How the Dutch all-electric ambition was caught up by reality

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Partner for Progress

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Colophon

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Preface

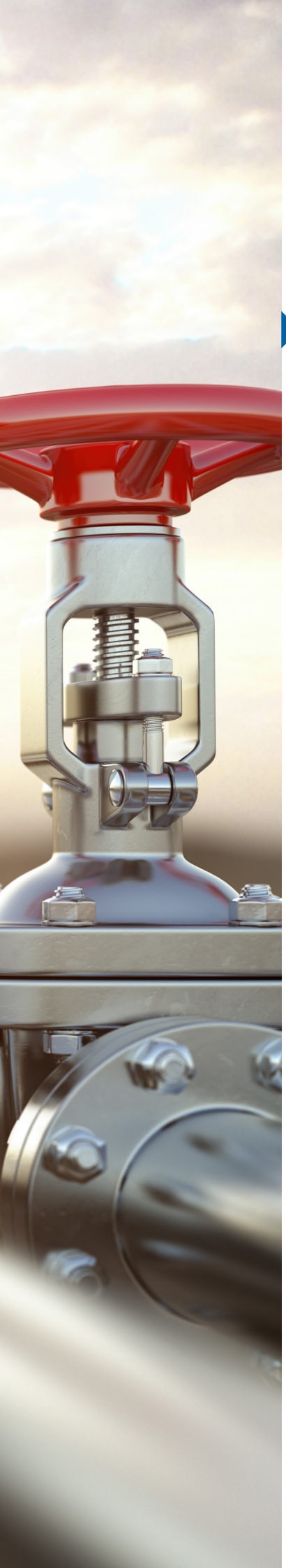
Kiwa Technology is an independent technical consultancy firm in the Netherlands, specialized in methane gas, biogasses and hydrogen. Kiwa Technology is concerned with quality, safety, materials, infrastructure and associated regulation.

This report contains the results of the short study that Kiwa has performed for one of its clients regarding the gas ban regulations in The Netherlands.

The Dutch strategy to reach a fossil fuel free society by 2050, the enacted government policy, and actions taken by stakeholders in the gas industry to maintain their current position in the future energy market, are considered.

This study aspires to create an understanding of the sequence of events and actions in The Netherlands and hence possibly provide substantiation for future business decisions looking to learn from the Dutch recent history concerning methane gas production and distribution, the eminent impact of the energy transition and the discussions surrounding this topic.

The events and actions in The Netherlands could be relevant to European level strategy and applicable in many countries. The framework of this study is constructed by consulting publicly available (online) sources, for instance: letters to parliament, legislation, and related press releases, where events and actions are announced and explained. Interviews with experts from stakeholders relevant to gas distribution and the build environment provide more detailed information on the actions and initiatives in specific sectors. The content and conditions of the gas ban including the strategic decisions, regulations and important events influencing society are presented in a timeline parallel to the actions and initiatives of relevant stakeholders and provided with a short description.



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1.1 Background on the Dutch gas situation

In order to understand the viewpoints of stakeholders, a brief history to put methane gas in the Dutch context is essential. In 1959 a low caloric methane gas field was discovered in the Northern parts of the Netherlands. Dutch government decided to connect the entire country of The Netherlands to this source, spurring a rapid energy transition away from coal towards methane gas. The Dutch Gasunie was founded in 1963 to build and maintain a gas grid to connect local businesses and households. To facilitate the conversion of town gas appliances to methane gas, The VEG Gasinstituut was founded. The activities of Kiwa at Apeldoorn originate from this institution.

Within 10 years 75% of the Dutch households had the ability to use methane gas. A strong desire for lower dependence on foreign oil rose during the Dutch energy crisis of 1973, at the same time the Dutch coal reserves became almost depleted and finally knowledge grew on the high pollution rates of burning coal. Methane gas became the fuel for Dutch industry, households and electric power stations. Today the Netherlands is the largest producer of methane gas within Europe and has a central role in storing and distributing methane gas throughout Europe. This will change in the nearby future, however, due to the decreasing gas extraction volumes. Methane gas is produced in The Netherlands, imported from Norway and Russia and exported to Germany, United Kingdom, France, Belgium and Italy. Up until 2014 the Dutch government yearly received ten to fifteen billion euro's from methane gas revenues, in total the Dutch government received over four hundred billion euro's in revenues. Furthermore, the Dutch oil- and gas sector alone creates over 16.500 jobs and the sector forms a constant booster for universities and institutes.

Needless to say: methane gas has a profound role in Dutch heating and economic development.

The Dutch gas grid connects around 91 percent of eight million houses and over 1,1 million utility buildings to methane gas. The Dutch gas grid consists of a high pressure transport grid of around 12.000km (owned by Gasunie Transport Services) and low pressure regional distribution grids of around 125.000km (owned by multiple DSO's). The high pressure transport grid operates on 40-80bar. The regional distribution grid operates on 8 bar and less through reduction at substations as early in the grid as feasible to 100mbar on street-level. A final pressure reduction to 30 mbar takes place within households. All in all: the Dutch gas grid is branched throughout the whole country.

Though economy and standard of living grew, producing methane gas did not come without downsides. The first earthquake as a result of the extraction of gas in the Northern part of the Netherlands was recorded on the 5th of December 1991. Many earthquakes followed, differing in magnitude. Houses continued to get damaged and get heavily devaluated. An earthquake with a magnitude of 3,6 on the Richter scale on the 16th of August 2012 formed a tipping point. Due to increasing resistance as well as an increased focus on the need for a transition towards fossil-free energy, the Dutch government decided in 2014 to work towards the end of the production of methane gas from the Groningen field. Currently more than half of the Dutch gas is extracted from fields other than the Groningen field. These include offshore and smaller onshore fields.

The subsequent steps are further detailed upon in the timeline (see paragraph 3.7). Prior to the timeline, the highlights with most important gamechangers, two significant decisions, and actions taken by the DSO's are explained.

1.2 Timeline highlights

The following list summarizes the main gamechangers in the history of the Dutch energy system. EU and government decisions predominate, however events and public opinion are also well represented.

- From the 1960's the gas network quickly expanded and became an indispensable part of Dutch society.
- In 1991 the first earthquake related to the Groningen gasfield was recorded which gave rise to public unrest and resistance to regional gas extraction. In 1993 the NAM recognized the link between gas extraction and earthquakes after own investigation.
- The 1997 Kyoto Protocol and subsequent 2005 EU ETS Directive with emission reduction targets for 2020 compelled the government to take action. The Dutch 2020 targets could be easily achieved by electrification in combination with other power saving measures (insulation). Electric heat pumps which use heat from ground water or the ambient air as a source of sustainable energy were introduced to reduce the carbon footprint of space heating. The idea that 'all-electric' would solve our emissions issue was born.

- Subsidy schemes SDE (2008) and SDE+ (2011) were expanded to fuel the energy transition. The techniques that were predominantly subsidized focussed on producing green electricity (solar/ wind) and green gas production.
- An earthquake of 3.6 on the Richer scale in 2012 was cause for an investigation by the State Supervision of Mines (SodM). SodM concluded that earthquakes in the region could become more severe. SodM therefore recommended to limit gas production as quickly and as much as possible.
- In 2014 government announces to phase out gas extraction from the Groningen gas field.
- In the years following the Paris climate agreement in 2015, the realization grew that 'all-electric' was not the solution to meet the 2030 and 2050 targets. Apart from energy supplied in the form of electrons, energy based on molecules remains essential. By this time the growing demand for electricity exposed the limited capacity of the existing infrastructure. New electricity grids could not be built fast enough to keep up with demand. The complicated process of spatial planning, shortage of technical personnel and materials all contributed to this. Electrification plans of the industrial sector would require extensive grid expansion. Furthermore part of the industrial processes require high temperature heat, which could not be generated by electricity. Sustainable gasses like green gas and hydrogen might become a realistic and necessary alternative for methane gas.
- In 2018 the government decides to end methane gas extraction from the Groningen field as soon as possible and end of production in 2030 the latest. Furthermore, the obligation of DSO's to connect customers to the gas grid was removed from the Gas Act. As Dutch DSO's only perform legally obliged work, this is in effect a 'connection ban'. In the meantime network operators started an increasing amount research programs, experimental projects and small and large scale pilot projects.
- SDE++ (2020) was revised. The focus shifted from energy production to CO2-reduction and techniques like CCS could apply for support. Furthermore a separate subsidy scheme for green gas or CO2-free gases was established and obligation to blend green gas in the built environment and/or industry.

1.3 Three significant decisions: Dutch gas ban, 'Law progress energy transition' and the 'all-electric' dream

1.3.1 Dutch gas ban 2018

After a four year period of drastically reducing gas extraction from the Groningen gas field, the Dutch government decided the production of methane gas from the Groningen field should be terminated in 2030 at the latest. The main reasons to do so were:

- earthquakes which increasingly damaged the surrounding environment
- the Groningen region economically became increasingly unattractive
- a continuing reinforcement policy for the houses in the region was necessary.

This led to the decision to terminate production in the Groningen field as soon as possible: less then 12bln m3 per year in 2022 (production was 21.6bln m3 at that time) and full stop afterwards. The following conditions applied to reach this goal:

- Increased nitrogen production facilities by 2022 to add nitrogen to convert offshore and imported high caloric methane gas into low calorific gas, to make it suitable for Dutch end users. This potentially reduces the need for Groningen-gas by 7bln m3. The N2 facility completion is postponed due to shortage of critical parts.
- The 145 major industrial consumers, with 200 locations, were to stop using low caloric gas by 2022, through accelerated energy transition to alternatives. This potentially reduced the need for Groningen-gas by 4.4bln m3.
- Increased sustainability of the built environment: newly built houses without gas connection as the standard, subsidy for residents to improve houses (e.g. solar panels) and all-electric solutions whenever possible (see next paragraph for more details). The potential reduction of these incentives remained unclear.
- In rural areas there were positive investment returns as large tracks of cheap land were covered with solar panels. In those areas the dimensions of the electricity grid were smaller.
- Reduction of export of Groningen-gas to Germany, Belgium and France. This potentially reduced the need for Groningen-gas by 3bln m3, however drastic actions are needed from the mentioned countries. For example: Stadtwerke Hannover are switching from Dutch L- to H-gas, a process that takes 3 years to complete.
- Production from the Groningen gas field was to meet security of supply and no longer to reach the established yearly extraction level as agreed upfront.

1.3.2 'Law progress energy transition'

As of July 2018 the Dutch law 'law progress energy transition' (law VET) came into effect. As part of this law the Dutch gaslaw was changed to effectively prohibit new gas connection in the built environment:

- Article 10.6 of the Dutch gas Act obliges DSO's to connect customers to the gas grid. With law VET Article 10.7 is added, stating that this obligation is no longer valid for small consumers (houses and small companies). As Dutch DSO's only perform legally obliged work, article 10.7 is in effect a 'connection ban'.
- Article 10.7 states that there is no connection obligation for
  (1) newly build houses,
  (2) areas with a gas-grid and plans for an alternative heating source to be realized
  (3) new connections in currently existing houses

In addition, the underlying law building decree 2012, article 6.10.2 was altered: the obligation for a DSO to make a connection to a gas grid is limited to those cases where the DSO is still obliged to do so based on the Dutch Gas Act.

Under strict conditions, mayors from municipalities were allowed to make exceptions and assign designated areas where the gas connection obligation for new buildings still applied. In the years of 2018-2022 several newly built homes were connected to the gas network, despite the ban, despite the removal of the obligation for DSO's to make a connection.

1.3.3 'All-electric' as alternative to cope with the gas ban and reach climate goals

The discussion to reach climate goals by reducing CO2 and increasing social pressure to reduce production from the Groningen field boosted all-electric solutions as alternatives. This was aided by a fierce lobby from relevant stakeholders in Dutch national politics. The general idea was: 'Gas is not needed, lets increase the amount of sustainable electricity significantly through incentives on solar and wind. Then the need for methane gas will decline and climate goals will be reached.' In practice this has proven to be and remains to be unfeasible in the Netherlands; in addition to energy supply in the form of electrons there a need for energy based on molecules will remain to exist. Currently, in large parts of the country excess electricity produced cannot be fed back into the grid and in several areas entrepreneurs producing green electricity using wind and solar power, cannot be connected to the electricity grid.

Electricity producers

The electricity grid has largest capacity in densely populated areas and at production sites. However, the capacity of all the existing electricity grids is not prepared for a full-capacity electric heat pump in every dwelling in the street. At the same time, entrepreneurs primarily applied for solar and wind subsidies in low-priced rural areas, allowing for a positive business case. In rural areas the electric grid was (and still is) insufficient to take in these increased amounts of decentralized sustainable electricity. Another complication is the increased amount of solar panels on residential houses. On a local level, this destabilizes electricity grid currents, leading to flickering lights in residential areas.

Electricity consumers

The all-electric-path led to increased electricity consumption in the Netherlands. This was primarily due to a rise in driving electric, and using electricity for heating and cooking, and the onset of electrification in the industrial sector. Currently in certain areas, mainly historic centres of towns and cities, supermarkets or catering industry cannot apply for a new connection. The large electrification potential of the industrial sector will require even larger connections to the electricity grid in the future.

As a result, decentralized and centralized electricity grid quickly became fully utilized in large areas, forcing DSO's to apply congestion-management, effectively prohibiting new connections and occasionally even temporarily disconnect industrial users.

Additional complications and tested solutions

Pilots to store electricity were successful on a local scale, but is not an option for the entire Dutch electrical system due to the sheer needed physical size of storage facilities. The lack of electrical engineers, mechanics and contractors that were and still are available to upgrade and extend the network as well as the enduring lack of materials cables cause additional problems. Furthermore, the costs of expanding the electricity grid to allow for large scale all-electric solutions would run in the billions. It was perceived that these costs, that eventually will be transferred to end-users, are too high.

Following this initial surge to implement all-electric solutions, electricity and gas producers, electricity and gas grid operators are convinced that sustainable electricity AND gas is the way to move forward. Currently an effort is being made to make different energy-sources available for different regions: hybrid boilers, green gas, biogas, hydrogen and electricity.

1.4 Changes in business operations of network operators

Both regional network operators and national gas network operator (Gasunie) have an excellent view of the structure of our energy system. Shifting towards all-electric and eliminating gas completely was deemed unfeasible by the gas grid operators. Already in 2005 national gas grid

operator, Gasunie, started to collaborate with different stakeholders, including the national electricity grid operator and NGO's, to explore possible and feasible scenarios to reach the emission targets. Within regional network operators, where gas and electricity form two branches of the same company, the all-electric surge shifted the focus from gas to electric. Pilot programs to facilitate the all-electric ambition were initiated (zero-on-the-meter homes), the investments made in the gas grid were reduced and the conversations around sustainable gasses diminished.

"The Dutch government boasts alternatives for fossil energy via several subsidy schemes. The subsidy scheme SDE aims at accelerating the implementation of sustainable electricity, heat and gases. Innovation in these fields is supported by general instruments for, amongst others, sustainable electricity, biomethane and hydrogen. The Netherlands is convinced that this portfolio deserves full support in order to realise the energy transition."

Member of public private partnership.

A new era begun in the years following Paris agreement. When more detailed plans to meet the 2030-2050 climate goals were made, the realization struck that all-electric was no feasible solution. The vast amounts of energy needed by the industrial sector and congestion of the electricity grid rendered this all-electric scenario impossible. Network operators were motivated to encourage the climate transition and congruently establish a new purpose for their gas infrastructure. New to the business operations of network operators were the elaborate discussions with stakeholders of all sorts (including NGO's). These meetings were set up to collectively assesses realistic scenario's to reach the emission reduction targets and continue to date (2005: Gasunie, ~2015-2017: DSO's).

Within network operator organisations, the few staff members focussing on innovative techniques and sustainable alternatives for methane gas transformed into teams parallel to the growth of the green gas market grew and the realisation by other stakeholders that all-electric would not be a solution.

New techniques were developed and projects established to experiment with new techniques and sustainable gasses (green gas and hydrogen). The first projects involved small investments, technical staffing and cooperation with stakeholders on local government level. Following this category were projects with bigger investments and the involvement even more stakeholders including residents.

"The level of investment in the gas grid was been reduced, as a result of the gasban and focus on the electricity grid. The last years however realization has started to sink in that existing houses, schools, local industry etc are difficult to decarbonize without sustainable molecules. Also the enormous growth of sustainable electricity production can no longer be accommodated on the electricity grid alone. Therefore it is necessary that investments in the gas grid remain, to accommodate for renewable gasses in the near future".

Member of one of the three largest Dutch DSO's

1.5 Current state of affairs in The Netherlands

Currently a large part of the built environment in The Netherlands relies on natural gas as energy source for heating and cooking. Most newly built houses are being isolated according to high standards and only connected to the electricity grid. Connecting all facilities and sectors to the electricity grid exclusively is, however, not possible. An energy carrier based on molecules still is and will continue to be an essential part of the Dutch energy system. Sectors including marine and road mobility, industry, production of fertilizers and plastics, remain to rely on these molecules.

To accelerate the energy transition initiatives are being launched throughout the entire value chain and in all sectors: mobility, transport, build environment and industry. Several hydrogen fuelling stations have been built and more are under construction. Gasunie is developing a national hydrogen network and is focussing on large scale CCS location near the Port of Rotterdam. The Port of Amsterdam plans to develop a hydrogen distribution network in the port. And pilot projects by regional network operators become more numerous.

Roadmaps and national programs for green gas and hydrogen are presented from the year 2020 onwards. In December 2021 the government presented plans in which they announced a blending obligation for green gas, subsidy schemes for CO2-free gasses (e.g. hydrogen) and green gas, and published plans for the build of nuclear power plants.

In conclusion, the exact combination and contribution of the different techniques in the Dutch energy landscape is far from definite. Everything is still possible. A fact which is painfully illustrated by the recent increase in gas extraction to answer to contractual export agreements.

1.6 Stakeholders, relevant parties and organisations

The most relevant actors are briefly detailed upon below.

NAM, Dutch Oil Organization. The NAM produces oil and gas. NAM was founded in 1947 by Shell and ESSO. NAM holds the concession to extract methane gas from the methane gas field in the Groningen field. Other concession holders, smaller in size than the NAM are extracting in the Dutch territory, on shore and on the continental shelf in the North Sea.

Gasunie, Transmission gas grid operator. Gasunie was founded in 1963 after discovery of the large methane gas field. Gasunie is the grid operator for the national transport grid of methane gas. It maintains infrastructure for large-scale gas transport in The Netherlands and Northern Germany. Gasunie has two subsidiaries that manage the grid: Gasunie Deutschland and Gasunie Transport Services Netherlands. Underground seasonal storage facilities are managed by Gas Storage parties.

SodM, State Supervision of Mines (SodM) used to be a Dutch service that was established in 1810 and is charged with the supervision of mineral and energy extraction in the Netherlands. After discovery of the methane gas field SodM became the state supervisor over production, transport and distribution of methane gas. SodM is an executive body of the department of Economic Affairs and Climate. It acts primarily from a safety perspective. Gas network operators are being supervised by SodM on safety.

NBNL, NetbeheerNederland. NBNL is the Branche organization of the electricity and gas grid operators in the Netherlands. Learnings are shared and projects are done together. NBNL improves collaboration and protects the interests of its members with the Dutch Government.

Subsidy schemes of the government

RVO, Government body for entrepreneurs. RVO is part of the Dutch ministry of economic affairs. RVO stimulates entrepreneurs to be innovative and speed up energy transition through subsidies, tenders and knowledge sharing.

TKI topsector energy, TKI supports innovations that are necessary for the transition to an affordable, reliable and sustainable energy system. It does so via subsidies and TKI has different departments, the most relevant being TKI New Gas. TKI New gas is a typical network organization. The partners all come from gas- and industry sector. It coordinates theme wise programs and can provide innovation subsidies for public-private projects. Government funding is corresponding with EU funding regulations.

DSO's, regional service operators. The Dutch grid operators work in a regulated market, each with its own network in a part of the Netherlands. In the past, about 130 DSOs were active in Town-orientated networks. Shareholders were local communities. Caused by the liberalization of the energy markets, the shares of smaller networks went to the bigger ones. As a result, 6 DSOs remain. The grid operators have governmental supervisors and fixed tariffs for distributing energy and gas. Dutch grid operators therefore are not each other's direct competitors: it is not feasible to have multiple grids next to each other. The grid operators are benchmarked by state supervision to increase efficiency.

The DSO's have both electricity and gas networks. There are some areas where electricity and gas are supplied by different DSOs. These situations are historically determined.

NGO's, like Greenpeace and **Urgenda,** multiple interest organizations in the Netherlands operate as well within the discussions around the energy transition. It is worth mentioning Urgenda. Urgenda successfully filed a case against the Dutch government where it was established that the government has a legal duty to prevent dangerous climate change. Recently, the Dutch greenhouse gas emissions met the requirement by Urgenda (25% less compared to 1990 levels), mainly by shutting down coal fired electricity plants.

Throughout history stakeholders and events have influenced each other. In the design for an accessible overview, each has been given their own specific frame, in order to visually distinguish between stakeholders (see figure 1 below). The political and socioeconomical events are outlined by a red frame. A timeline item concerning a certain technique or gas can be distinguished by frames with unique background colour. Green gas is gas from biomass that complies with the Dutch network code.

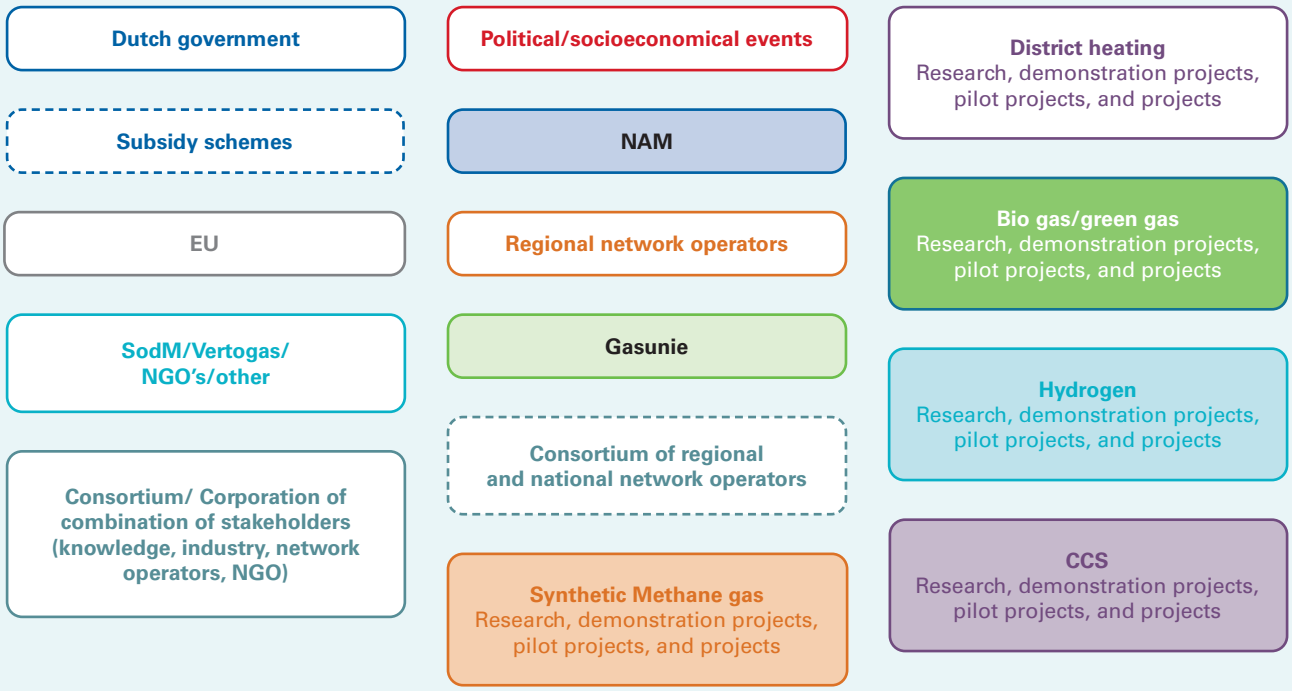
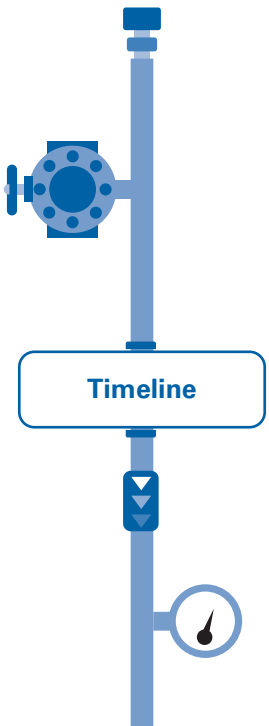


Figure 1: Legend of stakeholders, events and techniques/gasses presented in the timeline

2. Timeline



1947

Dutch government commits itself to purchasing all methane gas extracted by the NAM in the Netherlands. To the benefit of all Dutch citizens.

1943

Discovery of Schoonebeek oil field.

1947

Foundation of the Nederlandse Aardolie Maatschappij, **Dutch petroleum company, NAM.**

The NAM is concerned with the production of oil and methane gas in the Netherlands and on the Dutch continental shelf.

50% of the shares were owned by Shell, 50% by were owned by Esso (now ExxonMobil).

1959-1960

Discovery of Groningen gas field by NAM. The field contains an estimated 2740 billion m3(n) of recoverable methane gas.

1963 (March)

Foundation of the **'Partnership Groningen'** to arrange matters related to the exploitation of the Groningen gas field. Furthermore a base for the foundation of the Nederlandse Gasunie was laid.

In this agreement the **Dutch state** indirectly owned 40% of the shares (through the **Dutch State Mines** (later DSM and EBN)). The **NAM** owned 60% of the shares.

1963 (May)

Start production of Groningen Gas field.

1963

Foundation of the **Nederlandse Gasunie**, a public company that is responsible for the transport of Dutch methane gas.

10% of the shares were directly owned by the **Dutch state**, 40% by the **Dutch State Mines** (later DSM and EBN) and 50% shared by **Shell** and **Esso** (now ExxonMobil).

1963-1968

Gasunie was charged with the task of laying a pipeline network to **connect all Dutch households and industry to Groningen gas.** In 1968 the last Dutch town was connected.

1960-1970

Government expectations were that nuclear energy would eventually displace the use of methane gas. Therefore government policy was to sell methane gas as quickly as possible to both domestic and foreign parties.

1973

Oil crisis. Explosive increase in price per barrel due to political actions by the Arab oil-producing countries actions. These included prise increase of 70% and production reduction of 5% per month.

1974

As a response to the oil crisis and criticism towards nuclear energy the government revised previous strategy (box 1960-1970) and introduced the so called **'small fields policy'**.

More gas was to be extracted from smaller fields to reduce production from the Groningen gas field in order to keep the **Groningen gas (partly) as a** reserve.

As exploitation and operation of small fields is more expensive, the **Dutch state reduced its profit share,** to make exploration more attractive.

1970-1990

Debates surrounding **nuclear energy**. Initially nuclear energy was supported due to the novelty of the technology and the oil crisis.

Not soon after, criticism of the use of nuclear energy followed, which was based on environmental aspects and the Chernobyl nuclear disaster.

1970-1980

Creating **biogas** by **fermentation of organic waste** (sewage sludge, organic household waste and manure) was first applied and grew. Laboratory scale testing with manure and organic material fermentation. **[14]**

In the late '70's almost all sewage treatment plants were equipped with this technique where the produced methane was sufficient to meet the plants power needs. Though sometimes used as energy source, methane was still often seen as **waste product** rather than useful by-product.

1970-1980

District heating projects became profitable because of the high oil prices.
Heat distribution networks were constructed in new residential areas and in existing districts to make use of the efficiency of combined heat and power (CHP).

1980-1990

Due to rising energy prices, interest in biomass as renewable energy increased. Especially the possibilities for **biogas** through manure fermentation drew attention.

1991

First earthquake induced by Groningen gas field reported.

This led to damage to houses and concern and unrest among residents.

1993-current

The **frequency** of induced **earthquakes increases** in the next decades.

This led to increased concern, unrest and resistance among residents. **Civil associations** fighting against gas exploration and production were founded.

1993

NAM recognizes, after own investigation, there is a link between the earthquakes and extraction of methane gas.

~ <1998

Electricity connection in homes is mandatory.
Connection to the gas grid was by choice.

1998

Electricity Act was instated by the Dutch government. It stipulates that suppliers should be able to supply power to any customer in The Netherlands. Consumers can now choose their own supplier.
This act forms an important first step towards a free energy market. **[12]**

1997

Kyoto Protocol
EU determines The Netherlands should reduce emission with 6% compared to 1990.

End '90- start '00

Electricity as well as gas connection in homes becomes mandatory. Now no technologies were excluded to market competition. There was a lot of confidence that the market share of the micro CHP would grow tremendously. Also, gas was thought to help unloading the electricity grid.

2000

Gas Act was instated by the Dutch government. The Gas Act forms the foundation of a free gas market, as it permits multiple gas suppliers to be active on the market. **[11]**

2003-2006

Government installs regulation **MEP** that subsidises production of sustainable electricity. This regulation was stopped due to untenable amount of applications

2005

Liberalization of small consumers **the European gas market** by EU to create equal opportunities and promote market competition.

2005 (July)

Gas trading company GasTerra spun off from Gasunie.
From now on Gasunie will be concerned with the transport and storage of methane gas. GasTerra will be concerned with gas supply and trading, mainly from the Groningen field.

2005

EU ETS Directive was launched.

~2005

First time the idea: 'we need to eliminate gas' was introduced as a means to reach emissions reduction targets.

~2005-2010

The mandatory connection to the gas grid is revoked.
Gas demand for space heating decreased, which made micro CHP unprofitable.

~2005-2010

NGO's involved in energy system scenario discussions.

~2005-2010

The statement 'we need to eliminate gas' initially caused some unbelieve and resistance within national gas network operator Gasunie, because of its unfeasibility, considering the way we have set up our energy system. Eliminating gas would be impossible.

This was quickly followed by a **change in mindset** and **action**.

All different kinds of stakeholders were assembled to access each and everyone's starting points and possible scenarios to reach the targets **with the current energy system in mind**. Quite ground breaking was the fact that stakeholders, with whom discussions have never been held before, were approached to contribute (e.g. NGO Greenpeace).

Thinking in terms of possibilities to speed-up the energy transition gives perspective for network operator activities. Projects to sustainable gasses (green gas, heat, CCS, hydrogen).

2005-2012

Co-firing of **biomass** in cogeneration or combined heat and power (CHP) plants increased. Adding biomass to power plants to produce electricity was a way to generate green electricity and supported by the MEP subsidy scheme.

2006

The onset of **green gas** production in the Netherlands can be found in the foundation of the **Workgroup Green Gas** and their published starting document in which the following **ambition** is outlined:

By 2020 10% of the methane gas could be replaced by green gas, meaning a yearly production volume of 4 billion Nm3. **[15]**

The members of the Working Group Green Gas represented i.a. knowledge institutions, Gasunie, energy companies, delegates from the government.

2006

Independent Grid Management Act was instated by the Dutch government. It stipulates that network operators are not allowed to carry out any commercial activities apart from managing the electricity and gas networks.
From here on out network management is separated from production and supply of gas and electricity.

These activities should be split off into separate companies before January 1st 2011.

2006-2010

Foundation of regional gas network operators as we know them today (Coteq, Enexis, Liander, Rendo, Stedin, Westland Infra).

2008-2011

To achieve the 2020 renewable energy goals for the Netherlands, set by the EU, the Government installs a subsidy scheme: **SDE (later SDE+, now SDE++)**. This scheme aims to encourage businesses and private individuals to invest more in sustainable energy.

This regulation reimburses i.a.: biomass electricity, biogas production, solar pv, wind on land/see, hydropower.

Budgets for different categories were determined and set. As a result the budget for techniques solar and wind were greatly exceeded and others remained unused. Therefor from 2011 SDE was adjusted so that all techniques would compete for the same incentives.

2008

Official document from the **Workgroup Green Gas** describing their vision on how to develop a green gas market on a short term basis. **[15]**

~2008-2012

A tipping point in network operators' mindset. Earlier, problems were solved strictly within their own domain: electric or gas. This mindset changed and communication between parties increased. Which is important as collaboration is key to solve the system integration issues necessary for the energy transition.

2009

Gasunie establishes **Vertogas,** a company which issues GoO's **(Guarantee of Origin)** for **green gas** on behalf of the government. Vertogas inspects whether the gas meets the quality requirements for such a certificate and can truly be called 'green'.

2009

The **market** for **green gas** was launched.

Three producers **green gas** were issued certificates allowing them to **inject** their product into the existing gas distribution network.

2007-2011

Pilot project Ameland: adding up to **20%vol hydrogen** in consisting gas infrastructure.

Setup
A solar panel powered elektrolyser produces green hydrogen. The hydrogen is added to methane gas with incremental increases to the maximum allowed percentage of 20%vol. The mixture of hydrogen and methane gas was transported through existing pipelines to be used in an apartment block with 14 households.

Lessons learned/ points of interest
The project shows that blending hydrogen with methane gas has no detectable negative impact on the gas distribution materials, indoor installations and the new specially selected appliances that were used.

Investment
Project to experiment and/ or establish proof of concept: low investments, short duration/ short cyclic, no residents directly involved, continuous testing locations, education and training.

A project by the municipality of Ameland, Joulz, Stedin, GasTerra and contractor Kiwa Technology.

The research report can be found here (NL). **[9]**

2010

Green Gas Netherlands is founded by the Province of Friesland, the municipality of Leeuwarden, Netbeheer Nederland, Gasunie, GasTerra, Eneco, Essent, E.ON Benelux and LTO Noord.

Green Gas Netherlands is a national foundation that **assembles all information in the field of green gas and biogas** in order to accelerate developments in the green gas market and increase the production of green gas.

2010

Debates surrounding **nuclear energy** resurface.

~2010

The statement 'we need to eliminate gas' caused unbelieve with regional gas network operators.

The story in which electricity is generated using green, sustainable resources is a beautiful story. However the quantities that would be needed are impossible to generate.

After this 'statement got, it became quieter within the regional network operators. **Talking** about **sustainable gases disappeared** from the agenda and **investments in gas infrastructure declined**.

2011-2020

Government installs SDE subsidy scheme successor: **SDE+ (later SDE++).**

This regulation reimburses: i.a.: biomass heat production, biogas production, solar pv and solar thermal, wind on land, geothermal, hydropower.

All techniques now compete for the same incentives, which promoted competition and lead to cost reductions. For wind on see separate tenders would be issued. Furthermore, due to a lot of interest, the government decided to exclude incentives on the purchase of solar panels and solar boilers for private individuals.

2012 (August)

Earthquake with an estimated magnitude of 3.6 on the Richter scale forms tipping point and leads to investigation by SodM.

2012

Research from the State Supervision of Mines (SodM) concludes that future earthquakes in the region could become more severe. **[5]**

SodM recommends to **limit gas production as quickly and as much as possible. [6]**

2012-2016

TKI Gas was founded in 2012. From 2012 to 2016 their goals were to contribute to a more sustainable energy management and contribute to the knowledge and general position of Dutch businesses and knowledge institutes. **[13]**

TKI Gas focussed on five themes:

- **Green gas digestion**
  Ambition: Produce 300 million Nm3 green gas by 2020 and 2 billion Nm3 by 2030.
- **Green gas gasification**
  Ambition: Develop and demonstrate a gasification technology with 70-75% efficiency.
- **Upstream Gas**
  Ambition: Develop and implement innovative techniques to make gas extraction and production safer and with minimal environmental impact.
- **Small scale LNG**
  Ambition: Ensure fifty seagoing vessels, fifty inland vessels and five thousand trucks run on LNG.
- **CCUS (Carbon Capture, Utilization and Storage)**
  Ambition: Ensure CCUS will be widely used.

2013

The **'Energy Agreement for sustainable growth'** was enacted by the government. Some of the most important focus points were: more windmills, incentives for home insulation, and tax advantage for generated green energy.

2014

Government decides to phase out gas extraction from the Groningen gas field from 2014 onwards. This concerns gas both for domestic use and export. **[8]**

2014

Roadmap 'Renewable Gasses' was published by government. It shows the perspectives for the production of biogas, green gas (for the short term), hydrogen and methane (for the long term) and the actions needed to realize that potential. Key findings are:

- Gas through fermentation is thought to increase, because of the growth in waste flows.
- To make production and use more affordable a mix of fossil fuel pricing, promoting green fuels and/ or market segment regulation through quota or obligations.

More details can be found in **[16]**.

2014-2018

Pilot project Rosenburg (phase 1): producing **synthetic methane gas** from hydrogen for heating in the **build environment**.

Setup
An installation uses hydrogen to create synthetic methane gas, which is transported to and used in an apartment building with 25 households. The synthetic gas is of al quality to regular methane gas.

Lessons learned/ points of interest
Because of the possibility that appliances could only withstand a limited amount of hydrogen admixing, this pilot aiming to produce synthetic natural gas using hydrogen was launched.

The municipality of Rotterdam has been engaged in the process from the start of the project. Their active involvement and positive mindset contributed to a smooth collaboration and smooth progress of the project.

The project was successful. However, with the aim to become completely CO2-free methanisation and subsequent burning like in this is not the solution for the build environment. A follow-up project was launched partly heating the building with hydrogen using hydrogen boilers (see Pilot project Rosenburg (phase 2).

A project by Stedin. **[10]**

2014

Facing-out domestic transport and export of Groningen gas, frees up Gasunie's pipelines and starts discussion on repurposing those networks.

2015

Paris climate agreement, the Conference of Parties were a world-wide gamechanger.

~2015-

Realization that hydrogen might become a realistic and necessary energy carrier to meet the 2030 and 2050 targets.
Previously, electrification and power saving measures were sufficient to reach the 2020 targets.

2015-2018

Within regional network operators there is **an increase in interest in sustainable energy solutions.** An increase in interest from local governments and citizens is also experienced. In response, several steps were taken by the operators. For example, they stimulated new development, developed practical tools themselves, pursued starting pilot projects. Two concrete examples are:

DSO Stedin became proactively involved in district energy scans. An energy transition model was developed that assesses the most cost and energy efficient way of heating area's on district level. This model (only available in Dutch) can be found via this link. **[24]**

The Stedin model is a combination of the top 3 models in NL (Vesta MAIS from PBL, CEGOIA from CE Delft and ETM from Quintel). The input parameters of these models, e.g. the costs for a heatpump, were equalized and in all three the technique considered were set to be similar. These 3 models with each 3 scenario's produce in 9 results. When all 9 show the same outcome, the solutions for a district are more robust.

Actions were taken in multiple directions by **DSO Liander** on the topic of **hydrogen** including the following examples:

- **Technical research:** investigations to the available knowledge and gaps was done. And research to answer technical questions that for which an answer could not be found was initiated. An example of this is the Start of national research program **HyDelta** (see frame on one of the next pages).
- **Standardization:** initiating in conversation with the standardization institute NEN, to figure out how to speed up the creation of standards for hydrogen and how to coordinate this with all stakeholders concerned. This led to the establishment of the Normalization platform Hydrogen in the build environment and industrial environment in 2018.
- **Strategic business:** Internal discussions about the role that they want to fulfil in this story: solely the network operators part or are there chances to expand into the commercial market. Both these options are still under debate, but the framework in which the DSO's operate is determined by regulation and legislation, like the EU directive on common rules for international markets in renewable and methane gasses and in hydrogen. **[25]**
- **Pilot projects:** initiatives from neighbourhood associations, sustainable initiative groups and initiatives coming forth from discussions with municipalities were collected. The most promising ones were selected to realize in practice. Pilot project **Lochem** was one of these (see frame on one of the next pages).

2015(-2020)

NGO **Urgenda** wins lawsuit against the Dutch State.

The court enforced that the Dutch state, must reduce greenhouse gas emissions by at least 25% by the end of 2020.

After the State's appeal was dismissed and cassation was denied the government announced CO2 reducing measures in 2020.

2015

Government believes in and focusses on 'all-electric' to reach a carbon-natural future.

2015-current

The all-electric-approach, meant that existing residential houses would have to be disconnected from the gas grid. Several **experiments converting neighbourhoods to all electric** were conducted by network operators, several pilots are still ongoing.
DSO's have shared their experiences on these ambitions **'zero-on-the-meter'-projects**. Examples and lessons learned

Amsterdam city centre
Around 2017 Amsterdam city centre, the canal area, wanted to switch to all-electric'. They wanted to pioneer with this in the Netherlands, and be a frontrunner in the energy transition. They didn't realize the difficulty of this project. First of all, all roads along the canals had to be opened for the expansion of the electricity grid and removal of gas pipes. Secondly, ten additional substations, each the size of half a football field, were needed throughout Amsterdam. Two factors that render this task impossible. And this is even without mentioning the very high costs for insulation of old buildings. This is an example of how talking about energy transition in combination with not knowing how it works, does not create actual progress and confirmation that all-electric is not suitable for city centres.

Purmerend
As part of the program 'aardgasvrije wijken' 68 homes would be disconnected from the gas grid. The remodelling of these homes included, but was not limited to, isolation (create a shell around the house) installing, triple-glass, a modern kitchen suited for all-electric, solar panels and heat pumps.
This project has been going on for 3.5years, currently only 64 from the 68 homes are disconnected. On a yearly basis these homes are 'zero-on-the-meter', but because of seasonal variations these homes could not be completely disconnected from the grid. According to a rough estimation, the conversion per home costed €60.000,-, whereas the costs to build a new house were €55.000 at the time. The costs and time to transform the houses is exceeding all expectations and causes doubts to whether projects likes these are the correct approach towards zero-emission goals.

Van der Pekbuurt (Amsterdam)
The municipality of Amsterdam aimed to remove the gas grid connections in thirty-two residential houses with architectural and historical value. Isolation was complicated due to the restrictions to altering the neighbourhood's appearance. For heating these homes would be connected to a heat network. However, to provide the heat for these 32 homes, the heat provider asked for large connection to the gas grid to power a large boiler. This boiler has an efficiency of approximately 70%, and after some additional energy losses due to transport, the energy reaches the 32 homes. A boiler in residential homes has an efficiency of approximately 92%. Indicates that in term of efficient use of gas has decreased. Furthermore the estimated registered project costs amounted to €130.000,- per home, which brings the total to € 4.160.000,- for 32 homes.
The municipality official's goal was achieved: the gas connections were removed from this specific postal area, but in reality gas is still the energysource behind the heating of these homes..

These pilots where electrification of existing residential houses went **slower than expected** and were **more expensive than expected**, which **contributed to the believe in municipality and government circles that 'all-electric' could impossibly be the only solution.**

Currently activities to start similar pilot projects are very limited.

2016

As the result of the Paris agreement, the Hydrogen council (collaboration in mobility industry) was established. Car and motor manufacturers fuel suppliers, etc. collectively declared that they saw hydrogen as a suitable successor to diesel and would collectively investment billions. This fuelled the believe of other sectors and stakeholders that hydrogen would become a thing and drove them into starting up their hydrogen activities again.

2017

Pilot project Stad aan 't Haringvliet: using **green hydrogen** for heating in the **build environment.**

Setup
Stad aan 't Haringvliet, a city with 600 houses, will gradually be converted from a methane gas to green hydrogen city.
Green hydrogen will be locally produced and used to heat the mainly old, detached, hard to heat houses. The existing pipelines from Stedin will be used to transport the hydrogen.

Investment
A **large scale pilot project:** high investments, long duration, permanent, larger scale, residents involved on neighbourhood level, existing distribution

Partners and more information on this pilot can be found here (NL). **[26]**

2018-2023

Pilot project Rosenburg (phase 2): producing and using **green hydrogen** for heating in the **built environment.**

Setup and aim
Locally produced green hydrogen is transported though a gas pipeline to the boiler house of the apartment complex. The pipeline consists of the same materials as used in regular methane gas networks and the hydrogen is consumed by hydrogen boilers.

Lessons learned/ points of interest
The municipality of Rotterdam has been included in the process from the start of the project. Their active involvement and positive mindset contributed to a smooth collaboration and smooth progress of the project.

Investment
Project to **experiment** and/ or **establish proof of concept:** low investments, short duration/ short cyclic, no residents directly involved, continuous testing locations, education and training.

A project by Stedin. **[10]**

March 2018

Government decision to end methane gas extraction from the Groningen field as soon as possible. **End of production 2030** the latest.

Securing gas supply by increasing import of Norwegian and Russian high calorific gas, to which is nitrogen is added to create low calorific gas. **[3]**

2018

Government **ban** on **gas connection.**

Government removes the obligation of DSO's to connect new customers to the gas network from the Gas Act. As Dutch DSO's only perform legally obliged work, this is in effect a 'connection ban'.

New buildings can do with all-electric because of efficient insolation. The statement arose to 'eliminate gas'.

2019-
Over the years this statement became more nuanced and changed to: 'We need to eliminate methane gas'.

March 2018

Gasunie prepares new **nitrogen plant** to facilitate gas extraction reductions in Groningen. Plant is expected to be **ready in 2022. [4]**

2018-2025

Realization of a **gas terrain for hydrogen** and **small network** in the **Green Villa**ge.

The Green village is an innovation area where new technologies in the field of sustainable energy supply, water and waste systems are tested and applied in a 'real life' environment.

Setup and aim
Several regional network operators have installed a gas train for hydrogen. They aim to gain experience and knowledge on the field of operation and maintenance of a hydrogen distribution network.

Lessons learned/ points of interest
- Laying the pipelines and installing the train was not difficult.
- Extra care and attention should be paid when establishing and executing working methods due to differing properties of hydrogen compared to methane gas.
- The neighbourhood and local environmental services were not yet prepared for this project, which prolonged the licensing process. This can be partly attributed to non-existing legislation for hydrogen transport with the specs of a distribution network.

Investment
Project to **experiment** and/ or **establish proof of concept:** low investments, short duration/ short cyclic, no residents directly involved, continuous testing locations, education and training.

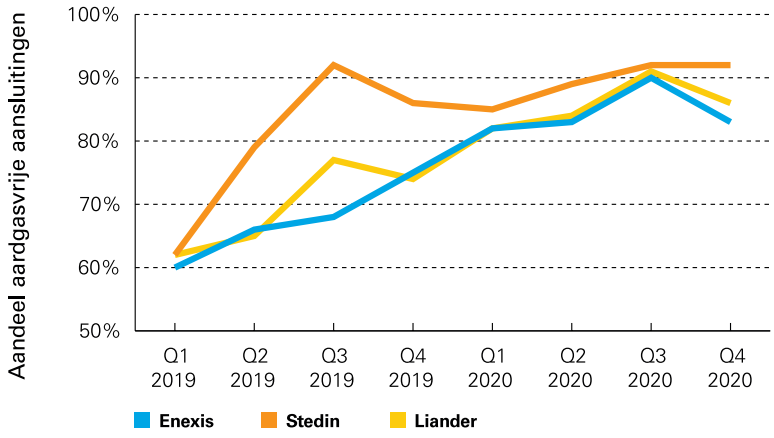
A corporation of Alliander, Enexis and Stedin.

More information on the hydrogen gas train can be found here (NL). **[27]**
More information on the sustainable energy system in general can be found here. **[28]**

2018-2022

Despite the 'gas ban', the removal of the obligation for network operators to connect every new build home to the gas grid, and despite the firm lobby by NGO's and officials not to connect these homes, several new build home project were still connected to the gas network by DSO's.

- In the period of 2018-2022 the authorities have received and granted 6382 applications for a gas connection. These came from different areas in several municipalities. **[29]**
- The share of methane gas-free new-build homes has increased, but the percentage of homes without connections to the gas network is not a 100%. See graph with percentage of gas-free homes below. **[23]**



2018>

Societal awareness and search for sustainable alternatives increases. Because of the prevailing public opinion 'gas is bad, electricity is good', the number of applications to disconnect existing houses from the gas grid increases. Electricity consumption increases and network operators put every effort into expanding the grid and smart grid innovations. Despite their efforts we are now facing net congestion.

2018-2025

Pilot project Lochem: Using hydrogen in the **build environment** to heat several houses with a landmark status which are difficult to isolate.

Setup
Hydrogen is supplied by tube trailers and transported through a hydrogen pipeline and repurposed existing methane gas infrastructure. A 100% hydrogen central heating boiler will be installed in each of the 10-15 houses to provide heat. The conversion to hydrogen is originally planned to be temporary, meant for period of 3 years (2022-2025), but has the possibility to be extended.

Lessons learned/ points of interest
Identifying, connecting and **maintaining engagement** of **all stakeholders** related to this pilot project ensures its success. One opposing stakeholder in this intricate web would already seriously complicate the realisation of the project.
The following stakeholders are involved: EU, national government, provincial government, local government, ACM, standardization, banks, insurance companies, advisors, installers, institutional investors and pension funds, housing associations, network operators, RES, security region, subsidy providers, tenants and home owners, licensors, interest groups.

Investment
A **small scale pilot project**: medium investments, medium duration, small scale, residents involved on own initiative, existing distribution network.

A project by Liander, Remeha, Kimenai, Interest association Protected Cityscape Berkeloord, Paticipating residents, Energy cooperation LochemEnergie. Special involvement of the province of Gelderland, municipality of Lochem and Kiwa.

2019-2026

Pilot project Oosterwolde (Sinnewetterstof).

Setup
To relieve the power grid an **electrolyzer** (1,4 MW) next to the GroenLeven **solar park** (60 MW) in Oosterwolde will be constructed.

Goal
The goal for network operator Liander is to gain experience with the application of an electrolyzer regarding control, controllability and safety.

Investment
Project to **experiment** and/ or establish **proof of concept:** low investments, short duration/ short cyclic, no residents directly involved, continuous testing locations, education and training.

Partners in this project are: Alliander, GroenLeven, Ecomunity-park/ BioSintrum, Venekoten and OrangeGas

More information on this pilot can be found here (NL). **[30]**

2019

TKI New Gas was founded in 2019. Their focus lies on supporting innovations in the field of sustainable molecules and their climate neutral replacements that are important for a successful energy transition.

TKI New Gas focussed on four themes.
- Hydrogen
- Green gas
- Geo-energy
- Carbon capture, utilization and storage

2019

Signing climate agreement and presentation of the Dutch targets and measures.

2019 (July)

GTS presents figures that show that gas extraction from Groningen can already be nil in mid-2022. Closure in **2026** the latest is pursued. **[7]**

2017-2019

The Klimaattafels (Climate tables) were founded. Bodies consisting of representatives of governments, companies and civil society organizations that make agreements about sector-specific measures to reduce CO2 emissions and reach Paris targets. The five climate tables in The Netherlands are: electricity, built environment, industry, agriculture and land use, and mobility.

~2019

Gasunie starts with CCS Project 'Porthos'.

Prior to this project CCS opportunities have been accessed. The idea was not supported by society and subsidies were not in place.

2020

Pilot project Uithoorn houses up for demolition in the **build environment** were temporarily converted to hydrogen

Setup and lesson learned
In a number of homes up for demolition, the existing methane gas network was temporarily converted and adjusted to be suitable for hydrogen. Valuable insides on the amount of time it takes to prepare the gas network for transport and use of hydrogen in existing homes were gained.

Investment
Project to **experiment** and/ or establish **proof of concept:** low investments, short duration/ short cyclic, no residents directly involved, continuous testing locations, education and training.

A project by Stedin.

More information and the technical report can be found here (NL). **[31]**

2020

Roadmap Green Gas
Government policy to facilitate upscaling of green gas focusses on:

- A separate subsidy scheme for green gas or CO2-free gases
- An obligation to blend green gas in the built environment and/or industry
- An energy tax reduction on green gas.
- TKI Nieuw Gas was asked to compose an innovation agenda highlighting innovations with the highest potential and how to best implement those.
- Precondition that biomass must be sustainably produced and processed.
- specify contribution to making end-use sectors more sustainable.

More information can be found in sources **[18]**, **[17]**.

2020

Government policy for establishing a role for hydrogen in the CO2-free energy system. Focus lies on 4 key aspects:

1. laws and regulations
2. cost reduction and upscaling green hydrogen
3. sustainable end consumption
4. supporting and flanking policy

2020-current

Government installs SDE+ subsidy scheme successor: **SDE++.**

This regulation reimburses: i.a.: biomass heat production, biogas production, solar pv and solar thermal, wind on land, geothermal, hydropower.

The most important change from SDE+ to SDE++ is that the focus now shifted from energy production to CO2 reduction. Furthermore a couple of new techniques are became eligible for compensation.

2020-2022

Start of national research program **HyDelta**, that aims at the **safe integration of hydrogen** into the **existing** gas transport and distribution **infrastructure**. The consortium focusses on the transport of hydrogen and subdivided the most essential questions into three work packages.

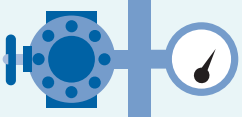
1. Hydrogen safety: is concerned with questions regarding transport of hydrogen in the existing methane gas infrastructure.

2. Hydrogen in the gas grid: is concerned with questions regarding the operation, maintenance, and component selection for the transport of hydrogen in the existing gas transmission and distribution infrastructure.

3. Value chain & Hydrogen admixing: investigates the current state of art of the hydrogen technologies, the potential business cases that exist around them, and an investigation into the topic of hydrogen admixing from a policy perspective.

HyDelta is a consortium of DNV, Kiwa, Gasunie, Netbeheer Nederland, New Energy Coalition, TNO and is funded by TKI, Hydrogen Europe, FCH JU.

More detailed information on the can be found on: Hydelta.nl. **[32]**



2020- current

Realisation of the Kiwa-Alliander **Hydrogen Experience Centre**: a **training** and **demonstration** facility for conversion projects in the **build environment**.

The Hydrogen Experience center is primarily designed to be a training facility for gas distribution technicians and installers. Besides that it also serves as a demonstration location to show anyone, from local government to interested residents, that it is possible to bring hydrogen to the build environment.

Setup
The Hydrogen Experience Center is a home which is connected to the methane gas distribution network as well as a hydrogen distribution system fed by tube trailers. The same distribution pipelines are used for the methane gas and hydrogen. Two boilers reside in the house: one running on methane gas and one running on 100% hydrogen. Technicians and installers can train the technical skills necessary for the conversion process from methane gas to hydrogen and practice maintenance skills on the hydrogen distribution network outside of the building.

Lessons learned/ points of interest
- Bringing hydrogen to the build environment is technically well possible.
- Working methods to switch from boilers for methane gas to boilers for hydrogen need to be established with careful attention. This also applies to working methods for converting, re-commissioning and maintenance of the distribution pipelines.

Investment
Project to **experiment** and/ or establish **proof of concept**: low investments, short duration/ short cyclic, no residents directly involved, continuous testing locations, education and training.

More information on the activities surrounding this facility can be found here. **[33]**

A project by Kiwa and Alliander.

2020-2023

Realization of a **hydrogen pipeline** and **small network** for testing hydrogen **equipment, appliances and heating systems** on **EnTranCe**.

Setup and aim
A hydrogen pipeline was installed on the testing grounds and connected to the already existing ring network for hot water, cold water, electricity and gas.
Companies, researchers and students can experiment with, test and improve their hydrogen equipment. Examples of these are heating systems for homes or hydrogen conversion systems.

Investment
Project to experiment and/ or establish proof of concept: low investments, short duration/ short cyclic, no residents directly involved, continuous testing locations, education and training.

The partners empowering EnTranCes can be found here. **[34]**

2020-

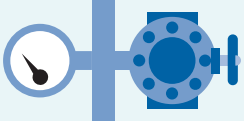
Pilot project Wagenborgen: Using hydrogen in combination with hybrid heat pumps in the **build environment** to heat a residential area.

Setup
Green hydrogen is supplied by a local farmer and transported through partly new, party repurposed gas pipelines to a residential area with approximately 40 tenants in Wagenborgen. A combination of a 100% hydrogen boiler, hybrid heat pump, solar panels and isolation are installed to heat the houses. The houses are expected to be connected to the hydrogen network at the end of 2022.

Lessons learned/ points of interest
The municipality of Eemsdelta has been engaged in the process from the start of the project. Good communication with the municipality and the residents is one of the things that makes this project unique.

Investment
A small scale pilot project: medium investments, medium duration, small scale, residents involved on own initiative, existing distribution network.

Partners in this project are: Groninger Huis, Enexis Groep, Energiewacht, Intergas and Clean Energy.



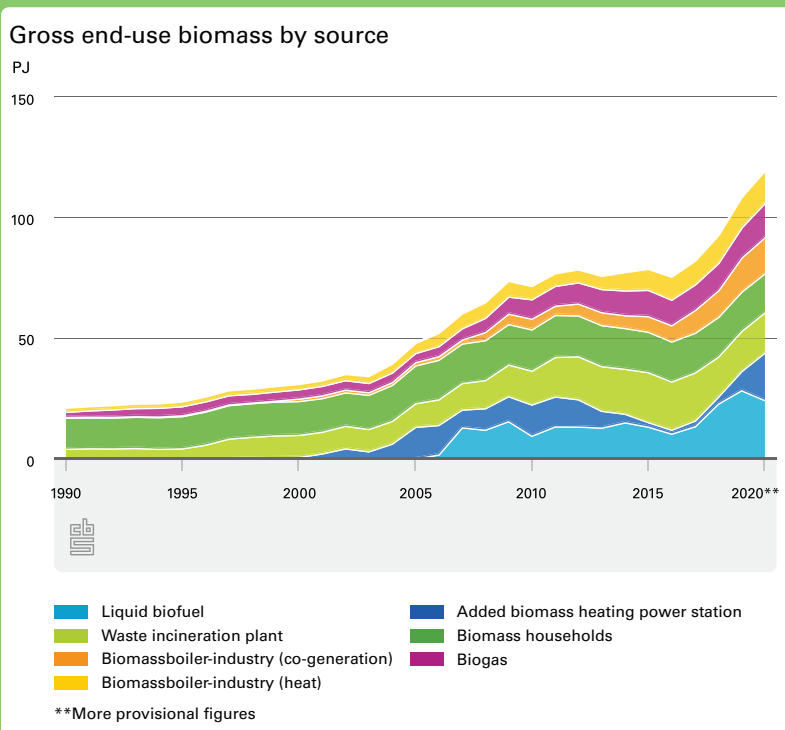
2021-current

Government announces plans based on the Roadmap Green Gas:

- Blending obligation for green gas: in 2030 In 2030 20% of the used gas should consist of green gas.
- Subsidies for CO2-free gasses and green gas. Specific examples are:
  - supporting gas-fired power stations so that they can use CO2-free gas.
  - subsidies for the purchase of hybrid heat pumps
  - subsidies to support the production of hydrogen using electrolysis technique (min. 0.5 MW)
  - supporting green gas producers

Current

The amount of **biomass** produced and used for different applications has increased over the years. 1000PJ = 31,6 BCM **[35]**



Current

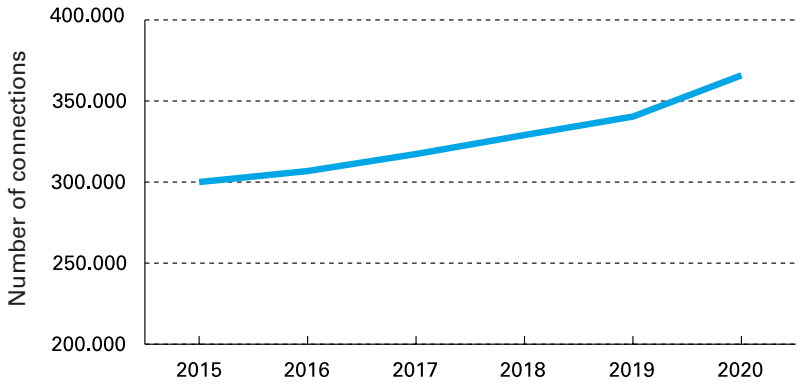
Numbers of **green gas** producers connected to the gas grid have risen over the years and consumption of green gas keeps rising.

From 2019 to 2020 the share of green gas increased by thirty percent.
- 2019: 148 million cubic meters
- 2020: 196 million cubic meters (equivalent to 1,915 GWh). **[36]**

For some network operators green gas has become standard business instead of exception.

Current

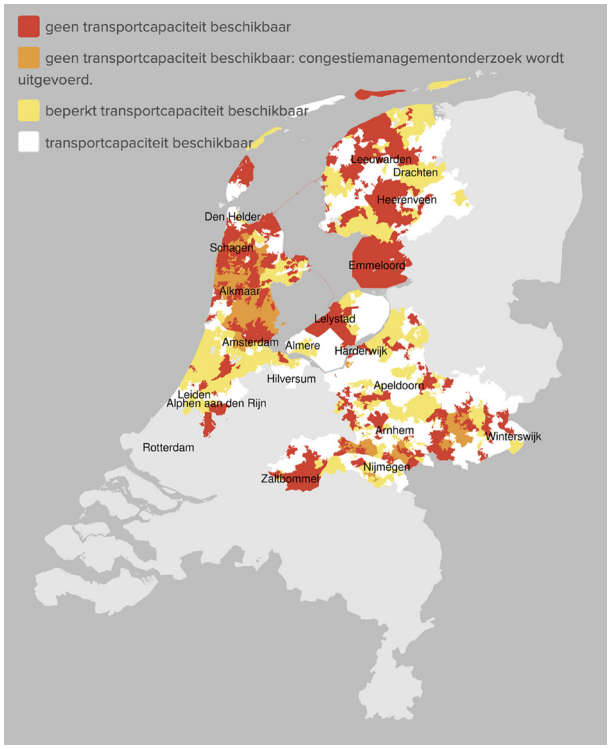
The amount of houses that is connected to large **district heating** networks is still growing. [23]

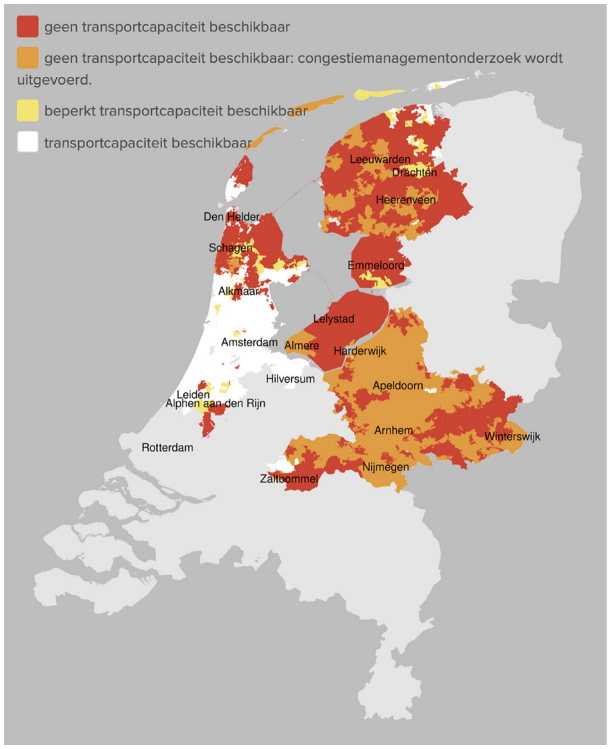


Current

The situation of **congestion** of the **Dutch electricity grid** operated by DSO Liander. The image on the left depicts the availability of connections for power consumption. In the red and orange areas entrepreneurs cannot settle as their establishment cannot be connected to the electricity grid (e.g. supermarkets). On the right an image of the producers that want to feed back into the grid. The red zones are predominantly rural areas where a surplus of decentralized green electricity, produced by solar of wind, cannot be fed back into the grid. **[37]**

The legend of the pictures is as follows: Red no transport capacity available; orange no transport capacity available, congestionmanagement research being conducted; yellow limited transport capacity available; white transport capacity available.





Current

Detailed planning and investigation for the development of the **hydrogen backbone** from Gasunie.

More details on the plans and phases of development can be found here. **[38]**

Current

Gasunie is involved in project Amaris. A project for large scale CO2 transport and storage in empty gas fields under the North Sea.

More details on the current state of the project can be found here. **[39]**

2022

Start of national research program **HyDelta 2.**

A continuation of the HyDelta research program of 2022.

HyDelta 2 is a consortium of DNV, Kiwa, Gasunie, Netbeheer Nederland, New Energy Coalition, TNO and is funded by TKI, Hydrogen Europe, FCH JU.

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