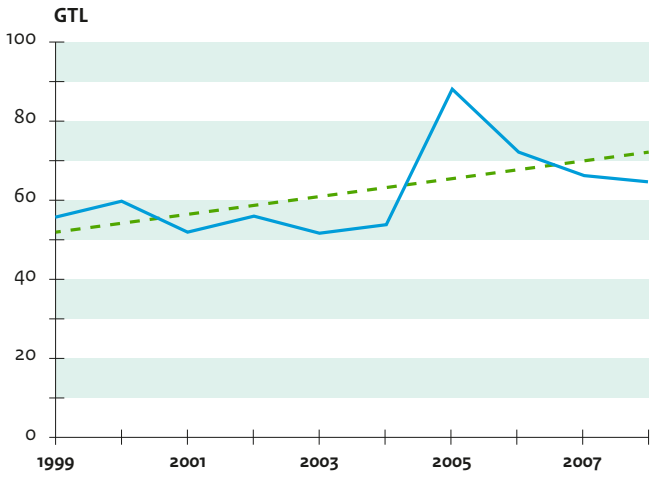
Figure 11 *Patents in boilers.*



The Netherlands has the ninth position with Shell, Philips, Flamco, Honeywell, Bekaert, Nefit and Gastec Technology as the most important players. Germany ranks first, followed by the US and Italy. In Germany the patents are mostly applied for by Bosch and Vaillant. Nefit owns Bosch and executes the development of Bosch HR boilers in the Netherlands.

Gas-to-liquid (GTL)
Patents on GTL technology grew slowly from 60 to 65 patents per year (cf. figure 12). There was a peak in 2005 with 90 patents.

Figure 12 *Patents on GTL.*



The Netherlands has an important second position because of Shell (ranking third internationally). The second Dutch applicant in this field is Albemarle (US company which bought Akzo Nobel Catalyst).

LNG
The number of patents on LNG grew slowly from 20 to 25 patents per year with a peak of 50 patents in 2006 (cf. figure 13).

Figure 13 *Patents on LNG.*

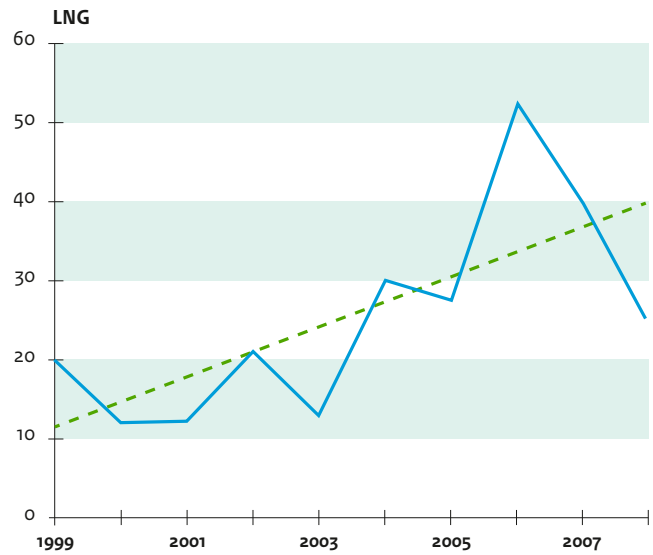


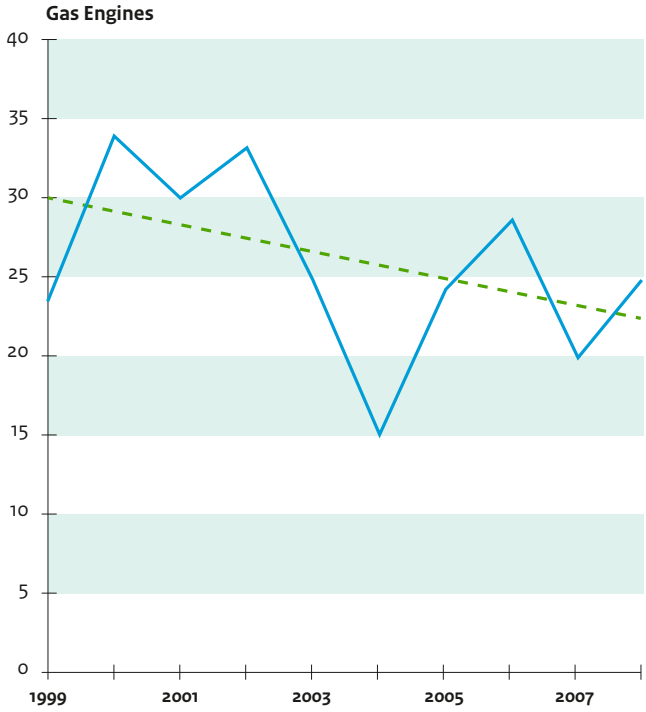
Table 5 *Top applicants in the field of LNG.*

Applicant	Country	Total
Shell	CA, NL	54
Conocophillips Co	US	25
Linde AG	DE	23
Air Production & Chemistry	US	14
Exxonmobil Upstream Res Co	US	14
Hitachi Ltd	JP	9
BP Oil Int	GB, US	7
Inst Francais du Petrole	FR	6
Chevron Inc	US	5
Statoil ASA	NO	5

Here the Netherlands holds the second position, entirely because of Shell, who also applied for the most patents on an international basis.

Gas engines
In the field of gas engines, the number of Dutch patents is maintained at around 25 patents per year (cf. figure 14).

Figure 14 *Patents in gas engines.*



The Netherlands has tenth position with Shell and Dropscone as the main applicants. The international leader is BMW Ag, Westport Power Inc and Toyota Motor Co Ltd.

5 Specific subsidy programmes for gas

This chapter provides an overview of the specific programmes supporting R&D and the deployment of gas technologies.

5.1 Stimulation instruments for research and sustainable energy

Projects on gas are mainly supported and subsidised via EOS, (OV) MEP and SDE. The EOS programme (Energy Research Subsidy) supports specific energy research projects. The (OV)MEP and SDE programmes only stimulate biogas projects for the production of sustainable electricity.

Figure 15 *Subsidies per instrument per year.*

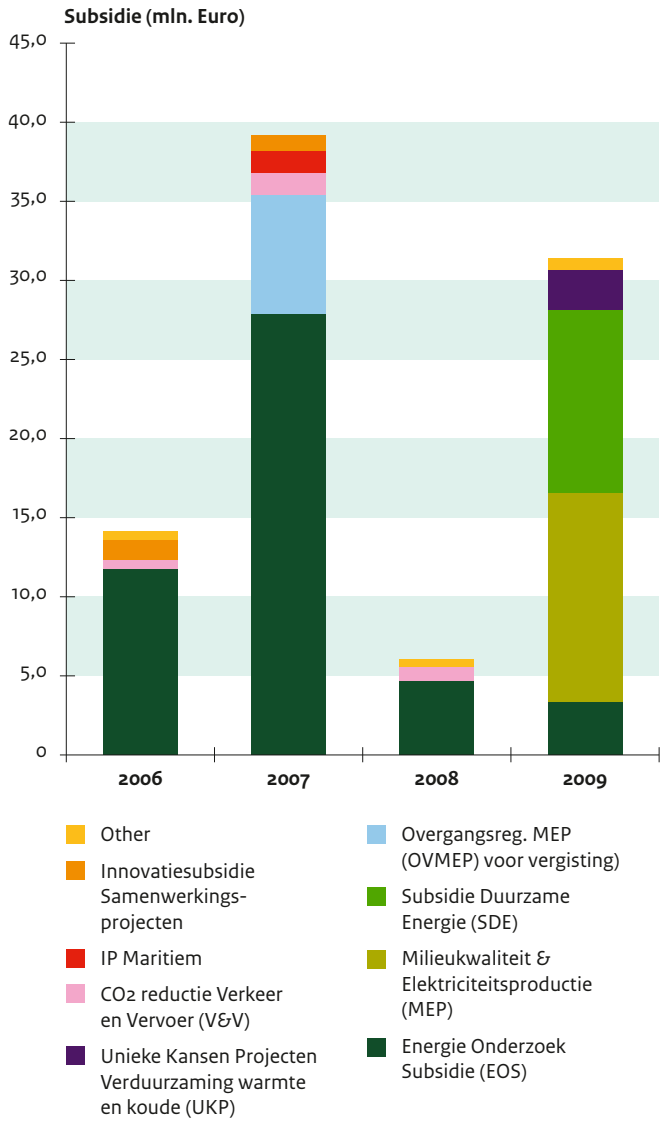
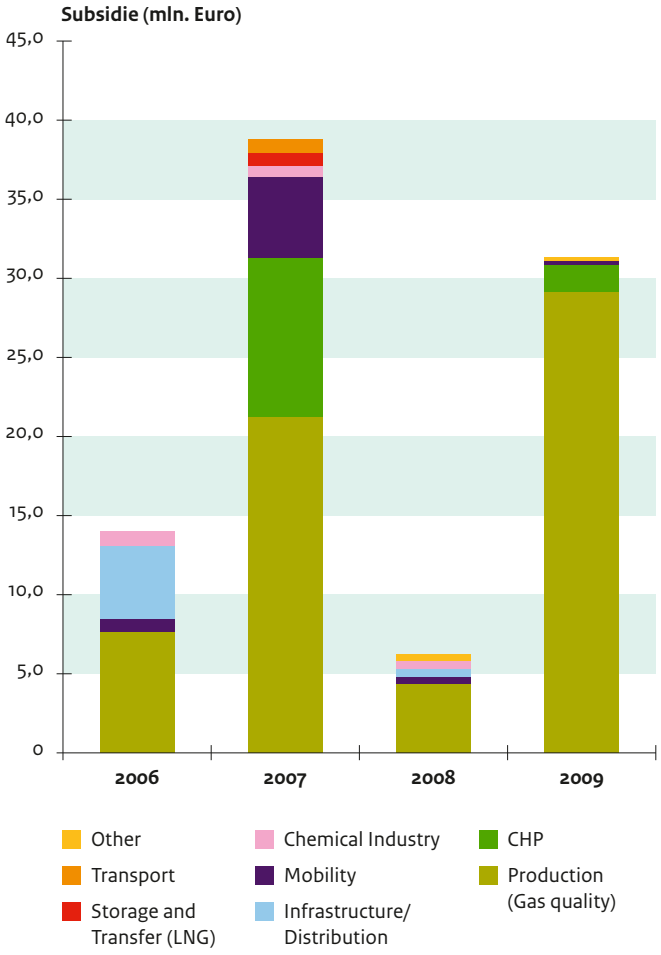


Figure 15 shows that the amount of subsidies for gas projects is not constant over the years. The EOS programme focuses on topics such as biomass, industrial efficiency, built environment, CCS, hydrogen and solar and wind energy. Projects are always clustered in one of these research themes. Gas technology projects can be found within Biomass projects (gasification, biogas) or in hydrogen production or, for example, in enhanced natural gas production using CO_2 injection (EGR).

5.2 Gas chain classification

The subsidised projects can be classified by their relevance for parts of the gas chain; cf. appendix 3 for definitions of the different categories. We have distinguished production, transport, infrastructure, storage & transfer and the use of gas in mobility, CHP and chemical industry (cf. figure 16). Most of the subsidised projects focus on gas production and CHP.

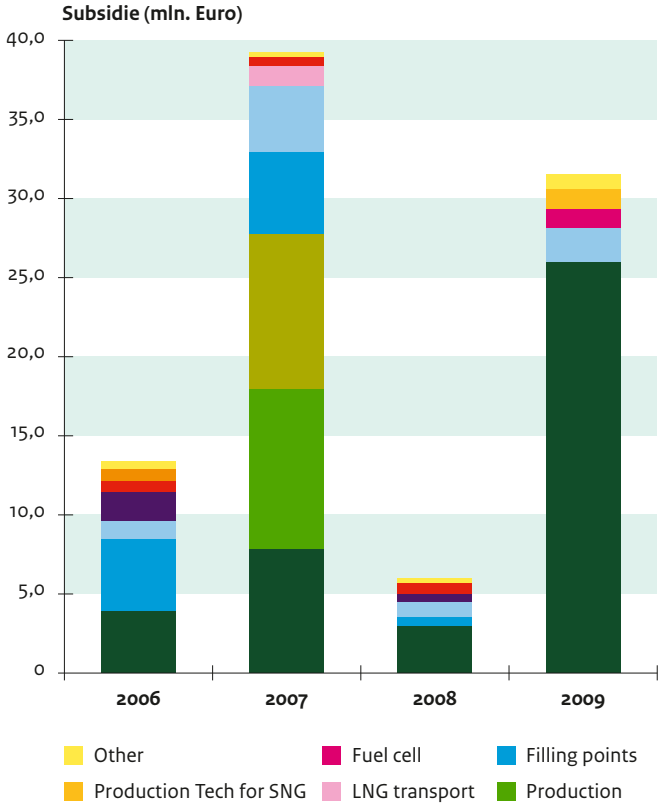
Figure 16 *Subsidies per part of the gas chain per year.*



5.3 Gas technologies and innovations

Figure 17 gives an overview of the subsidies per year per technology field.

Figure 17 *Subsidies per gas technology per year.*

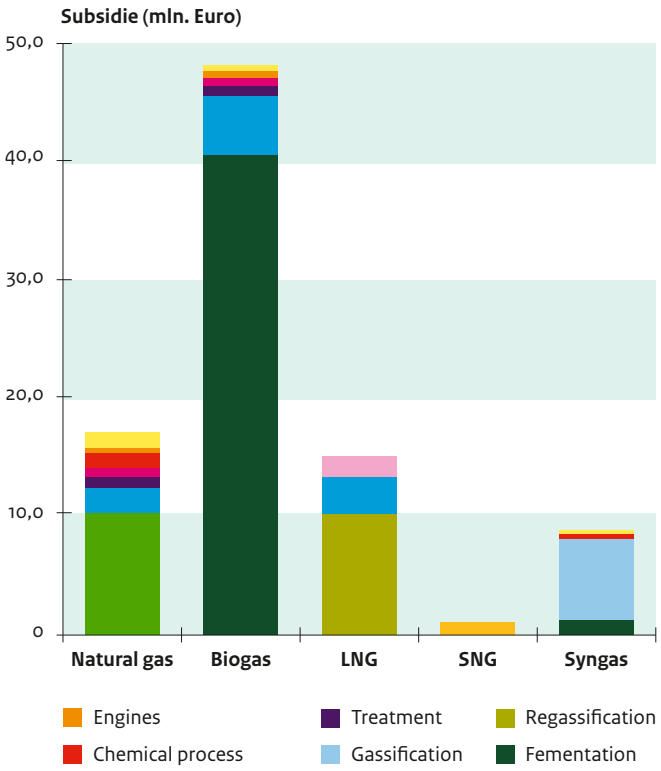


Most of the projects focus on the production of biogas by fermentation. In 2007, the categories production and re-gasification each concerned a single project of 10 million euros. There were specific projects on fuelling stations (filling points) for natural gas in 2006 and 2007.

5.4 Technologies per gas type

Figure 18 shows that biogas projects usually focus on fermentation and filling points. Natural gas or LNG projects usually involve re-gasification (only one UKP-project is involved).

Figure 18 *Different technologies per gas type.*



The subsidy for SNG concerns only two EOS projects on production technology for SNG (Milena-Olga technology). Syngas projects are mainly EOS-projects on the production of syngas by gasification.

5.5 Important partners in subsidised projects

About 50 organisations, mainly companies, participate in the projects. In table 6 the main applicants are listed.

Table 6 *Main applicants for subsidised projects.*

Organisation name	Organisation name	Organisation name
BiogaS International	Essent Warmte B.V.	Rolande LNG BV
Biogas Nistelrode	FMI Precision B.V.	Stichting Biomassa Vergassing Noord-Ned.
Biogas Plus	Gasunie Engineering & Technology	TNO
Cogas	Green Planet Holding B.V.	Science and Technology Holding B.V.
Crown Van Gelder N.V.	MAN Truck & Bus B.V.	SEQ Nederland BV
Energieonderzoek Centrum Nederland	N.V. Huisvuilcentrale Noord-Holland	Twister B.V.
Eissen Biogas BV	N.V. Nederlandse Gasunie	Universiteit Twente
ENECOGEN V.O.F.	NEM B.V.	Wageningen Universiteit

6 International R&D collaboration in EU FP7

The Seventh Framework Program funds gas related R&D collaboration projects via the themes Energy and Nano, and Materials & Production technology. Some projects are funded via a special SME programme. We have analysed all of the submitted projects (total list) and the approved projects on the so-called 'main list'.

6.1 Technology

In table 7 and 8 we have analysed the projects on the main list (approved projects) and the total list (submitted projects) in the different categories for technology and type of gas.

Table 7 *Overview of approved projects.*

Total subsidies	Typ e gas			
Technology	**Natural gas**	**Biogas**	**Syngas**	**Total**
Gas treatment	-	-	1.1	1.1
Gas turbines	-	-	1.0	1.0
Gas-to-Liquids (GTL)	0.8	-	-	0.8
Gasification	-	-	0.5	0.5
Fuel cells	-	0.5	-	0.5
End total (million euro)	**0.8**	**0.5**	**2.5**	**3.8**

The total grant for gas projects in FP7 is 3.8 million euro. Most FP7 grants are used for syngas projects. Gas treatment is also an important topic similar to the national R&D projects (cf. 4.4). The total list gives an impression of the main topics. Most R&D is related to biogas and syngas. However none of the biogas and only some of the syngas projects were accepted. Regarding syngas, the Gas To Liquids related projects are most prominent. A few LNG and SNG related projects were submitted but these were all rejected for funding.

Table 8 *Overview of submitted projects.*

Total subsidies	Type gas					
Technology	**Natural gas**	**Biogas**	**LNG**	**SNG**	**Syngas**	**Total**
Gas-to-liquids (GTL)	0.8	-	-	-	9.6	10.4
Fermentation	-	2.2	-	-	-	2.2
Gasification	-	-	-	-	2.1	2.1
CHP	-	-	-	-	2.1	2.1
Gas treatment	-	0.5	-	-	1.4	1.9
Feed in / mix	-	1.0	-	0.2	-	1.2
SNG production	-	-	-	1.0	-	1.0
Gas turbines	-	-	-	-	1.0	1.0
Fuel cells	0.4	0.5	-	-	-	0.9
Rest	1.1	0.5	0.2	-	-	2.8
Total	**2.4**	**4.7**	**0.2**	**1.2**	**16.2**	**24.7**

6.2 *Dutch participants in EU programmes*

A total of 44 Dutch companies and organisations submitted proposals. The organisations participating in more than one project are all knowledge institutes: ECN, TU Delft, TU Eindhoven, Universiteit Wageningen and TNO. The projectpartners are classified by technology in table 9.

Table 9 *Partners in approved FP7 projects.*

Number of projects	Technology					
Organisation	**Gas to liquids (GTL)**	**Gas burner**	**Fermentation**	**Syngas production**	**CHP**	**Total**
TU Delft	1	-	1	1	-	3
TU Eindhoven	1	1	-	-	1	3
ECN	-	-	-	-	2	2
Nuon	-	-	-	-	1	1
Avantes BV	-	-	-	1	-	1
Universiteit Utrecht	-	-	-	1	-	1
End total	**2**	**1**	**1**	**3**	**4**	**11**

6.3 *R&D collaboration in Europe*

In the funded projects the Dutch collaborate mostly with German, Italian and British partners. Others partners come from Greece, Sweden, Estonia, France and Belgium (cf. table 10).

Table 10 *Foreign partners in the submitted projects.*

Country	# participations
DE	56
IT	38
ES	32
UK	27
FR	24
BE	22
EL	21
SE	21
PL	18
DK	15
Other	88
Total	**430**

7 Trade missions and exhibitions abroad

The programme for Collective Promotional Activities (CPA) is a subsidy for collective trade missions and for participation in trade fairs abroad. The applicants are industry associations such as the IRO (Association for Dutch suppliers for the oil and gas industry), the FME CWN (Association of entrepreneurs in the technological industry) and the VGT (Association Gas Turbine).

CPA supports both Collective Fair Submissions (CBI) as well as Outgoing Missions (UM). Subsidies are relatively small (50,000-100,000 euro). CPA can be part of a 2g@there project which consists of different activities, such as collective fair entries and trade missions abroad. Table 11 lists all CPA projects regarding gas technology.

Table 11 *List of CPA projects.*

Applicant	Project title	Year	Subsidy (x1000 euro)
IRO	CBI Olie&Gas Kazakstan (Kioge)	2006	0
IRO	CBI Olie en gas Iran	2006	39
FME-CWM	UM Olie- en gasindustrie Canada	2006	93
FME-CWM	UM Energie en watervoorziening Kazachstan	2006	66
VGT	CBI + OV 20th. World Energie Congress, Italië	2007	119
IRO	CBI ADIPEC VAE	2007	73
VGT	CBI Energie, Maleisië	2008	51
Netherlands-African Business Council (NABC)	UM Olie & gas/ Infra, Angola	2008	103
IRO	CBI Olie & Gasindustrie, Maleisië	2008	48
IRO	CBI Olie & Gasindustrie, VAE	2008	56
FME-CWM	UM Gas en Olieindustrie, Egypte	2008	59
VGT	CBI PowerGen Asia 2009, Thailand	2009	47
FME-CWM	UM Olie-en Gasindustrie, Algerije	2009	67
VGT	CBI Power Gen 2010, Singapore	2009	52
IRO	UM Olie- en Gasindustrie, Maleisië	2009	17
Koninklijke Metaalunie	UM Metaalsector, Oekraïne	2009	60
IRO	CBI Olie en Gas, Australie	2010	85
NCH	UM Gaswinning, Egypte	2011	51
KURT Int.	UM Gasindustrie	2011	31
Total			**1.117**

Table 12 lists organisations that have participated three or more times in a CPA and includes a short profile.

Most companies are suppliers of gas related technologies. The organisers of the missions are IRO, FME and VGT.

Table 12 *Organisations participating >3 times in CPA's.*

Organisation	# participations	Profile
Petrogas Gas-Systems	8	Gas installations, metering & regulation stations, dehydration, LPG systems
Aarding Thermal Acoustics	7	Gas turbine exhaust and acoustical systems
NEM	6	Boilers, dampers, diverters, heat recovery steam generators
Stork Turbo Blading	6	Expander, turbo charger, compressor and turbine blades.
Power Piping International	5	Piping systems, polyurethane pipe support for LNG
Van Heck	5	Water control and movement, high capacity/pressure pumps, dredging
Bronswerk Heat Transfer	4	Heat transfer systems, fluid-flow systems, gas extraction, transport, storage, LNG vaporiser
Mokveld Valves	4	Valves for oil and gas industry (e.g. chokes, check valves), production, transmission and processing
Rosen Europe	4	Inspection and cleaning tools for pipelines, coiled tubing, tanks
Stork Thermeq	4	Boiler systems, de-aerators, gas turbine inlet cooling, burners
Van Beest	4	Standard fittings for chain and steel wire rope, high tensile shackles
Brush HMA	3	Generators for gas, steam or hydro turbines, turbo-generators
Gemco International	3	Maintenance and repair workshop facilities, warehousing, training, education
Hilarius Haarlem Holland	3	Welding consumables for unalloyed and low-alloyed steel, aluminium and non ferrous materials
NMI Certin	3	Independent testing and certification institute, metrology services
B.J. Többen Beheer (Task Environmental Services)	3	Drilling, rental of solids control equipment
Burdock Project Consultants	3	Interim professionals, consultancy oil & gas maintenance and offshore
Dovianus B.V. (Dopak)	3	Sampling systems for liquids, gases, liquefied gases and solids
Energetic Cleaning Technologies	3	Cleaning of industrial boilers, pipes, condensers, tanks, reactors
Frames Energy Systems	3	Oil & gas treatment, separation, heat exchangers, flow control
N.V. Kema	3	Energy consulting and testing, certification
PECO Special Fasteners	3	Fasteners (bolts, nuts, washers)
Sulzer Turbo Services Venlo	3	Service, parts and maintenance for gas and steam turbines, generators, expanders
Tideway	3	Offshore dredging, landfall construction, pipeline stabilisation
Tri-O-Gen Group	3	Use of waste heat from motors and gas turbines

Appendix 1: Short overview of Dutch gas policy and trends

The transition from conventional fuels to renewables will take at least a few decades and natural gas will play an important role during this transitional period. Natural gas has the lowest CO_2 emissions of all fossil fuels and gives more flexibility in our electricity production system. This is important if we are to become increasingly dependent on non-continuous, sustainable energy sources such as wind and solar systems. There is a growing consensus on the crucial role of gas in our energy mix:

- it is a crucial sector of our economy;
- it can help us meet our climate goals;
- it can help guarantee energy supplies for the future.

The Dutch gas sector has a large innovative potential. Promoting and supporting relevant new initiatives for cooperation between knowledge institutions and the gas sector will develop a strong knowledge infrastructure. More knowledge development, innovation and valorisation are crucial aspects in our gas policy which incorporates the Gas Hub strategy, the Energy Report 2011 and the new Top Sector policy. Regulatory barriers hindering for example biogas projects may be removed by the newly developed Green Deal policy. These policies are summarised in the following paragraphs.

Top Sector policy on Energy and the Green Deal

Innovations and new technologies are important for the position of gas in our future energy mix. The Netherlands has been one of Europe's key gas producing countries for 50 years. As a result, we have a relatively well-developed, knowledge infrastructure in this sector. New technologies will allow the Netherlands to explore and exploit new fields and new varieties of gas. New gas applications will be developed and this will generate increased economic activity. Fostering game-changing innovation is an essential part of the new Top Sector policy. The gas industry has been selected as one of the main topics in the Dutch 'Energy' top sector[3]. Stimulating cooperation between the gas industry and knowledge institutions and expanding R&D efforts related to the gas hub have been mentioned in order to optimise the benefits of our natural resources. LNG is also mentioned as a topic in the Top sectors of Water and Logistics.

The former Shell CEO Jeroen van der Veer led the top sector team on Energy. Two proposals were presented:

1) a new fiscal instrument for capital investments to stimulate the private sector to make more use of applicable innovations developed by technological institutes and universities,
2) the formation of a steering group involving people from the private sector, academia and the government, to foster investments in innovations.

The Minister has asked the gas sector to propose a Innovation contract involving RD&D from companies and knowledge institutes starting in 2012. The Innovation Contract Gas was signed in April 2012. In August 2012 the foundation TKI Gas has been founded. The first TKI GAS projects will start early september 2012 focussing on: Upstream, Small Scale LNG, Green Gas, Societal Aspects and Power to Gas / Gas to Energy.

The Green Deal policy aims to help people, companies, municipalities, and other parties realise their energy projects. The Green Deal policy is still evolving. Several gas initiatives have been touched upon, including biogas production in the North of the Netherlands and a biomass gasification initiative in the province of North-Holland.
The Green Deal policy is not a subsidy but a cooperative method which aims to remove the barriers that hinder projects and prevent them from materialising. The government will try to:

- connect parties;
- share knowledge;
- change any laws that hinder progress in this regard.

In June 2012 the Minister signed a Green Deal with industry focussing on removing the barieres and the implementation of LNG as transportation fuel for shipping and transportation.

Energy Report 2011

The government of the Netherlands gave gas and the gas hub strategy a central position in the Energy Report 2011 that was sent to the House of Representatives in June. A central aim of the energy policy is to realise a "new style" industrial policy. The development of the gas hub is one of the two main pillars of this new style industrial policy. In the Energy Report 2011, the government of the Netherlands accentuates the following:

To strengthen the Gas hub we should:

- maintain the level of production;
- enable development of gas storage infrastructure;
- optimise and enlarge transport capacity;
- support innovation and knowledge development.

Important policy actions that we are considering or implementing are:

- the need for investments in regulated infrastructures;
- adaptations to the Gas law to make cross-border investment participation possible to foster the North-western European market;

3 *Energie in beweging: advies topsector Energie, Jeroen van der Veer, June 2011, www.top-sectoren.nl/energie.*

- the aim to allow minority privatisation of the grid to attract new capital;
- economic diplomacy being an integral part of the energy diplomacy.
- to support initiatives on test, technology and knowledge buildup around the theme LNG.

With this new policy, gas investments and infrastructure are firmly anchored in our present and future energy system.

Gas Hub policy

The Netherlands is entering a new era in which it needs to reconsider its strategic options for its position within the Northwest European gas market. Although the Netherlands is still the main producer of gas in the European Union, its production has matured and gas reserves in both the Groningen field and small fields are decreasing. Also, international climate policies and objectives focused on significantly reducing CO_2 emissions (by 80% or more) in 2050 and improving energy efficiency are changing the energy mix of the Netherlands and other European countries.
These developments and a perceived lack of visibility of gas in the debate on future energy systems require a new strategy for gas and the position of the Netherlands in the gas market.

The Netherlands has a number of competitive advantages allowing it to become the centrepoint of the North West Gasrotonde (gas hub). Opportunities can be identified in:

- a gas transport network that is of the very best quality and is well connected to networks in our neighbouring countries;
- the coastal location, making it relatively easy to transport LNG;
- diverse options for developing underground storage in exhausted gas fields and salt caverns;
- the current market position of The Netherlands with a number of large producers and vendors of natural gas;
- the virtual trading place TTF and the merged gas markets APX and Endex;
- an open gas market that makes investment attractive (also for foreign parties);
- a huge number of parties that are active in The Netherlands within the sphere of gas: shippers, national and international energy distribution companies, (foreign) gas producers;
- a substantial gas sector with a great deal of expertise.

The Gas Hub policy embraces a long-term vision on the role of gas as energy source; gas being a core element in the future energy mix due to its low carbon footprint, flexibility and availability.

Economic potential of the gas sector according to the Brattle report
The Brattle Group has used a model simulating the Dutch economy to estimate that the Dutch gas sector currently supports about 11,600 Full Time Equivalent (FTE) jobs directly, 31,500 indirectly and 23,300 induced jobs (jobs created as the gas sector interacts with the rest of the Dutch economy).
The value of goods and services produced around the Dutch gas sector is about €41 billion, about 7% Dutch GDP (2005). The gas sector contributes a total of €16.7 billion in final demand each year, about 3% of Dutch GDP in 2009. Gas exports from the Netherlands were valued at €14 billion and €10 billion in 2008 and 2009 respectively, which represented around 3-4% of the value of all Dutch exports.

The Brattle Group also reported on the economic potential of the Dutch gas sector simulating the Gas Hub scenario involving an additional €7.7 billion of investments. The Gas Hub scenario could create up to 136,000 FTE job-years, and €21.4 billion of additional goods.

Brattle concludes that the Netherlands has an excellent geographic position and regulatory and gas infrastructure which make it an attractive place to invest in transit pipelines and import gas via pipeline and LNG terminals. The existing R&D initiatives in the Netherlands and the geographic nexus of industry expertise and university-based research are a strong advantage. The Netherlands could capitalise on these initiatives and focus on a growth areas such as biogas, which could be used as a platform for future exports and growth. However, once initial R&D work is done, the market should be left to decide which technologies will ultimately be successful.
The Netherlands can use all of these advantages to implement a Gas Hub strategy that could, in turn, successfully stimulate the economy and create jobs. There are some risks such as the volatile nature of gas demand in neighbouring markets and competition from other EU Member States in developing similar gas-based services, however, none of these risks negate the attractiveness of the gas hub strategy.

The Dutch government considers strengthening the economic dimensions and the earning potential of the energy sector as important goals (cf. the Coalition Agreement of 30 September 2010). The further development of the Gas Hub will make a substantial contribution towards this goal.

Public awareness and safety
Allthough not in the Netherlands, still the accident with the BP Deep Water Horizon in April 2010 raised public awareness concerning the safety and risks of onshore and offshore installations.

Unconventional gas
The future of unconventional gas in The Netherlands is uncertain. The presence of this gas has not yet been proven and exploration still has to be initiated. . Some concessions have been granted and several locations are planned to be explored. Even in case the presence of this gas is demonstrated, the transition towards a production phase depends highly on public acceptance of the activity. Societal unrest has grown because of reports of ground water pollution in the USA and the occurrence of minor earthquakes near a shale gas exploration site in the UK. The Minister of ELI has asked State Supervision of Mines (SSM) to investigate the matter before any irreversible steps are taken.

In an ongoing effort, research is being done to enhance and expend the production of mature gas fields. A new trend is small scale, low cost reusable production equipment for the development of small gas fields and low-cost drilling facilities.

The Gas Hub Consultative Platform
The ministry of Economic Affairs, Agriculture and Innovation instituted the 'Gas Hub Consultative Platform' for consultation and cooperation with the gas industry and research institutes. The platform provides a forum to align and discuss new initiatives and strategic issues. The primary objective of the Consultative Platform is to facilitate the development of the Gas Hub through:

- coordination, strategic discussions and exchange information;
- engaging the business community in policy development;
- initiating cooperation and promoting the multi-year Gas Hub action plan.

The first meeting in February 2010 resulted in the formation of four working groups focusing on four important topics of the Gas Hub policy:

- the role of gas in the energy mix of Northwest Europe;
- the development of the Northwest European Gas Hub;
- the Dutch mining climate;
- a shared gas communication strategy.

Each working group encompassed representatives from the companies and organisations participating in the Gas Hub Consultative Platforms. In November 2010, each group produced a working paper containing the actions and recommendations concerning the specific topics. The companies involved in the working group on Mining policy are currently developing new ideas and generating knowledge and innovative ideas for new technologies.

International developments and security of supply

The Netherlands is linked with the surrounding countries via the international connected gas network, enabling an international gas market to function. In 2008 Dutch gas production accounted for 36% of EU gas production (Eurogas, January 2010, 'Statistics 2008').

The two Russian-Ukrainian gas crises in 2006 and 2009 convinced many of the strong connection between geopolitics and natural gas. A notion of scarcity and security of supply had been dominating the public and political debate on energy and the crises caused higher natural gas and LNG prices for a short period of time.

A glut of natural gas has since emerged due to decreasing global energy demands as a result of economic recession and increasing production of unconventional gas in the USA. The glut in the supply of natural gas has led to lower prices.

European gas consumption will increase by over 40% by 2035 and more and more power plants will rely on natural gas. Both gas demand and supply have already increased dramatically in recent years.

Together with these international market developments, events such as the uprisings in North-Africa and the Middle East and the tragic earthquake in Japan have had a huge impact on the way governments look at the energy mix and the role of natural gas. The energy plan presented by Chancellor Angela Merkel at the end of May is one example of the results of this impact and events that affect worldwide prices of LNG and pipeline gas.

In the coming decades, Dutch gas stocks will reduce and the level of imported gas will increase. As a result, North West Europe will demand increasing levels of gas from Russia and Norway and LNG from other parts of the world. Energy policy focuses on supplier diversification, transport routes and sources which will prevent The Netherlands becoming dependent on one type of energy, one country or one company.

There is no blueprint for the gas mix of the future. The market will invest and determine the gas mix that will probably encompass the following gases by 2030:

- Dutch natural gas (Groningen and small fields),
- Russian gas via North Stream pipe line,
- LNG (global),
- Norwegian gas,
- Biogas from fermentation and gasification of biomass.

International Energy Agency: Golden Age of Gas

The International Energy Agency (IEA) expects that the 21st century will be 'the Golden Age of Gas'. Based on the assumptions of the GAS Scenario, from 2010 onwards gas use will rise by more than 50% and account for over 25% of world energy demand in 2035.

The factors that drive natural gas demand and supply increasingly point to a future in which natural gas plays a greater role in the global energy mix. Global uncertainties afflicting the energy sector can be seen as opportunities for natural gas. It can help to diversify energy supply, and so improve energy security. It can provide the flexibility and back-up capacity needed as more variable capacity comes online in power generation.

Despite of the public perception the global natural gas resource base is vast and widely dispersed geographically. Conventionally recoverable resources are equivalent to more than 120 years of current global consumption. Unconventional natural gas resources are now estimated to be as large as conventional resources. It must be noted that these unconventional resources are located in areas which in general are different from the 'classical' gas areas such as Russia, Europe, West Africa and the Middle East. They occur in North America, China, Australia, South and Africa. This changes the gas market.

The scenario indicates a 'golden age' of gas but, despite the benefits mentioned, there will always be uncertainties regarding lower economic growth, greater cost or other obstacles to unconventional gas production, higher achievements in energy efficiency and

changes that improve the relative competitiveness of other fuels. Uncertainties, however, can also work conversely and help push gas demand even higher.

As a country that has been producing gas for over half a century, the bright prospects for gas and the predicted `Golden Age´ are good news for the Netherlands. Over the past few years, billions have been invested in the Netherlands in the exploration and production of gas, in transport infrastructure and in gas-fired power plants. These investments are transforming the Netherlands into the central hub for Northwest Europe.

The IEA Committee on Energy Research and Technology (CERT) published the paper entitled "Gas beyond 2020" which concludes that views on the role that gas could play in the energy mix have now changed. Natural gas is increasingly being identified as the solution for the transitional period to 2050.

Replacing ageing coal-fired power plants with state-of-the-art gas-fired power will reduce CO_2 emissions. Bio-based methane can also be used in place of natural gas in existing plants and pipelines. Natural gas could also contribute towards decarbonising the transport sector as natural gas (CNG or LNG) has the lowest emissions of greenhouse gas, particulates, and pollutants.
The CERT concludes that more R&D is needed to improve our current set of technologies as well as continue basic research into new areas. No single energy source currently available will solve all problems such as costs, public acceptance, performance, environment, and safety issues. It is clear that further R&D is needed to lower costs and improve efficiencies of existing energy technologies.

Innovating the gas sector

Cumulative production of natural gas from the Netherlands passed the 3,000 billion cubic metres mark in 2010. At the same time, the volume of prospective resources remains at around the same level as before, albeit that the average field-size in this class is orders of magnitude smaller, often below the current economic cut-off volume for development. There are clearly some major challenges ahead to add more reserves and maintain production at high levels.

New technologies are needed to maximise production from the maturing gas fields; new gas fields must also be found to maintain current production. New, more efficient technologies could make the exploitation of new (small) gas fields economically interesting. The Dutch government is trying to stimulate innovation and cooperation via TNO's research programme, its ownership of EBN, and also promotion of innovative exploration via the license policy for gas exploration and production.

Gas research programme TNO 2012
The Ministry of ELI has tasked TNO with using its annual budget to contribute towards the gas hub policy. The following policy-based issues play a role herein:

- How can we safely get the most from the Dutch gas stocks/fields?
- How can we ensure the transition from the currently used low calorific Groningen gas to newly imported high calorific gas runs smoothly and what are the consequences for infrastructure?

This is further elaborated in the following research lines:

- Encouraging and developing innovative techniques for (extending) the production of mature gas fields in close cooperation with NOGEPA, the branch organisation of Dutch gasproducers.
- Researching new aspects of gas in non-conventional fields in close cooperation with EBN.
- Developing strategies in order to expand gas storage capacity and supporting social debate from an independent standpoint with facts regarding shale gas.
- Evaluating and researching the policy in relation to reliability and the safety of installations, pipelines and process installations.
- Inventorising the risks, environmental impact and essential infrastructure that correspond to the potential production of unconventional gas in The Netherlands.
- Charting the technical implications of the conversion of NL infrastructure and consumer specifications from low calorific Groningen gas to new types of gas. Studying strategies and consequences for user-groups.
- Reinforcing and combining Dutch expertise in the field of LNG. Setting up and expanding the LNG TR&D foundation in collaboration with Dutch industry and technical Universities (3TU).

EBN
EBN is active in the exploration for, production of and trade in oil and gas in the Netherlands. Together with other national and international oil and gas companies, EBN invests in exploration and production and in gas storage facilities in the Netherlands. EBN seeks to promote cooperation between the supply industry, government and academia in order to advance knowledge and technology. Turning maturing resources into reserves in the offshore focus areas is one of the challenges ahead. Activities to extend field life, along with exploration and the development of challenging reservoirs, will be needed to counter the declining production from identified resources.

License policy for gas exploration and production
The Ministry is responsible for permissions and licensing in relation to the exploration and exploitation of gas fields. Important aspects are safety and environmental issues, such as subsidence and ecological situations. The Ministry is advised by TNO, EBN (Energie Beheer Nederland), the Mining Council (Mijnraad) and State Supervision of Mines (SSM).

Small fields policy

The government's small field policy was introduced in 1974. The Gas law stipulates that gas producers can sell gas at a certain pace, under reasonable conditions and in conformity with market prices to GasTerra (buying guarantee). In addition, Gas Transport Services

(GTS) is bound to transport gas from small fields. This also ensures that the balance function of the Groningen field can be continued as long as possible.

Sustainable gas supply – stimulating biogas production

Biogas can contribute to a sustainable gas supply. At the moment the amount of biogas produced in the Netherlands is small, but the government is stimulating development by means of energy innovation and biogas production subsidies. Treated biogas can be injected into the existing gas grid to partly replace fossil natural gas. In order to guarantee sustainable production, the biogas producers receive special certificates (Vertogas, est. 2009). The production of biogas is stimulated via the "Subsidie Duurzame Energie" (SDE) programme.
The first SDE+ call was executed in July 2011. About 65% of the available 1.5 billion euros will be spent on biogas projects.
Six applicants requested a total of 90 million euros for biogas hub projects. Twenty six applicants requested a total of 930 million euros for biogas production using digesters.

Gas quality: transition to future gas composition

The Netherlands, as a gas exporting country, is used to natural gas with a very constant composition. The Netherlands has two different gas grids: the low and the high calorific gas grid.
The Slochteren gas field produces a low calorific natural gas that is distributed and used by nearly all households and about 80% of industry. Large industrial gas consumers are connected to high calorific gas that is produced by offshore gas fields.

Due to the rising amount of imports from different gas sources, LNG and the production of biogas, the composition in the high and low calorific gas grids will fluctuate. To safeguard effective transition towards future gas qualities, the Ministry of Economic Affairs, Agriculture and Innovation has initiated a project group called 'Projectbureau Nieuw Aardgas'. This project group will support the transition towards a more flexible system.

Dutch 'gas building'

This so-called gas building is a public/private collaboration, which began in 1963, between four partners for the exploitation of the Groningen gas field which is founded on two pillars. One pillar concerns production which is operated on the account and risk of the Maatschap Groningen (NAM 60% and EBN 40%) by the Nederlandse Aardolie Maatschappij with a 50% Shell and 50% ExxonMobil shareholdership. The second pillar concerns the sale of the produced gas which is now executed by GasTerra. EBN has a stake of 40% in the Maatschap Groningen. GasTerra is owned by EBN (40%), the State directly (10%), Shell (25%) and ExxonMobil (25%).

National trends and developments

A literature scan was conducted to identify significant trends and developments.

Gas exploration and production
A new trend is small scale, low cost reusable equipment for the development of small gas fields (on and offshore).

Gas infrastructure
Lower gas transport tariffs, a slow economy, the uncoupling of market prices for oil and gas and the possible presence of unconventional gas are factors that may affect future investments in gas infrastructure. Several R&D projects and institutes are exploring the possibility of making gas infrastructure more flexible with respect to different kinds of gas such as syngas, hydrogen, LNG, unconventional or biogas. This can be achieved by making the infrastructure hardware suitable for all kinds of gasses or via a smart ICT-controlled gas grid: a 'smart gas grid'.

Gas Storage
Thanks to the huge Groningen gasfield, The Netherlands can currently deliver flexible gas. This does not just take place within The Netherlands itself, but also in our neighbouring countries (within a range of about 500 km). This is of huge added value because, as a result, we are able to meet the various gas demands of end-users in every season. The flexibility in production levels of the Groningen gasfield, however, is diminishing. Substantial investments in gas storage are vital in order to be able to fulfil fluctuating gas demands in the long term. New strategies must be developed to enlarge the gas storage capacity, optimise the use of empty gas fields and further investigate CO_2 storage combined with enhanced natural gas recovery.

Gas composition and gas treatment
In the long-term, as a result of LNG import, biogas feed-in and future gas imports from Norway and Russia, the Dutch industry and households will experience changes in gas composition.
A policy has been made requiring investments from all parties concerned. The following agreements were made[4]:

- Shippers will refrain from importing gasses with a very different gas composition during the transition phase,
- The LNG terminal will minimise gas composition changes with careful tank management,
- Gas Transport Services will blend nitrogen into gas to control the calorific value and will set-up a system to provide local gas composition data to the industry,
- The industry will adapt their processes to be able to use all kinds of imported gasses.

Future Dutch gas grid and gas appliances will have to be flexible with respect to the composition of the gas distributed. Many companies will aim to develop low cost gas treatment technologies and gas composition control technologies.

4 *Kamerbrief ELI, "Rapportage inventarisatie gevolgen transitie nieuw aardgas voor H-gasgebruikers," 14 juni 2011.*

LNG
The Netherlands is on the eve of a big shift in its natural gas supply. The Gate LNG Terminal is currently operational and feeds gas into the grid. The direct use of LNG as a transport fuel for inland shipping or trucking has been studied by TNO and is being put into practice by a small number of companies. Engines fuelled by LNG/diesel emit less CO_2 and hardly any SO_x, NO_x and particle matter compared to engines fuelled by (marine) diesel fuel. Several companies have started to promote LNG as transport fuel as it can meet the most stringent emission requirements for both trucking and shipping. All electric is for trucking or shipping not an option. It is expected that in the near future more R&D will done on small scale use of LNG.

Biogas
The production of biogas is increasing. Many local governments are investigating in combinations of biogas production and the use of biogas for their municipal vehicles. In the North of the Netherlands the production of biogas is starting to take shape with so-called Biogas hubs. Issues with the gas quality and feed-in gas specifications may however slow down this growth and low cost gas treatment technologies are needed to ensure that biogas remains a commercially sound alternative.

Northern and Eastern parts of the Netherlands are focussing on the production of biogas via digesting. The province of North-Holland strives to develop expertise on biomass gasification.

Gas for mobility
Municipalities, Water Authorities and wastewater treatment operators are investing in natural gas fuelled vehicles. Despite subsidies, media attention and the available technology, the use of natural gas has not yet increased dramatically however the use of LPG has been decreasing for years.

Central heating boilers
The Netherlands has a strong position in terms of high efficiency central heating boilers for households. Nefit (Bosch group), Intergas, Remeha and Itho are important players, and are working on micro CHP technologies. The deployment of micro CHP boilers or fuelcells in households, however, has not yet met expectations. High costs, lower subsidies and an expected decrease in the future household heat demand seem to have slowed down deployment.

Liquefied Petroleum Gas (LPG)
The LPG market has been slowly decreasing for years. Dual fuel (LPG/diesel) engines for trucks have been developed by several companies but are not yet commonly used. A change in the LPG trend is not expected in the coming years.

Synthesis gas
Synthesis gas is regularly discussed in (news)papers or policy documents and has remained a topic of a great deal of research. Large-scale experimentation or deployment is not expected in the coming years in the Netherlands.

Appendix 2 Definitions of different types of gas

Natural gas
Natural gas is a gas consisting primarily of methane, typically with 0-20% higher hydrocarbons (primarily ethane). It is as a fuel and a major feedstock for fertilisers. Before natural gas can be used as a fuel, it must undergo processing. The byproducts from that processing include ethane, propane, butanes, pentanes, and higher molecular weight hydrocarbons, elemental sulphur, carbon dioxide, water vapour, and sometimes helium and nitrogen.

LNG/LBG
Liquefied natural gas or LNG is natural gas that has been converted temporarily to liquid from (approximately –162 °C) for ease of storage or transport. Liquefied natural gas takes up about 1/600th the volume of natural gas in the gaseous state. The reduction in volume makes enables cost efficient transport for long distances. LBG refers to Liquefied Bio Gas.

CNG/CBG
Compressed natural gas (CNG) is made by compressing natural gas to less than 1% of the volume it occupies at standard atmospheric pressure. It is stored and distributed in hard containers at a pressure of 220 bar usually in cylindrical or spherical shapes. CBG refers to Compressed Bio Gas

SNG
Substitute (or synthetic) natural gas (SNG) can be produced from fossil fuels such as lignite coal or biofuels. The production process of SNG involves gasification, gas cleaning, shift and methanation.

Syngas
Syngas (from synthetic gas or synthesis gas) is a gas mixture that contains varying amounts of carbon monoxide and hydrogen. Syngas can be produced by: steam reforming natural gas or liquid hydrocarbons, gasification of coal or biomass, and in some types of waste-to-energy gasification facilities.
Syngas is combustible and often used as a fuel source or as an intermediate for the production of other chemicals or SNG.

Biogas
Biogas is a methane rich gas produced by the anaerobic decay of organic matter (biomass). Biogas is often produced in landfills, and sewage sludge and manure anaerobic digesters.

LPG
Liquefied Petroleum Gas (LPG) is a flammable mixture of hydrocarbon gases used as a fuel in heating appliances and vehicles. Varieties of LPG bought and sold include mixes that are primarily propane, mixes that are primarily butane, and - most commonly - mixes including both propane and butane. Propylene and butylenes are usually also present in small concentration.

Shale gas
Shale gas is natural gas produced from shale. Presence not yet proven in the Netherlands.

Tight gas
Tight gas is natural gas produced from low permeable conventional reservoirs.

Coalbed Methane
Coalbed methane is natural gas produced from coal seams. Presence not yet proven in the Netherlands.

Appendix 3 Definitions of categories for gas type, infrastructure and technology

Category	Definitions
Gas chain elements	**Projects focussed on**
Production	Production of gas from a gas field
Exploration	Search and development of new gas fields
Infrastructure	Gas networks, and equipment for measuring flows
Storage	Storage of gas underground or in a tank
Transport	Gas networks, transport and transfer installations and LNG/CNG carriers
Mobility	Gas used as a fuel for mobility
Chemistry	Gas used as a chemical feedstock
CHP	Gas used for the combined production of heat and electricity
Gas technologies	**Projects focussed on**
Gas treatment	Removing CO_2, H2S, water, mercury or other compounds from natural gas
Underground storage	Storage of gas in an empty gas field
Burner technology	Development of new gas burners
Gas conversion	Chemical conversion of natural gas often focussing on the production of hydrogen
Fuel cells	Development of fuel cells systems converting gas to electricity
Drilling technology	Development of drilling techniques
Gas turbine	Development of gas turbine parts, burner technology and controls
Heating boilers	Design of large heating boilers for utility and industrial use
Gas quality	Development of instruments to continuously monitor gas composition
Gas pipes	Development of pipes and accessories
LNG/CNG tankers	Development of tanker ships or offshore load and off-load technology
Engines	Development of (multi fuel) engines for gas
ORC / Kalina	Development of technologies to reuse waste heat
Offshore	Development of drilling platforms
Production	Production technologies for exploitation of small gas fields
Sensors	Development of gas sensors
Tank storage	Storage of LNG or CNG in tanks
Safety	Technologies for inspection of gas pipes (corrosion) and prevention of leakages
Gasification	Research and development to produce syngas
Fermentation	Converting organic waste into biogas in a fermentation process
GTL	R&D of technology converting natural gas into liquid fuels (petrol, diesel fuel)
Filling points	Deployment of natural gas fuelling stations for cars, trucks of busses
Gas production	Technology for production of gas from a gas field

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