The Netherlands 2020

Energy Policy Review

International Energy Agency

INTERNATIONAL ENERGY AGENCY

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Foreword

The International Energy Agency (IEA) has conducted in-depth reviews of the energy policies of its member countries since 1976. This process supports energy policy development and encourages the exchange of international best practices. By seeing what has worked – or not – in the "real world", these reviews help identify policies that deliver concrete results. Since 2017, the IEA has modernised the reviews by focusing on the key challenges in today's rapidly changing energy markets.

As one of the founding members of the IEA, the Netherlands has a long and deep history with the Agency. I greatly appreciate the support of the Netherlands for our work in numerous areas, including participation in the IEA Technology Collaboration Programmes, Clean Energy Transitions Programme, and the Clean Energy Ministerial. I also thank the Netherlands for its longstanding co-operation and support for the IEA's work on energy access in Africa.

The Netherlands is aiming for a rapid transition to a carbon-neutral economy that underpins economic growth and energy security. To drive this transition, the Netherlands has a strong commitment to cutting greenhouse gas emissions. It aims to reduce emissions by 49% by 2030 and by 95% by 2050 – compared with 1990 levels. Its 2019 Climate Agreement defines policies and measures to support the achievement of these targets and was developed through a collaborative process involving parties from across Dutch society.

The Netherlands has made notable progress in its transition to a carbon-neutral economy. Thanks to increasing energy efficiency, energy demand shows signs of decoupling from economic growth. The share of energy from renewable sources doubled from 2008 to 2019, with especially strong growth in recent years in offshore wind and rooftop solar. However, the Netherlands remains heavily reliant on fossil fuels and has a concentration of energy- and emission-intensive industries that will not be easy to decarbonise. The government should closely monitor the results of recent policies focused on reducing emissions and be ready to make adjustments as needed to keep the country on a path to carbon neutrality.

The Netherlands is a key player in European energy markets and beyond. It is an important transit and trade hub for natural gas, oil and electricity – and has a large oil-refining and chemical industry. The Netherlands aims to maintain its role as an energy hub while transitioning to a carbon-neutral economy by exporting renewable electricity and supporting the development of a robust market for low-carbon hydrogen. The government has adopted a Hydrogen Strategy to boost the production and use of low-carbon hydrogen and is supporting carbon capture and storage to lower industrial emissions.

The Netherlands responded quickly to the immediate economic impacts of the Covid-19 pandemic with generous support to people and industry while also keeping on a path to carbon neutrality. For instance, in line with recommendations from this report, the government introduced subsidies for electric vehicles in June 2020.

It is my hope that this in-depth review will help the Netherlands accelerate its transition to a carbon-neutral economy. The IEA is committed to helping the government achieve its goals of rapidly reducing emissions while maintaining a secure and affordable energy supply.

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Executive Director

International Energy Agency

ENERGY INSIGHTS

ENERGY SYSTEM TRANSFORMATION

ENERGY SECURITY

ANNEXES

LIST OF FIGURES, TABLES AND BOXES

Figures

Tables

Boxes

1. Executive summary

Overview

The Netherlands is aiming for a rapid transition to a low-carbon economy and has placed ambitious greenhouse gas (GHG) reduction targets at the centre of energy and climate policy. The 2019 Climate Act sets targets to reduce GHG emissions by 49% by 2030 and by 95% by 2050 (versus 1990 levels). The Netherlands has developed a detailed policy framework to drive the achievement of these targets. The core of this framework is the 2019 Climate Agreement, which was developed using the collaborative Dutch Polder system. Over 100 stakeholders from across society contributed to developing the 2019 Climate Agreement, which contains emissions reductions targets and measures in five sectors: electricity, industry, the built environment, mobility, and agriculture and the natural environment.

From 2008 to 2018, the population of the Netherlands increased by 5% and gross domestic product (GDP) grew by 9%. Over the same period, energy demand declined by 5% thanks in part to a 15% improvement in the energy efficiency of the economy. The Netherlands has also achieved notable reductions in GHG emissions. In 2018, GHG emissions were down 15% from 1990 levels. The Netherlands is home to a large concentration of energy and emission-intensive industries and remains heavily reliant on fossil fuels. From 2008 to 2018, the share of fossil fuels in total primary energy supply (TPES) declined only slightly, from 92% to 90%. As a result, a recent increase in economic activity has caused emissions reductions to stall. In 2018, energy-related GHG emissions were slightly higher than in 2014.

The Netherlands is also facing new energy security challenges. Natural gas is the largest source of domestic energy production and a key fuel for industry and for building heating. The Groningen gas field, located in the northeast of the Netherlands, is one of the largest gas fields in the world and was historically the main source of domestic gas production. In January 2018 and May 2019, natural gas production activities in the Groningen field cuased eathquakes that damaged over 10 000 buildings and resulted in strong public and political pressure to end gas production from Groningen as soon as possible. In response, the Dutch Cabinet issued decisions in March 2018 and September 2019 that aim to end gas production from Groningen by mid-2022, while ensuring security of gas supply by reducing gas demand and increasing the availablitiy of gas from sources other than Groningen. From 2013 to 2018, domestic gas production fell by 55% and energy import dependency increased from 29% to 72%. Because of steady demand for natural gas and falling domestic gas supply, the Netherlands became a net gas importer for the first time in 2018.

Analysis conducted in November 2019 by the Netherlands Environmental Assessment Agency (PBL) indicates that the Netherlands is not on track to meet the 2030 target of a 49% reduction in GHG emissions. An updated estimate of emissions reductions covering the impact of all of the Climate Agreement's measures as well as additional measures implemented in 2019 and 2020 is expected in October 2020. As the Netherlands implements the 2019 Climate Agreement and other policy initiatives, the government should closely track progress on emissions reductions and other energy sector targets and be ready to adjust policy as needed to keep the country on the path to a robust low-carbon economy while ensuring energy security.

Energy supply, demand and trade

Natural gas and oil are the most important fuels in the Dutch energy supply. In 2018, TPES came from natural gas (42%), oil (37%), coal (11%), biofuels and waste (5%), and small shares from nuclear, wind, solar, hydropower and geothermal. The Netherlands is still one of the largest gas producers in Europe; however, domestic gas supply and gas exports are rapidly declining as production from Groningen is being phased out. Domestic oil supply is small, especially in comparison to the large oil demand. All coal is imported and is used primarily for electricity generation and steel production. The electricity supply is also heavily reliant on fossil fuels. In 2018, electricity generation came primarily from gas (52%) and coal (27%).

Fossil fuels also dominate Dutch energy demand. In 2018, oil and gas covered 77% of total final consumption (TFC), while electricity covered just 16%, the second-lowest share among IEA member countries. The dominance of oil and gas and the low level of electrification are driven by the large industry sector concentrated on refining and chemicals production and the high level of natural gas heating. In 2018, oil and gas covered 80% of industry demand, while natural gas covered 71% of residential demand and 48% of service sector demand, mainly for heating. Greenhouses in the large agricultural sector are also a major source of gas demand for heating.

Dutch energy demand is driven primarily by industry demand, which varies with economic activity and accounted for 44-47% of TFC between 2008 and 2018. Heating demand has a major impact on Dutch energy demand. The highest level of energy demand in recent history occurred in 2010 and was driven by unusually cold weather. As with most IEA countries, Dutch transport demand is dominated by oil. However, the Netherlands has an extensive rail network that is almost completely electrified and is a global leader in electric vehicle (EV) deployment and EV charging infrastructure, with around 200 000 registered EVs and over 50 000 EV charging stations in 2019.

Energy from renewable sources accounted for only 7.4% of total final energy consumption (TFEC) in 2018, the third-lowest share among IEA member countries and well below the IEA median of 12.1%. However, renewable energy deployment is progressing rapidly. The renewable contribution to TFEC increased by 50% between 2008 and 2018. Bioenergy is the primary source of renewable energy and includes transportation biofuels and direct use of biomass in heating and electricity. The share of renewable electricity generation from wind and PV has grown quickly in recent years. It is expected that increasing generation from renewables will shift the Netherlands from its historic status as a net importer to a net exporter of electricity in the early 2020s.

The Netherlands is an important transit and trade hub for natural gas, oil, electricity and coal and has extensive cross-border and subsea oil and gas pipelines and electrical interconnections. Dutch ports play a key role in global and regional energy trade and have one of the largest concentrations of oil refining and marine bunkering fuels in Europe and a major liquefied natural gas (LNG) terminal. The Netherlands is also home to the Title Transfer Facility (TTF), the largest gas-trading hub in Europe.

Energy sector targets and policy

The Climate Act sets targets to reduce GHG emissions by 49% by 2030 and by 95% by 2050 (versus 1990 levels). The 2019 Climate Agreement and other initiatives define a broad framework of supporting policies and measures focused on achieving these targets. A new framework for research and innovation is being implemented under the Integral Knowledge and Innovation Agenda (IKIA), which defines 13 Multiannual Mission-Driven Innovation Programmes (MMIP) that focus research on driving emissions reductions across all sectors. One of the most important instruments to drive emissions reductions is the Stimulation of Sustainable Energy Production (SDE+) support scheme, which uses competitive auctions to award operational subsidies to renewable energy projects. From 2011 to 2020, SDE+ allocated EUR 60 billion of subsidies, which are paid out over a period of up to 15 years based on the amount of renewable energy generated. In 2020, SDE+ was expanded into the Sustainable Energy Transition Incentive Scheme (SDE++), which uses a similar auction process to award subsidies to a wider set of technologies based on avoided CO_2 emissions, including carbon capture and storage (CCS) and low-carbon hydrogen.

To encourage industrial emissions reductions, a carbon levy will be introduced in 2021. The levy will be paid for emissions above a certain threshold, which will be reduced annually through at least 2030 in line with 2019 Climate Agreement targets. To allow domestic industry to stay competitive globally while strongly reducing emissions, the government aims to balance the cost of the levy with financial support from SDE++, especially for CCS, which is expected to deliver the majority of emissions reductions in industry. Industry also has obligations to increase energy efficiency and reduce natural gas demand.

The largest electricity emissions reductions are expected to come from a ban on coal-fired generation, which requires coal plants to cease operating, or convert to alternative fuels, by 2030. Major reductions are expected from an accelerated deployment of renewable generation supported by SDE+, SDE++ and other measures. An effective offshore wind policy framework is driving rapid deployment and aims for 49 TWh of generation by 2030. Net-metering for small-scale PV has contributed to strong residential PV deployment.

Regional Energy Strategies aim to drive emissions reductions by supporting 35 TWh of onshore renewable electricity and a transition to low-carbon heating. Local governments, in co-operation with network operators, the private sector and social organisations, are developing these strategies to resolve barriers related to costs, spatial planning, social acceptance, cost impacts and integration of renewables. The government provides technical and financial assistance for the development and execution of the strategies.

Support measures for reducing transport sector emissions include policies pushing for the adoption of zero-emission vehicles (battery electric and hydrogen fuel cell vehicles) for personal, public and freight transport. These include tax incentives that encourage zero-emission vehicle purchases and measures supporting the development of infrastructure for EV charging and hydrogen fuelling stations. The Netherlands also aims for a broader shift to a more efficient and diverse mobility sector that supports walking, biking, mobility services and other measures to reduce emissions.

As a European Union (EU) member state, the Netherlands is subject to numerous energy sector targets based on EU directives. The Dutch National Energy and Climate Plan (NECP) defines measures to support the achievement of 2030 targets for GHG emissions reductions, renewable energy and energy efficiency set under the EU Clean Energy Package. The measures in the NECP are based primarily on the 2019 Climate Agreement.

Low-carbon gas transition

Natural gas is arguably the most important energy source in the Netherlands. In 2018, natural gas accounted for 90% of residential heating demand, 76% of domestic energy production, 51% of electricity generation, 43% of TPES and 34% of TFC. However, Dutch energy policy is pushing to rapidly reduce the role of gas in the energy system to support the transition to a low-carbon economy and to protect public safety in relation to earthquakes caused by gas production.

The government foresees that natural gas will be an important part of the energy system through at least 2030 and that low-carbon gases will play a critical role in transitioning to a carbon-neutral energy system, especially in industry and other hard-to-decarbonise sectors. To ensure reduced emissions from natural gas while maintaining energy security, the Netherlands is executing a broad policy agenda to reduce natural gas demand and accelerate the production and use of low-carbon gases. At the same time, the government aims to leverage existing gas infrastructure to support the transport and use of low-carbon gases and to enable CCS by supporting transport and storage of CO_2.

Several major policy measures have been implemented to reduce gas demand. The Natural-gas Free Districts Programme supports the transition of 1.5 million homes from gas to low-carbon heating by 2030. The Gas Act was amended in 2018 to change the existing obligation to connect new homes and buildings to the gas network into a ban on new gas connections. Numerous support programmes and requirements aim to reduce gas demand through energy efficiency or the deployment of renewables, particularly in the built environment and industry.

The Dutch Hydrogen Strategy and Green Gas Roadmap define plans to accelerate large-scale production and use of low-carbon hydrogen, and a variety of bioenergy-based gases, including biomethane. These strategies support the use of low-carbon gases across all sectors and aim to increase Dutch expertise in low-carbon gases as the country transfers away from natural gas. Biomethane production and injection into the gas grid has been expanding and several large-scale low-carbon hydrogen projects are being planned. The government is supporting accelerated deployment of low-carbon gases through dedicated research and demonstration funding. Low-carbon hydrogen and biomethane projects are also eligible for SDE++ funding.

The phase-out of Groningen gas production has notable impacts in relation to energy security. Groningen produces low calorific gas (L-gas), which covers a significant share of gas demand in the Netherlands, Belgium, and bordering regions of France and Germany, and is particularly important for meeting seasonal heating demand. The Netherlands has several policy measures specifically targeted at ensuring L-gas supply in the near term, while working to quickly reduce L-gas demand, including through regional co-operation.

Flexible energy systems

The Netherlands sees flexible and interconnected energy systems as essential to achieving a cost-effective transition to a low-carbon economy. Implementation of the 2019 Climate Agreement measures would result in at least 70% of electricity generation coming from renewables (mainly variable wind and PV) by 2030. The Climate Agreement also calls for 1.9 million vehicles powered by electricity or low-carbon hydrogen, broad electrification of heating and industrial processes, and large-scale production and use of low-carbon gases. This represents a major transition from the current energy system. In 2018, only 16.5% of electricity came from renewables, the level of electrification was low in most sectors and low-carbon gases met only 0.4% of energy demand.

To address these transformative challenges, the government is supporting the development of a digitalised energy system that enables high shares of variable renewable generation, broad electrification of end-uses, co-ordination between networks for electricity and low-carbon gases, and innovative new energy services. The new Energy Law planned for 2022 aims to support demand-side response (DSR), energy services and aggregators, and other measures to create more flexible and efficient energy systems and markets. To lay the foundation for flexible energy systems, the Netherlands is aiming for 80% of households to have a smart meter by the end of 2020. The Netherlands is also supporting the development of a market for energy management services. In 2018, around 1 million households had installed systems allowing them to manage their electricity consumption.

Steps towards flexible energy systems are being taking in many areas. Electricity system operators are co-operating with research centres to determine how smart charging can limit the impact of EVs on the electricity grid and how EVs can act as resources. System operators are also conducting pilot projects showing that distributed resources such as renewable generation, energy storage and DSR can support more efficient grid operations, for example, by providing ancillary services. The Hydrogen Strategy aims to support flexible energy systems by developing hydrogen production, transport and storage to support the integration of variable renewables and seasonal energy storage. To ensure continued progress towards flexible energy systems, the government needs to develop a clear approach to energy sector data, including data ownership and how data can be easily accessed while addressing issues of privacy and cybersecurity.

Fossil fuel subsidy review

In support of the transition to a low-carbon economy, the Netherlands conducted a review of fossil fuels subsidies (FFS), jointly led by the Ministry of Economic Affairs and Climate Policy and the Ministry of Finance. At the request of the government, the

Organisation for Economic Co-operation and Development (OECD) and the IEA facilitated the FFS review as part of this IEA review of Dutch energy policies. Based on consultations with the government, energy sector stakeholders and FFS experts, the OECD and IEA developed a FFS report highlighting policy measures which could be considered for reform and providing insights on how existing policy and budget processes could be adjusted to better identify and address issues relating to fossil fuels and the energy transition. The report was delivered to the government in April 2020 and will be used to inform the government response to questions from parliament concerning FFS and the potential need for energy policy, subsidy and tax reforms.

Key recommendations

The government of the Netherlands should:

- ☐ Monitor potential security of supply issues resulting from the mid-2022 closure of the Groningen gas field and growing dependence on natural gas imports, with a focus on reducing demand, decarbonising the gas supply and repurposing gas infrastructure.
- ☐ Ensure that energy policy supports strong deployment of digitalisation in all sectors and develop clear regulations on energy sector data, supporting transparency and easy access, while also addressing issues of privacy and cybersecurity.
- ☐ Ensure that the 2019 Climate Agreement GHG emissions reduction measures support cost-effective achievement of EU requirements, including targets for renewable energy and energy efficiency.
- ☐ Support early-stage deployment of emerging technologies that have the potential for cost-effective emissions reductions, to stimulate mobilisation of private funds and bridge the gap from demonstration to large-scale commercial deployment.
- ☐ Revise the regulatory framework for electricity markets to provide room for innovation and facilitate proactive development of an electricity system that can safely integrate increasing shares of variable renewable generation and support smart grid solutions.
- ☐ Drive commercial scale low-carbon hydrogen development in the near term by facilitating investment decisions and creating an adequate support scheme for scaling up electrolysis, carbon capture utilisation and storage, and supporting infrastructure.

2. General energy policy

Key data

(2018)

TPES: 72.9 Mtoe (gas 42.1%, oil 37.0%, coal 11.3%, bioenergy and waste 5.4%, nuclear 1.3%, wind 1.2%, solar 0.5%, geothermal 0.1%, electricity imports 0.9%), -6.7% since 2008

TPES per capita: 4.2 toe/cap (IEA average: 4.2 toe/cap, IEA median 3.7 toe/cap)

TPES per unit of GDP: 79 toe/USD million 2015 prices PPP (IEA average: 95 toe/USD million PPP, IEA median 83.5 toe/USD million PPP)

Energy production: 36.4 Mtoe (natural gas 76.2%, biofuels and waste 13.1%, oil 4.1%, nuclear 2.5%, wind 2.5%, solar 1.0%, heat 0.4%, geothermal 0.2%), -46.2% since 2008

TFC: 58.1 Mtoe (oil 42.8%, natural gas 33.6%, electricity 16.0%, district heat 3.4%, bioenergy and waste 2.5%, coal 1.4%, geothermal 0.2%), -5.1% since 2008

Country overview

The Kingdom of the Netherlands consists of four countries: the Netherlands and the Caribbean island nations of Aruba, Curaçao and Sint Maarten. The Netherlands is composed of 12 contiguous provinces located in Europe and 3 special municipalities located on the Caribbean islands of Bonaire, Sint Eustatius and Saba. The vast majority of the population, and economic and energy sector activity, are concentrated in the 12 European provinces of the Netherlands, which are located in northwest Europe in the Delta Region of the rivers Rhine, IJssel and Meuse. The Netherlands has land borders with Belgium and Germany, and a maritime border with the United Kingdom (Figure 2.1). The Netherlands covers around 41 500 square kilometres, with 50% of the land area less than 1 metre above sea level and around 20% below sea level.

The Netherlands has been a constitutional monarchy since 1815 and a parliamentary democracy since 1848. The country has a bicameral parliament. The House of Representatives has 150 seats with members selected through national elections and is the main chamber with responsibility for proposing legislation. The Senate has 75 seats with members selected by the governments of the 12 provinces and 3 special municipalities. The Senate has the right to approve or reject legislative proposals from the House of Representatives. The Prime Minister is the head of the government and along with the Dutch Cabinet executes the laws and regulations of the Netherlands. King Willem-Alexander is the head of state. The Netherlands has a tradition of multi-party coalition governments. No single party has held a majority in parliament since the 19th century. Policies on social, economic and energy matters are made in close consultation with the trade unions and employer organisations, represented through the Social-Economic Council.

Figure 2.1 Map of the Netherlands

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

The Netherlands has experienced steady population growth for several decades and is one of the most densely populated countries in the world. The population increased from 15.9 million in 2000 to 17.3 million in 2019, driving overall population density to 416 inhabitants per square kilometre. The population is concentrated in the Randstad area, which is comprised of the four largest cities of Amsterdam, The Hague, Rotterdam and Utrecht, which had around 8 million inhabitants in 2019. Amsterdam is the capital and most populous city, with around 875 000 inhabitants in 2019. The Hague is the seat of government and hosts the International Court of Justice. Rotterdam is home to one of the largest and busiest ports in the world. Utrecht hosts the largest university in the Netherlands and is a centre of research activities.

Despite its relatively small population and size, the Netherlands has a large and highly competitive economy. In 2018, the Netherlandsit had the 17th-largest economy in the world (IMF, 2020). In 2019, the Netherlands ranked fourth in the World Economic Forum's *Global Competitiveness Report* (Schwab, 2019). Gross domestic product (GDP) growth stalled following the 2008 financial crisis, but GDP began to steadily increase in 2013, reaching USD 919 billion[1] in 2018, a 9% increase from 2008 and a 28% increase from 2000. As in many OECD countries, the Netherlands has seen steady growth in the share of GDP coming from the service sector, which increased from 66% in 2008 to 70% in 2018 (Plecher, 2020). Industry plays a key role in the economy and is focused on energy-intensive activities, including oil refining and production of chemicals and steel. The Netherlands has a large agricultural sector, with the second-highest agricultural exports in the world after the United States (Rintoul, 2019).

The Netherlands has a well-developed energy sector. The country's strategic location makes it an important transit and trade hub for natural gas, oil, electricity and coal. The Netherlands has significant natural gas production and a large oil-refining and chemical industry. The country is both a major exporter and importer of energy, and the competitiveness of Dutch industry depends on affordable and secure energy supplies. The openness of the Dutch market and the high share of trade have helped to drive economic growth, but also expose the Netherlands to developments in global energy markets. The Dutch energy sector is a key driver of exports, innovation and economic growth and represented around 4% of GDP in 2018. The contribution of the energy sector to GDP has declined from a recent peak of around 6% of GDP in 2012. A large part of the energy sector consists of domestic production of natural gas. Hovever, government policy is focused on rapidly reducing gas production in line with climate targets and because earthquakes in northeastern Netherlands caused by natural gas production activities have resulted in damage to over 10 000 buildings and significant risks to public safety. Looking to the future, the government expects the energy sector's contribution to GDP to remain at around 4% through 2030, as increased economic activity related to renewable energy offsets a declining contribution from fossil fuels (PBL, 2019a).

The Netherlands is highly reliant on fossil fuels. In 2018, fossil fuels (mainly natural gas and oil) covered 90% of total primary energy supply (TPES), one of the highest shares in the International Energy Agency (IEA). The Netherlands is aiming for a rapid energy transition that will reduce reliance on fossil fuels while boosting economic growth. To drive this transition, the Netherlands has focused energy and climate policy on greenhouse (GHG) emissions reductions. The 2019 Climate Act sets targets to reduce GHG emissions by 49% by 2030 and 95% by 2050 (compared to 1990 levels). The 2019 Climate Agreement defines specific policies and supporting measures for meeting the 2030 and 2050 emissions reductions targets.

The Netherlands is a founding member of the IEA, the Organisation for Economic Co-operation and Development (OECD), and the European Union (EU) and co-operates on energy policy matters through numerous regional and international bodies and organisations. The Netherlands' energy policy is framed by EU requirements on issues including electricity and gas markets, energy efficiency, renewable energy, state aid, the environment and CO_2 emissions. As the Netherlands is a major energy trade and transit hub, close regional co-operation is a priority, especially on energy security. Co-operation has been expanding on all levels to address new energy challenges and

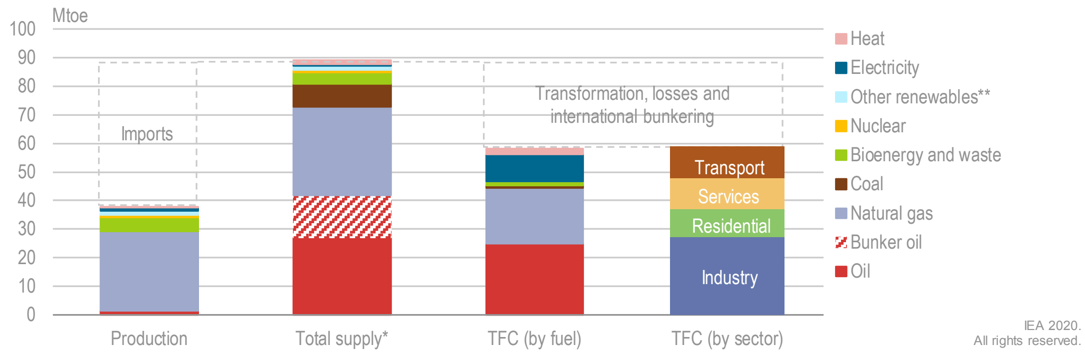
[1] GDP PPP (purchasing power parity) in 2015 USD.

opportunities, including the transition to a low-carbon economy, integration of variable renewable generation and other areas.

Supply and demand

Natural gas and oil are the most important fuels in the Dutch energy mix. In 2018, TPES[2] consisted of natural gas (42%), oil (37%), coal (11%), biofuels and waste (5%), and small shares from nuclear, wind, solar and other sources. The Netherlands has several large shipping ports and a major international airport. Including the bunker fuels used for international shipping and aviation at these facilities, oil accounted for nearly half of total energy supply in 2018 (Figure 2.2).

Figure 2.2 Overview of the Netherlands' energy system by fuel and sector, 2018



Oil and gas are the largest energy sources in the Netherlands. The industry sector has the highest energy demand, primarily for oil and gas used in refining and chemical processes.

* *Total supply* includes bunker fuels for international aviation and shipping (not part of TPES).

** *Other renewables* includes wind, solar, hydro and geothermal.

Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

While nearly all crude oil is imported, the Netherlands is a major producer of natural gas and home to the Groningen gas field, one of the largest fields in the world. Following multiple earthquakes related to natural gas production in the Groningen area, the government decided to rapidly decrease production from Groningen. As a result, the Netherlands became a net importer of gas in 2018 for the first time. Following additional earthquakes, the government announced an updated phase-out plan in September 2019, which aims to end natural gas production from Groningen as early as mid-2022.

The industry sector is the largest energy consumer in the Netherlands and accounted for nearly half of total final consumption (TFC)[3] in 2018. The other half of TFC is divided almost equally between the transport, residential and service sectors. Around 50% of industrial demand and a quarter of TFC comes from demand for oil products used for non-energy purposes in the large Dutch chemical and petrochemical sector.

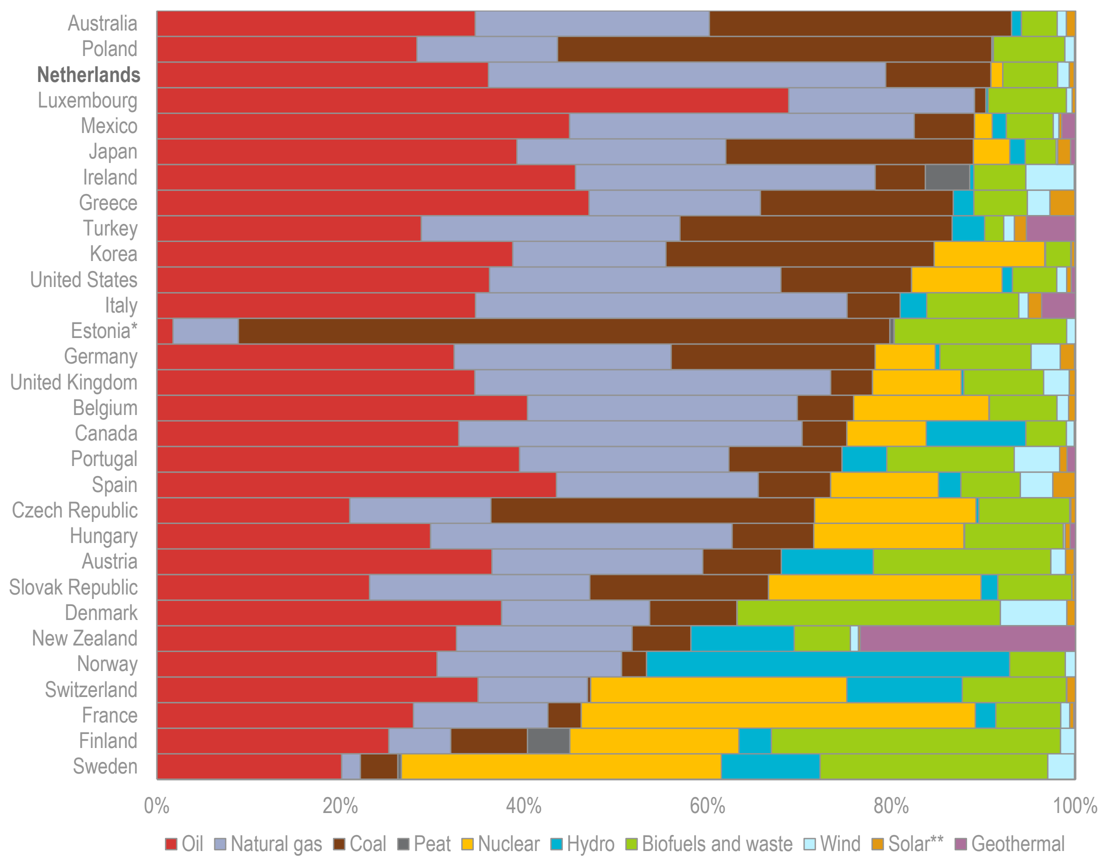
[2] TPES is comprised of production + imports - exports - international marine and aviation bunkers +/- minus stock changes. TPES equals the total supply of energy that is consumed domestically, either directly (e.g. fuels consumed in transport) or in transformations (e.g. fuels used in electricity generation).

[3] TFC is the final consumption of energy (electricity, heat and fuels, such as natural gas and oil products) by end users, and does not include transformations of one energy source into another (e.g. fuels used for electricity generation or crude oi used in refining to produce transportation fuels).

Supply

The Netherlands is highly dependent on fossil fuels. Oil, natural gas and coal together accounted for 90% of TPES in 2018, the third-highest share among IEA member countries (Figure 2.3). Natural gas covered 42% of TPES, the highest share among IEA member countries. From 2008 to 2018, TPES fell 7% to 73 Mtoe (Figure 2.4). Most of this decline resulted from lower supplies of oil and natural gas, with a 13% drop in oil supply and an 11% drop in gas supply. The supply of electricity from wind and solar has increased rapidly, but still represented only 1.2% and 0.5% of TPES[4] in 2018, respectively.

Figure 2.3 Breakdown of total primary energy supply in IEA member countries, 2018



Natural gas, oil and coal are the three largest primary energy sources in the Netherlands, and the total share of fossil fuels in TPES is the third highest among IEA member countries.

* Estonia's oil shale supply is shown as coal.

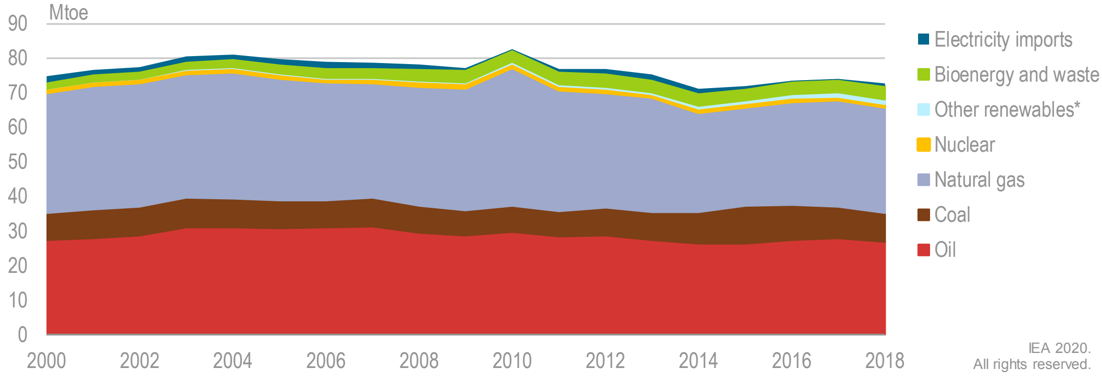
** *Solar* includes solar PV, solar thermal, wave and ocean power, and other power generation (e.g. from fuel cells).

Note: Countries are ranked by share of fossil fuels in TPES (from highest to lowest).

Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

[4] TPES includes thermal losses in power generation for fossil fuels, nuclear and bioenergy used in thermal power plants. For solar, wind and hydro power, the primary energy supply equals the produced electricity, which means that the role for these renewables in final consumption is underestimated when looking at the shares in TPES.

Figure 2.4 Total primary energy supply by source, 2000-18



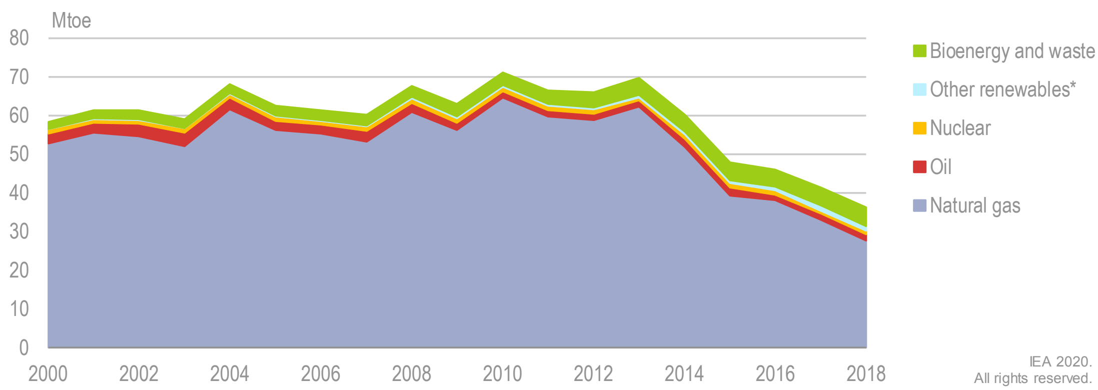
Except for annual variations due mainly to weather and economic conditions, TPES is on a slowly declining trend, with a 7% drop in the last decade.

* *Other renewables* includes wind, solar, hydro and geothermal.
Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Domestic production and import dependency

The ongoing reduction of gas production from Groningen has had a major impact on domestic energy production and import dependency. Natural gas production fell 55% from 2013 to 2018 (Figure 2.5). Gas production will continue to decline under the Groningen phase-out plan. In 2018, natural gas accounted for 76% of total domestic energy production followed by bioenergy and waste (13%) and small shares of oil and electricity from nuclear, wind, PV and hydro.

Figure 2.5 Energy production by source, 2000-18

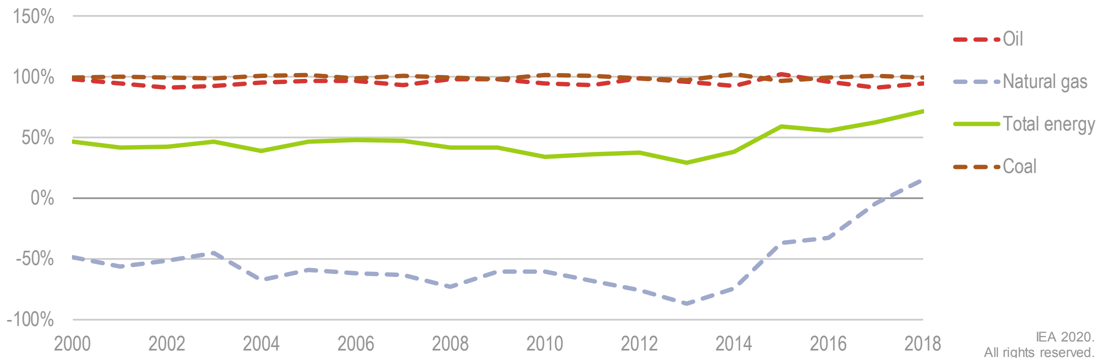


Natural gas covered 76% of total domestic energy production in 2018, but gas production is falling rapidly as production from Groningen is phased out due to the risk of earthquakes.

* *Other renewables* include solar, wind, hydro and geothermal.
Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

The drop in natural gas production made the Netherlands a net importer of gas for the first time in 2018 and has strongly impacted import dependency (Figure 2.6). Energy import dependency dropped from 42% in 2008 to 29% in 2013, as natural gas production was steady but domestic demand was reduced by the 2008 crisis. As of 2013, import dependency started to sharply increase and reached 72% in 2018, in line with falling domestic gas production and increasing energy demand. Domestic oil production is small, especially in comparison to the large industrial and transport demand for oil. Domestic coal production ended in the 1970s and the Netherlands is entirely reliant on coal imports, which primarily support electricity generation and steel production.

Figure 2.6 Import dependency by energy source, 2000-18



The reduction of domestic natural gas production has made the Netherlands a net importer of gas for the first time in 2018; overall import dependency has increased to 72%.

Note: Energy imports as a share of total primary energy supply plus international bunker fuels (oil).
Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

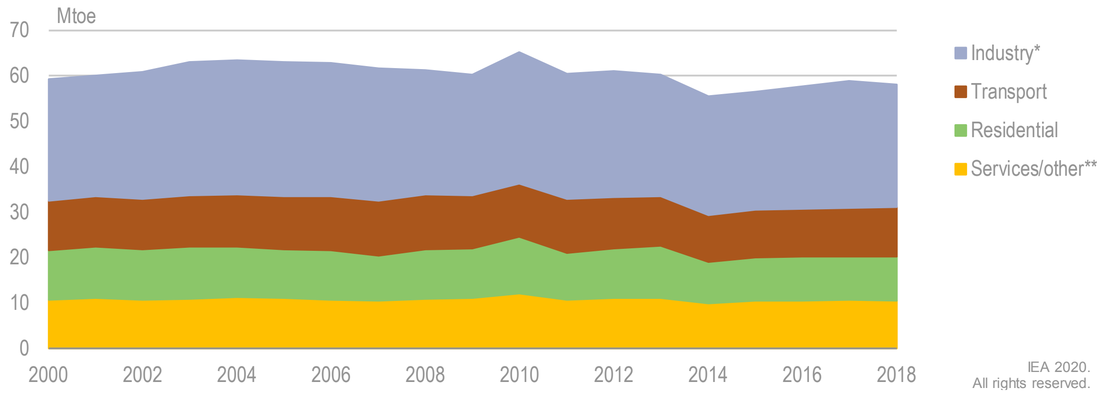
Demand

Energy demand in the Netherlands is primarily driven by industry sector demand, which varies with economic activity and accounted for 44% to 47% of TFC between 2008 and 2018 (Figure 2.7). Heating demand driven by annual temperature variations also has a major impact on total energy demand. TFC peaked at 65 Mtoe in 2010, due to unusually cold weather. Demand declined through 2014 because of reduced economic activity, but increased to 58 Mtoe in 2018 as the economy recovered. From 2008 to 2018, all sectors experienced an overall decline in demand. Residential sector demand decreased by 13%, transport demand dropped 9%, service sector demand fell by 3%, while industry demand was just 1% lower. One key reason for the drop in energy demand has been the significant reduction in the energy intensity of the Dutch economy (TFC/GDP), which fell 14% between 2008 and 2018.

Fossil fuels dominate Dutch energy demand (Figure 2.8). Together, oil and gas covered 77% of TFC in 2018. Electricity covered just 16%, the second-lowest share among IEA countries. The dominance of oil and gas and low levels of electrification are driven by the large industry sector concentrated on refining and chemicals production and the high level of natural gas heating. Oil and gas covered 80% of industry demand, while 71% of residential demand and 48% of services sector demand are covered by natural gas, mainly for heating. Heating of greenhouses in the large agricultural sector is also a major source of natural gas demand. Natural gas and coal are the largest sources of electricity generation.

Biofuels and waste cover some heat demand in the residential and service sectors. The share of district heating in the residential and service sectors is relatively low in comparison to other northern European countries, but district heating plays a notable role in meeting industrial heat demand. As in most IEA countries, Dutch transport demand is dominated by oil, but has a notable share of bioenergy driven by a biofuel blending mandate. The small share of electricity in transport demand comes mostly from the highly electrified Dutch rail network, but there is rapidly growing demand from electric vehicles (EVs).

Figure 2.7 Total final consumption by sector, 2000-18



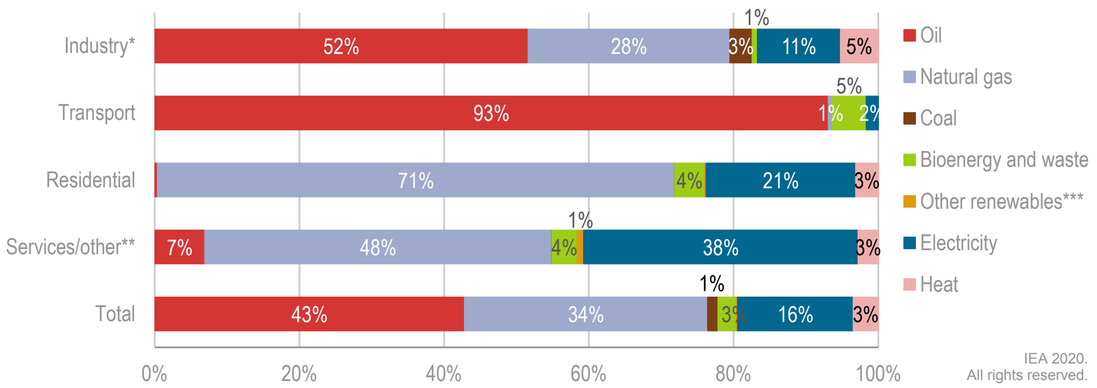
Industry accounts for nearly half of TFC in the Netherlands, dominated by demand from chemical/petrochemical industries. Heating is another key driver of overall demand.

* *Industry* includes non-energy consumption.

** *Services/other* includes commercial and public services, agriculture and forestry.

Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 2.8 Total final consumption by source and sector, 2018



Oil and natural gas accounted for 77% of TFC in 2018. The share of electricity is relatively low as the Netherlands has a high share of gas heating, especially in the residential sector.

* *Industry* includes non-energy consumption.

** *Services/others* includes commercial and public services, agriculture and forestry.

*** *Other renewables* includes geothermal and solar thermal.

Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Institutions

The Ministry of Economic Affairs and Climate Policy has the primary responsibility over energy policy and the design and implementation of measures supporting the achievement of the energy sector targets set under Dutch and EU laws and regulations. Several other ministries have responsibilities in relation to energy policy. The Ministry of Infrastructure and Water Management is responsible for policy concerning transport, including vehicle efficiency and emissions standards, renewable fuels and EVs. The Ministry of the Interior and Kingdom Relations is responsible for energy efficiency in buildings. The Ministry of Agriculture, Nature and Food Quality is responsible for energy efficiency in the agriculture sector. Local and regional authorities are responsible for spatial planning in relation to energy projects and the built environment.

The Netherlands Authority for Consumers and Markets (ACM) is the independent regulatory authority for the electricity, gas and district heating markets. ACM works to protect the rights of consumers and businesses. ACM regulates the electricity and gas transmission system operators (TSOs) and distribution transmission system operators (DSOs). The State Supervision of Mines (SSM) is the independent authority supervising exploration, production, transport and storage of minerals (including gas and oil) and focuses on safety, health, the environment and technically efficient extraction. Both the SSM and ACM fall under the supervision of the Minister of Economic Affairs and Climate Policy.

The Ministry of Finance owns the TenneT holding company, which has two subsidiaries. TenneT TSO B.V. is the Dutch electricity TSO and also owns and operates the offshore electricity grid connecting Dutch offshore wind generation to the onshore grid. TenneT GmbH is one of the four German TSOs. Gasunie Transport Services B.V. (GTS) is the natural gas TSO. GTS is a 100% subsidiary of Gasunie, a fully unbundled gas infrastructure company that is 100% owned by the Dutch state through shares held by the Ministry of Finance. There are eight DSOs, seven of which operate electricity and gas networks and one which operates only a gas network. All DSOs are owned by regional or local governments.

Energie Beheer Nederland B.V. (EBN) is a state-owned energy company supporting upstream gas and oil investment. The Ministry of Economic Affairs and Climate Policy is the sole shareholder. EBN is involved in almost every upstream gas and oil project in the Netherlands as a non-operating partner. EBN also has interests in offshore pipelines and underground storage.

The Netherlands Enterprise Agency (RVO) within the Ministry of Economic Affairs and Climate Policy has responsibility to monitor public spending on energy programmes and manages most of the support schemes for energy research, development and demonstration (RD&D); renewables; energy efficiency; and emissions reductions. The Netherlands Environmental Assessment Agency (PBL) is an autonomous research institute within the Ministry of Infrastructure and Water Management. The PBL conducts strategic policy analysis in the fields of environment and spatial planning, monitors implementation of national climate and energy objectives, and develops long-term climate and energy scenarios.

Energy sector targets and policy

The Netherlands has 2020 and 2030 targets for GHG emissions, energy efficiency and renewable energy, which are driven by national and EU laws, regulations and directives. The Netherlands has a national target for a carbon-neutral energy sector by 2050 and is pushing for aggressive 2050 energy sector targets at the EU level (see Chapters 3, 4 and 6 for detailed discussions on energy sector targets and supporting policies).

CO_2 emissions from large power plants and energy-intensive industries in the Netherlands are regulated under the EU Emission Trading systems (ETS), which uses tradable emission credits to drive emissions reductions across the EU plus Iceland, Liechtenstein and Norway. Sectors covered by the ETS are required to reduce emissions by 21% by 2020 versus 2005 levels and by 43% by 2030.

2020 EU targets

The majority of 2020 targets for the Dutch energy sector are derived from EU directives and regulations. The EU Renewable Energy Directive (RED) requires the Netherlands to reach a 14% renewable share in gross final energy consumption by 2020.[5] In 2018, the renewable share was 7.4%. PBL analysis conducted in 2019 indicated that the target would not be achieved and estimated the renewable share will reach only 11.4% in 2020 (PBL, 2019a). In response, the Netherlands has negotiated an agreement with Denmark for a statistical transfer of renewable energy[6] to ensure achievement of the 2020 renewable energy target (Euractiv, 2020). The Netherlands is on track to achieve the 2020 target of a 10% renewable energy share in transport, having reached a share of 9.6% in 2018 (Eurostat, 2020).

Under the EU Energy Efficiency Directive (EED), the Netherlands has 2020 energy efficiency targets of not surpassing 2 186 PJ of final energy consumption and not surpassing 2 541 PJ of primary energy consumption. In 2018, final energy consumption was 2 105 PJ, 4% below the target, and it is expected that this target will be met. Primary energy consumption was 2 710 PJ in 2018, 6% above the target, and it is expected that the target will not be met. Under the 2013 Energy Agreement, the Netherlands defined an additional target aiming for 100 PJ in final energy savings by 2020. PBL analysis indicates that the target will not be met with additional energy savings estimated to reach 81 PJ.

Under the EU Effort Sharing Decision (ESD), the Netherlands has a target to reduce non-ETS[7] emissions by 16% by 2020 versus 2005 levels. The Netherlands is expected to meet the target. In 2018, non-ETS GHG emissions had been reduced by 17% versus 2005 levels (PBL, 2019a; 2019b).

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[5] EU renewable energy targets are based on gross final consumption using the RED calculation methodology, which includes multiplication of the energy content for certain waste and residue-based biofuels and renewable electricity in transport. The IEA uses a different methodology.

[6] Under the EU RED, member states that are not meeting their renewable energy target can purchase renewable credits from members states that have exceeded their targets. No physical transfer of renewable energy is required.

[7] Non-ETS sectors include agriculture, residential, commercial, waste, non-energy intensive industry and transport excluding aviation within the European Economic Area.

Urgenda ruling

The Urgenda legal ruling requires that total CO_2 emissions be reduced by 25% compared to 1990 levels by the end of 2020. The government has recently implemented several measures to support achievement of the Urgenda target. PBL analysis published in 2019 indicated that the Netherlands is not on track to achieve the 25% target, with an expected emissions reduction of 23% in 2020. In response, the Dutch Cabinet introduced a plan in April 2020 for additional CO_2 emissions reductions that can be implemented quickly. The largest emissions reductions are expected to come from reducing coal-fired generation while maintaining a secure supply of electricity. Additional measures focus on energy efficiency in industry, construction, buildings and agriculture (Government of the Netherlands, 2020a).

Climate Act, Climate Agreement and Climate Plan

The 2017 Coalition Agreement called on the Netherlands to establish GHG emissions reductions as the core of climate and energy policy. The Coalition Agreement specified targets to reduce GHG emissions by 49% by 2030 and by 95% by 2050 (versus 1990 levels). These targets were set down as legal requirements in the Climate Act in May 2019. The target covers all GHG emissions in the Netherlands (Government of the Netherlands, 2020b). Dutch GHG emissions were 221 Mt CO_2-eq in 1990. As such, the Climate Act targets require GHG emissions to be less than 113 Mt CO_2-eq by 2030 and less than 11 Mt CO_2-eq by 2050. In 2018, GHG emissions were 188 Mt CO_2-eq.

Under the Climate Act, the government is required to develop a Climate Plan every five years that defines climate policy over a ten-year period. The first Climate Plan was adopted by parliament in April 2020 and covers the period 2021-30 (Government of the Netherlands, 2020c). The Climate Plan for 2021-30 contains all of the policy measures developed to meet the targets and requirements of the Climate Act, the 2017 Coalition Agreement and relevant EU directives. The Climate Plan for 2021-30 is based mainly on the measures, targets and goals defined in the 2019 Climate Agreement.

In 2018, the Netherlands began developing the Climate Agreement to define specific measures supporting the achievement of the 2030 and 2050 emissions reductions targets set in the Climate Act. Negotiations to develop the Climate Agreement followed the collaborative Dutch Polder system. Over 100 stakeholders contributed to developing emissions reductions measures focused on 5 sectors: electricity, industry, the built environment, mobility, and agriculture and the natural environment. Following extensive negotiations between the stakeholders, the Climate Agreement was finalised in June 2019 (MEACP, 2019a). The Climate Agreement defines 2050 carbon neutrality goals for the five sectors and specifies 2030 targets and measures intended to set the country on the path to 2050 carbon neutrality (Table 2.1).

Table 2.1 Climate Agreement 2050 goals and 2030 targets by sector

2050 carbon neutrality goals	2030 supporting targets
Carbon-free electricity system	At least 35 TWh of onshore wind and solar generation from systems with capacity above15 kW
	At least 49 TWh of offshore wind generation
Raw materials, products and processes in industry will be net climate neutral and at least 80% circular	50% reduction in primary feedstock demand
	Greenhouse gases from production processes and waste sector reduced to around 36 Mt CO_2-eq
	Sustainability improvements to the industrial heat system up to 300ºC achieved
	Electrification of industrial processes implemented
	Carbon capture and storage implemented in a cost-effective manner
	Low-carbon hydrogen production on the road to implementation
	Bio-based raw materials seen as the norm
Zero-emission mobility of people and goods	Zero-emission vehicles 100% of new sales and 1.9 million zero-emission vehicles in total
	One-third of all mobility energy consumption covered by renewable energy
	Reduce freight kilometres by 8 billion kilometres
	A minimum of the 32 largest municipalities will have zero-emission zones for city logistics
Net carbon-neutral agricultural and natural systems	Reductions of at least 1 Mt CO_2-eq in methane emissions, 1 Mt CO_2-eq from reduced energy demand in greenhouses and 1.5 Mt CO_2-eq through smarter land use
Carbon-free built environment	Natural gas phased out of 200 000 existing homes per year
	1.5 million homes and 15% of commercial and public buildings natural gas free
	At least 20% of building energy consumption (including electric vehicles) covered by renewables

Low-carbon hydrogen and green gases

The government sees low-carbon hydrogen and green gases as key options for supporting the energy transition, especially for hard-to-decarbonise end uses in industry and for heavy transportation and aviation. The Dutch Hydrogen Strategy and Green Gas Roadmap define strategies to accelerate large-scale production and use of low-carbon hydrogen and a variety of green gases including biomethane. These strategies support broad use of low-carbon gases across all sectors and aim to grow Dutch expertise in low-carbon gaseous energy carriers as the country transfers away from natural gas. As part of this effort, the government is looking to repurpose existing natural gas infrastructure.

2030 EU targets

Under the EU Clean Energy Package (CEP), all EU member states have an obligation to support EU-wide targets for CO_2 emissions reductions, energy efficiency and renewable energy. All EU member states had to submit a National Energy and Climate Plan (NECP) which defines national targets and policies supporting the EU-wide targets to the European Commission (EC) in 2019. The Netherlands delivered its NECP to the EC in November 2019 (MEACP, 2019b).

Within the CEP, the Emission Sharing Regulation (ESR) sets binding 2030 emissions reduction targets for each EU member state. The national targets support the achievement of the EU-wide target to reduce non-ETS emissions by 40% by 2030 versus 2005 levels. The Dutch NECP sets a target to reduce non-ETS emissions by 36% by 2030 versus 2005 levels. The CEP includes an updated RED, which sets an EU-wide target of a 32% renewable share in gross final energy consumption by 2030. EU member states are required to define a supporting contribution towards the renewable energy target in their NECP. The Dutch NECP sets a target to reach a renewable share of at least 27% by 2030. The CEP also includes an updated EED, which sets an EU-wide 2030 target to increase energy efficiency by at least 32.5% compared to a business-as-usual projection and sets binding targets for EU member states. The 2030 targets for the Netherlands are not surpassing 1 950 PJ of primary energy demand and 1 837 PJ final energy demand (in 2018, primary energy consumption was 2 710 PJ and final energy consumption was 2 105 PJ). The CEP also contains energy efficiency requirements for industry and government buildings.

The initial EC review of all draft NECPs submitted at the end of 2018 indicated that Dutch NECP targets for emissions reductions, energy efficiency and renewable energy all support the achievement of the EU-wide targets. The review of final NECPs is ongoing and the EC may request higher targets from the Netherlands or other EU member states (EC, 2019). The majority of the measures in the Dutch NECP are based on the Climate Agreement, but there are some additional measures to address specific EU requirements. Achievement of the Climate Act 2030 target (49% reduction in total Dutch CO_2 emissions versus 1990 levels) would support the achievement of the NECP targets for emissions reduction, energy efficiency and renewable energy.

The Dutch NECP advocates for increasing the overall EU emissions reduction target to 55% by 2030. This higher target is in line with ongoing discussions related to the European Green Deal. If a higher overall EU target is enacted, it could require increasing the targets and measures in the Climate Agreement and Dutch NECP. The Netherlands is also pushing for EU-wide carbon neutrality goals for 2050.

Supporting measures

The Climate Agreement and NECP detail a wide range of measures to drive emissions reductions across all sectors. These measures include levies, adjustments to tax policy, binding targets and obligations, funding for RD&D and pilot projects, loans and grants for energy efficiency and renewable energy projects, and operational subsidies for renewables and emissions reduction projects.

Energy RD&D

The Netherlands is in the process of realigning its overall energy RD&D programme to focus on achievement of the 2050 carbon neutrality goals defined in the Climate Agreement. A new framework for research and innovation is being implemented under the Integral Knowledge and Innovation Agenda (IKIA), which defines 13 Multiannual Mission-Driven Innovation Programmes (MMIP) that direct research to drive emissions reductions across all energy sectors. The framework is primarily adapting existing RD&D funding mechanisms to support the emissions reduction goals and some new mechanisms are being established (see Chapter 5).

New Energy Law

The Netherlands is in the process of developing a new Energy Law to modernise outdated electricity and natural gas regulations, support the implementation of the Climate Agreement and the EU CEP, and prepare for future developments such as hydrogen. In particular, the new Energy Law aims to support demand-side response, energy services and other measures to create more flexible and efficient energy systems and markets. Public consultations on the new Energy Law are planned for Q2 2020, aiming for a proposal to parliament in Q1 2021, and the law entering into force by January 2022 (see Chapter 7).

SDE+ and SDE++

One of the most important instruments to drive energy transitions in the Netherlands is the Stimulation of Sustainable Energy Production (SDE+) support scheme, which uses competitive auctions to award operational subsidies to renewable energy projects. From 2011 to 2020, SDE+ auctions allocated EUR 60 billion in funding to support the deployment of renewable energy projects. The final SDE+ auction was held in spring 2020 (the budget was expanded from EUR 2 billion to EUR 4 billion to support reaching the Urgenda emissions reduction target). In 2020, SDE+ was expanded into the Sustainable Energy Transition Incentive Scheme (SDE++), which uses a similar tender and auction process to award subsidies to a wider set of technologies based on avoided CO_2 emissions, including carbon capture and storage (CCS) and low-carbon hydrogen. SDE++ auctions will be held on an annual basis, with the first SDE++ auction planned for the second half of 2020. Annual payments to projects winning SDE+ and SDE++ support are expected to reach around EUR 3.3 billion by 2030 (EUR 2.3 billion per year for SDE+ and EUR 1 billion per year for SDE++). It is expected that SDE++ funding will be concentrated on reducing industrial emissions, but also support projects in electricity, heating, and renewable gases and transportation fuels.

Regional energy strategies

The Climate Agreement calls for the development of 31 Regional Energy Strategies to support emissions reductions through the deployment of 35 TWh of onshore renewable electricity generation and a transition to low-carbon heating in the built environment. The strategies are being developed by municipalities, provinces and water boards in co-operation with social organisations; network operators for gas, electricity and district heating; the business community; and residents. The strategies aim to resolve barriers related to spatial planning, social acceptance, cost impacts, and integration of variable wind and PV generation. The government is providing technical and financial assistance to assist with the development and execution of the strategies through the National Regional Energy Strategy Programme.

Electricity sector measures

In addition to SDE+, SDE++ and the Regional Energy Strategies, the Netherlands has several other policy measures supporting energy transition in the electricity sector. The government has developed a highly effective offshore wind policy framework that is driving accelerated deployment and decreasing project costs. Under this framework, the Netherlands is aiming for 49 TWh of generation by 2030. A net-metering scheme for small-scale PV is driving strong growth in residential PV deployment (see Chapter 6 for details on support measures).

In addition to rapidly increasing renewable generation, the Netherlands also aims to reduce electricity emissions through a ban on coal-fired generation, which passed into law in December 2019 and requires that the four coal-fired plants in the Netherlands cease operating, or convert 100% to alternative. The oldest coal-fired power plant (commissioned in 1993) must comply with the coal ban by 1 January 2025. Three coal-fired power plants commissioned in 2015 must comply with the ban by 1 January 2030. Strong reductions in coal-fired generation can also be sought as part of the measures to meet the Urgenda 2020 emissions reduction target (see Chapter 10).

Industry sector measures

To encourage energy transitions in industry, the government is establishing a carbon levy that will come into effect in 2021. The levy must be paid on emissions above a certain threshold, which will be reduced annually through at least 2030 in line with the Climate Agreement targets. The government is aiming to manage the levy in combination with SDE++ to allow domestic industry to stay competitive while investing in cost-effective emissions reductions measures. A significant share of the emissions reductions from industry is expected to come from carbon capture utilisation and storage (CCUS) (see CCUS section later in this chapter) and low-carbon hydrogen (see Chapter 8). Industry also has a requirement to reduce energy demand under the energy efficiency obligation (EEO) programme (see Chapter 4).

Building sector measures

The Netherlands has a focus on reducing natural gas heating in the built environment, including large heat demand from greenhouses. Key measures supporting the transition to low-carbon heating include the Natural-gas Free Districts Programme, which aims to transition 1.5 million homes from gas to low-carbon heating by 2030. The Gas Act was amended in 2018 to change the obligation for a gas connection into a ban of connecting new homes and buildings to the natural gas network. Numerous additional support programmes and requirements exist for the built environment in relation to low-carbon heating transition as well as energy efficiency and distributed renewable energy (see Chapters 4 and 6).

Transport sector measures

Support measures for energy transition in the transport sector include a push for adoption of zero-emission vehicles (battery EVs and fuel cell EVs) for personal, public and freight transport. Measures include subsidies for purchasing new and used zero-emission vehicles, lower taxes for zero-emission vehicles, and support for EV charging and hydrogen refuelling infrastructure. The Netherlands also aims for a broader shift to a more efficient mobility sector that supports walking, biking, mobility services and other measures to reduce emissions. The Netherlands also has a biofuel blending obligation. Vehicles with combustion-based engines will have an important role in transport in 2030 and beyond. To reduce emissions from these vehicles and ensure compliance with EU renewable energy targets, the government is supporting the development of sustainable advanced biofuels and has a biofuels blending mandate that includes requirements for advanced biofuels (see Chapters 4 and 6).

Energy taxation

The Netherlands has a broad energy tax that covers consumption of gas, electricity and districting heating. Consumers also pay a Surcharge for Sustainable Energy Act levy (ODE) on top of the energy tax. The ODE provides funding to support schemes for renewables and emissions reductions. The rates of the energy tax and the ODE depend on the level of consumption, with much lower rates for large consumers and an overall discount for gas used to heat greenhouses in the horticulture sector. Household self-consumption of electricity is exempt from the energy tax and the ODE levy. Energy products and fuels used to generate electricity are exempted from the energy tax (except coal).

The Netherlands is making adjustments to tax policy to support energy transitions. For example, to support the transition from natural gas to low-carbon heating, the government will increase taxation of natural gas by up to 43% by 2026 (compared to 2019 levels) and will lower taxation on electricity. In addition, the government is seeking to shift some energy tax burden from households to business. Up to 2020, households provided half of ODE funding, with the other half coming from businesses. In 2020, the ODE will be adjusted so that two-thirds of funding comes from businesses and one-third from households.

The vehicle tax system consists of a mix of taxes on the purchase and ownership of vehicles and the use of fossil fuels via the excise duty on diesel and gasoline. Overall, this system is designed to encourage the purchase of more efficient vehicles with lower emissions, as taxes are higher for heavier vehicles and for vehicles with higher emissions. There are significant tax reductions for zero-emission vehicles. The revenues from taxation of motor vehicles and excise duties rose in 2018 because of growing car sales, with a preference for more expensive vehicles and increased diesel and gasoline consumption driven by a shift to heavier vehicles, including SUVs.

Under Dutch law, all minerals in the subsurface, including gas and oil, are owned by the Dutch state. All companies producing gas or oil in the Netherlands pay a State Profit Share (SPS) levy of 50%. The SPS is a resource rent tax charged in addition to the prevailing corporate income tax of 25%. The government has proposed to increase the tax deduction for profits related to investment in offshore gas and oil production from

25% to 40%. The aim is to sustain offshore gas production to help maintain security of gas supply and keep gas infrastructure in place to support CCS.

In May 2020, the government delivered a letter to parliament offering a broad review of how fiscal policy could be adjusted to better support the transition to a low-carbon economy. The letter identified specific options for “tax greening” to adjust existing fiscal measures or introducing new fiscal measures to drive cost-effective emissions reduction in the five sectors of electricity, industry, the built environment, mobility, and agriculture and the natural environment (Government of the Netherlands, 2020d).

Fossil fuel subsidy review (focus area)

In support of energy transitions, the Netherlands conducted a review of fossil fuels subsidies (FFS), jointly led by the Ministry of Economic Affairs and Climate Policy and the Ministry of Finance. The review was conducted in line with the G20 FFS peer review process.[8] At the request of the government, the OECD and the IEA facilitated the FFS peer review process, as part of the IEA Energy Policy Review of the Netherlands.

In October 2019, the government organised an initial meeting with the IEA, the OECD, social organisations and international FFS experts to discuss FFS definitions and methods for developing a list of existing government policies and measures to be examined in the FFS review. The Clingendael International Energy Programme presented a paper reviewing FFS definitions and review methodologies and the Ministry of Economic Affairs and Climate Policy and the Ministry of Finance presented an initial list of measures to be considered in the review. The meeting participants provided recommendations to the government on the scope of the FFS review. Using these inputs, the government selected a broad definition of FFS in line with international standards and identified a list of specific measures to be considered in the FFS review.

A second meeting on FFS was held in November 2019 as part of the IEA In-depth Review of Dutch energy policy. The OECD also participated. Based on the findings and outcomes of the two meetings and additional inputs from the government, the OECD and the IEA developed a report that analysed FFS in the Netherlands and provided policy recommendations. The report was delivered to the government in April 2020 and will be used to inform the government response to questions from parliament concerning financial incentives for fossil fuels and the potential need for energy policy reforms.

The FFS review complements government efforts to cast light on the state of FFS and their relevance for energy, climate and fiscal policies. In a self assessment report (NSR), the government identified 13 measures in the form of tax exemptions or reductions, benefiting both the production and consumption of fossil fuels. Together, these measures amount to at least EUR 4.48 billion of forgone government revenue. While none of these measures were put forth for reform in the NSR, the government views the FFS review process as part of its commitment to better align fossil fuel policy with climate and energy transition objectives.

[8] As part of the G20 commitment to phase-out inefficient FFS that encourages wasteful consumption, several G20 member countries have undergone a peer review of their FFS, supported by the OECD. The Netherlands, an Invited Guest Country under G20 presidencies, decided to use a similar process for its FFS peer review.

For the FFS review, the government chose to maintain a broad definition of FFS that accounts for both direct budgetary transfers and tax measures that result in forgone government revenues. Fiscal measures are the main way the government delivers incentives to fossil fuels. Several tax exemptions and reductions are granted to energy-intensive industries and other energy consumers, including greenhouse agriculture. Although the tax distribution between households and businesses was recently adjusted to reduce the burden on households, Dutch energy taxes are still very degressive, translating into a heavier tax burden on households and other small-scale energy consumers. The FFS report notes that the inclusion of the degressive energy tax structure in the NSR is an important step towards assessing the efficiency of this policy design and identifying options for reform.

The FFS report notes the centrality of the EU Energy Tax Directive (ETD) – framework legislation that harmonises energy taxes in the EU to ensure the well-functioning of the EU single market – in deciding the scope of FFS in the Netherlands. As some Dutch tax measures are mandatory under the EU ETD, they are not included in tax expenditure reports of the Netherlands and therefore not subject to the periodic evaluation process. The FFS report encourages the government to include these measures in its tax expenditure reporting.

A main reason the government invoked for maintaining low effective tax rates on energy-intensive users is to provide an international level playing field for domestic industry and reduce the risk for carbon leakage. The low tax rates levied on larger energy consumers and the tax benefits provided to industrial users result in relatively lower energy prices than for industry sectors in other IEA member countries, including neighbouring EU member states. The FFS report suggests that the government continue to assess the sectors that are the most at risk of carbon leakage in order to better target tax relief programmes and identify alternative measures. The carbon levy that will be introduced in 2021 for reducing industrial emissions is a welcomed effort towards aligning carbon prices with climate objectives.

Government support for fossil fuels extends beyond measures provided through lower taxation on energy use. While production from the Groningen natural gas field will be phased out by mid-2022, the government is interested in maintaining gas production from other domestic gas fields to support energy security and limit energy imports. In 2010, the government introduced an investment allowance providing a 25% tax deduction for offshore natural gas production. The allowance has not led to the desired level of gas production and in May 2020, a proposed law was presented in the Dutch parliament to expand the allowance to cover all new investments in onshore and offshore exploration and production for both natural gas and oil, regardless of field characteristics and to increase the tax deduction from 25% to 40% (Government of the Netherlands, 2020d).

The Dutch FFS review is an important step to promote transparency of public policies and government budgets and foster greater accountability on the use of public resources. The FFS review is also in line with the EC recommendation that NECPs list all energy subsidies, in particular for fossil fuels, and define actions and plans to phase out FFS. The Dutch NECP refers to the FFS report as an input for formulating Dutch policy on providing the right financial incentives in relation to energy transitions.

The planned 2020 evaluation of energy taxation is an opportunity for the Netherlands to identify FFS reform options. The government is encouraged to maintain a broad interpretation of tax and non-tax provisions that support the use and production of fossil fuels, including those that fall under the purview of the EU ETD. In particular, incentives for the production of fossil fuels should be examined as part of the evaluation of energy taxes to better determine how government support measures influence the demand and supply of fossil fuels and the deployment of long-lived carbon-intensive projects. The FFS report encourages the government to consider the following recommendations for improving FFS evaluation and identifying opportunities for reform:

- The government may consider maintaining a broad scope for the inventory of FFS, including subsidies for both the production and consumption of fossil fuels, with transparent stakeholder consultation.
- The government may also take into account the negative externalities of the use of fossil fuels when evaluating the energy taxation and public finance supporting the use and consumption of fossil fuels. This is in the context of aligning public financial flows with its energy and climate objectives and international commitments under the Paris Agreement, in the context of the NECP and the United Nations Sustainable Development Goals processes.
- The government may incorporate tax exemptions and refunds that are under the purview of the EU ETD in the tax expenditure reports of Netherlands, e.g. exemption to aviation and maritime transport and fuels used in electricity.
- The government may broaden the scope of the periodic policy reviews to include other tax and non-tax measures that can influence the use and production of fossil fuels and help the country achieve its climate targets.
- The government may include the impact of energy taxation, alternative measures and the reforms in its policy review of energy taxation to ascertain how the final burden is shared among consumer groups and interactions with other policy measures proposed in the Climate Agreement.

Digitalisation (focus area)

Digitalisation plays an essential role in energy transitions and energy policy should support strong deployment of digital technologies and solutions, especially in the transport, buildings and electricity sectors. In particular, the government needs to develop a clear approach to energy sector data, including who owns data and how data can be easily accessed, while also addressing issues of privacy and cybersecurity.

For transport, digitalisation will be critical to provide real-time information on vehicle location, routing and transport demand to help optimise the overall mobility system. Digitalisation will also be key to support EV smart charging, by allowing price and control signals to encourage charging when and where there is abundant production of low-cost, low-carbon electricity or to delay or relocate charging to times and locations that reduce the impact on the electricity network.

The Netherlands is a leader in the deployment of smart charging infrastructure. The electricity TSO (TenneT) and several DSOs co-operate with ElaadNL, the Dutch knowledge and innovation centre for smart charging infrastructure, to determine how smart charging can limit the impact of EVs on electricity networks. Pilot projects in the

Netherlands are demonstrating how EVs can be used for demand-side response (DSR) to support flexible operation of the electricity system (see Chapter 7 for details on smart charging and Chapter 4 for details on EV infrastructure policy).

The Netherlands aims for 80% of households to have a smart meter by 2020. The DSOs are responsible for smart meter deployment and own the meters and associated data. In 2018, around 5.2 million smart meters had been deployed, covering 54% of Dutch households. Data from smart meters enable options for both network operators and consumers to support more flexible and efficient operation of electricity and gas networks.

Data from smart meters gives increased insight on the status of electricity and gas networks, which helps to reduce operation and maintenance costs. Smart meter demand data will allow network operators to more quickly detect and localise disruptions to operations and take the needed steps to prevent costly widespread disruptions. Smart meter data will help to reduce costs by providing better insight on when and where network infrastructure needs maintenance. Digitalisation can support data collection on a wide range of network indicators to improve grid performance. For example, dynamic line rating (DLR) uses distributed sensors to collect data on the performance of electricity transmission lines. DLR give TSOs more accurate data on actual transmission capacity, helping to reduce grid congestion and provides better insight on when and where transmission investment is needed.

Smart meters and supporting digital systems will also allow better managing energy in the built environment to increase efficiency, reduce costs, integrate distributed generation and energy storage, and support flexible operation of electricity and gas networks. Digital connectivity allows a range of appliances and building equipment to be monitored and controlled. This enables DSR supporting overall system flexibility, by shifting the time or reducing the intensity of building energy demand. For example, deployment of digital smart thermostats can help building users monitor and regulate heating and cooling loads or allow these processes to be managed by energy service companies. Digitalisation can also help integrate variable renewables by enabling better alignment between energy demand and variable renewable generation (see Chapter 7 for details on DSR and Chapter 4 for supporting policy in the built environment).

TenneT has been conducting pilot projects examining how distributed resources, including renewable generation, energy storage and a variety of DSR resources, can be aggregated to support grid operations by participating in the ancillary service markets. In particular, one pilot project showed that distributed resources including batteries, heat pumps, residential water heaters and EVs could be aggregated to supply frequency control services to the grid through the frequency containment reserves (FCR) market. The Netherlands is also developing a retail market for energy management services enabled by smart meters. Milieu Centraal, an energy and environment foundation established by the government, in co-operation with Energie Nederland – the association of Dutch energy suppliers – and the DSOs, runs a website offering information to consumers with a smart meter on contracting energy management services.

To develop coherent and supportive policies on digitalisation, policy makers need access to specialists with digital expertise. Education policies and technical training should ensure an adequate pool of relevant expertise to support policy makers and provide the knowledge on digitalisation needed across numerous sectors and industries. Policies and regulations should ensure timely, robust, verifiable and secure access to the necessary data for all relevant stakeholders, while addressing issues of privacy and cybersecurity. Policies must also ensure appropriate flexibility to deal with the rapid developments in digital and communication technologies. It is also critical that policies focus on system benefits. A systems level approach is particularly important in the electricity sector, where the transition to a flexible system may require significant changes in market design. Policy driving RD&D of new technologies and services also needs to support the development of digital solutions in all areas of the energy system.

Assessment

The Netherlands is highly reliant on fossil fuels. Together, oil and gas covered 77% of TFC in 2018. The dominance of oil and gas is driven by the large industry sector centred on refining and chemicals production and the high level of natural gas heating. Natural gas and coal are also the largest sources of electricity generation. As in most IEA countries, Dutch transport demand is dominated by oil. From 2008 to 2018, the Netherlands experienced an overall decline in energy demand. One key reason for the drop in demand is the significant reduction in the energy intensity of the Dutch economy (TFC/GDP), which fell by 14% between 2008 and 2018.

The Netherlands is a major producer of natural gas and home to the Groningen gas field, one of the largest fields in the world. As a result of earthquakes related to natural gas production and in line with overall energy policy, production from Groningen will be phased out as soon as mid-2022. The drop in Groningen production made the Netherlands a net importer of gas for the first time in 2018, and increased import dependency to 72% in 2018. The government is taking numerous steps to reduce gas demand, scale-up low-carbon alternatives, and ensure domestic and regional security of gas supply.

The primary focus of Dutch energy policy is transitioning to a low-carbon energy system. The 2019 Climate Act sets targets to reduce CO_2 emissions by 49% by 2030 compared to 1990 levels and by 95% by 2050, and contains a structural and legally binding framework for developing and regularly evaluating supporting policy and measuring progress towards the emissions reduction targets. The 2019 Climate Agreement details a wide range of measures to drive emissions reductions across all sectors and supports the achievement of the 2030 and 2050 emissions reduction targets. Climate Agreement measures include levies, adjustments to tax policy, binding targets and obligations, funding for RD&D and pilot projects, loans and grants for energy efficiency and renewable energy projects, and operational subsidies for renewables and emissions reduction projects.

Provinces and municipalities have a significant role to play in the implementation of the Climate Agreement, as they will take the lead in developing Regional Energy Strategies that are critical to the deployment of onshore renewable energy generation and the transition to low-carbon heating. The strategies require collaborative work with numerous stakeholders and must address notable barriers in relation to spatial planning, social acceptance and cost impacts. The government should ensure that the national programme provides local governments with the resources to quickly build the capacity needed to successfully develop and execute the strategies.

In its first assessment of the Climate Agreement in November 2019, the PBL reported that the proposed CO_2 reduction measures will be insufficient to achieve the 49% reduction target by 2030 and will result in a reduction of 43-48%. The government should quickly begin to work with energy sector stakeholders to develop additional measures beyond those in the Climate Agreement to support achievement of the 2030 target and put the Netherlands on a clear path to meeting the 2050 target. The government should examine and consider revising the process of updating policy established under the Climate Act to ensure that this process provides enough flexibility in developing and implementing additional measures if or when it is found that current measures do not support achievement of energy sector targets.

In support of the transition to a low-carbon energy system, the Netherlands conducted a review of fossil fuel subsidies (FFS) with the support of the OECD and the IEA. The FFS review provides insights and recommendations on policy changes, especially in relation to energy taxation, which could help to drive energy transitions. The FFS review supports the government's response to questions from the Dutch parliament on FFS and will be used when examining potential policy reforms.

Digitalisation plays a key role in supporting energy transitions by allowing more efficient and flexible operation of the energy system. Energy policy should support strong deployment of digital technologies and solutions, easy and transparent access to energy data, and robust data privacy and cybersecurity. The Netherlands is taking steps to leverage the benefits of digitalisation, including deploying smart meters, developing a market for energy management services, supporting EV smart charging and conducting pilot projects on DSR from distributed resources. The government should continue to foster a supportive and flexible regulatory environment to allow digitalisation to grow in all sectors and ensure a co-ordinated approach on digitalisation RD&D.

The Netherlands must also meet EU 2030 targets for renewable energy, energy efficiency and CO_2 reductions. The measures to support the achievement of these targets are defined in the NECP and are based on the Climate Agreement. Achievement of the 2030 49% emissions reduction target would support achievement of the NECP targets. The NECP also advocates for a 55% reduction in EU-wide CO_2 emissions by 2030 versus 1990 levels, compared to the current EU-wide target of a 40% reduction. If the EU-wide target is increased, the Netherlands will likely have to increase its national targets for renewables, energy efficiency and CO_2 reductions and develop additional measure beyond those called for in the Climate Agreement and the NECP.

Recommendations

The government of the Netherlands should:

- ☐ Design additional policies and measures to proactively address potential obstacles to meeting the 2030 Climate Agreement targets, in ongoing consultation with all key stakeholders.
- ☐ Incorporate into regular reviews of Climate Agreement implementation an assessment of unintended consequences, including possible impacts on the investment climate, and make additional policy adjustments as necessary.
- ☐ Monitor potential security of supply issues resulting from the mid-2022 closure of the Groningen gas field and growing dependence on natural gas imports, with a focus on demand reduction, decarbonisation of gas supply and repurposing gas infrastructure.
- ☐ Ensure that energy policy supports strong deployment of digitalisation in all sectors and develop clear regulations on energy sector data, supporting transparency and easy access while also addressing issues of privacy and cybersecurity.
- ☐ Assist local governments in developing the necessary capacities to design and implement Regional Energy Strategies and other new initiatives by providing financial resources, training and opportunities for knowledge exchange.

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3. Energy and climate change

Key data

(2018)

GHG without LULUCF*: 187.8 Mt CO_2-eq, -12.4% since 2005, -14.9% since 1990

GHG with LULUCF*: 192.7 Mt CO_2-eq, -12.4% since 2005, -15.2% since 1990

Energy-related CO_2 emissions: 155.3 Mt CO_2, -10.2% since 2005, -2.0% since 1990

CO_2 emissions by fuel: natural gas 43.8%, oil 32.5%, coal 21.6%, other 2.2%

CO_2 emissions by sector: heating and electricity generation 35.5%, transport 20.4%, industry 17.2%, residential 10.7%, services 9.5%, other energy 6.7%

CO_2 intensity per GDP**: 0.16 kg CO_2/USD (IEA median 0.16 kg CO_2/USD)

*Land use, land-use change and forestry (Source: UNFCCC).

**GDP in 2015 prices and purchase power parity (PPP).

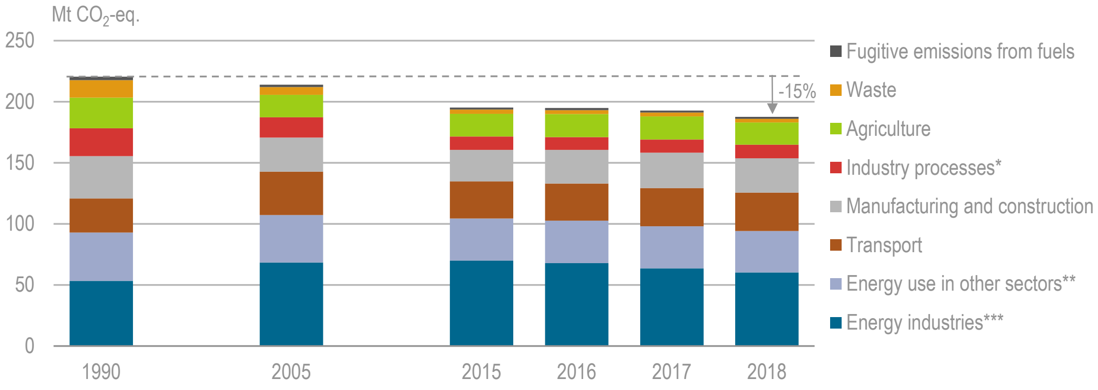
Overview

The Netherlands has placed ambitious emissions reduction targets at the centre of climate and energy policy. The 2019 Climate Act requires the Netherlands to reduce greenhouse gas emissions (GHG) by 49% by 2030 compared to 1990 levels and by 95% by 2050. The targets cover GHG emissions from all sectors. The Netherlands faces challenges in achieving these targets, as it is heavily reliant on fossil fuels and has a concentration of emission-intensive industries. Although GHG emissions dropped 15% from 1990 to 2018, reductions have stalled in recent years. Energy-related CO_2 emissions accounted for 83% of total GHG emissions in 2018 (Figure 3.1).

To support the achievement of the ambitious emissions reduction targets, the government is reworking climate and energy policy. The 2019 Climate Agreement specifies emissions reduction measures across the entire economy, concentrating on reducing energy sector emissions. RD&D policy has been aligned to focus on emissions reductions, energy sector support schemes have been updated or expanded to focus on emissions reductions, and coal-fired generation is banned after 2030. Government policy is focused on rapidly reducing gas production in line with climate targets and because earthquakes in northeastern Netherlands cuased by natural gas production activities have resulted in damage to over 10 000 buildings and significant risks to public safety. As such, the government will phase out gas production from the Groningen gas fields by mid-2022 and is working to reduce natural gas demand, especially for heating.

Analysis by the Netherlands Environmental Assessment Agency (PBL) in 2019 indicates that the Netherlands is not on track to meet the 2030 emissions reduction target. While the Netherlands implements the Climate Agreement and other policy initiatives, the government needs to closely track progress on emissions reductions and be ready to make policy adjustments to keep the country on the path to a robust low-carbon economy.

Figure 3.1 Greenhouse gas emissions by sector, 1990, 2005 and 2015-18



As of 2018, the Netherlands had decreased GHG emissions by 15% versus 1990 levels, but reductions are still not on track to meet the 2030 49% reduction target.

* *Industry processes* include mineral, chemical and metal industries.

** *Energy use in other sectors* includes commercial, residential, agriculture, forestry and fishing industries.

*** *Energy industries* include public electricity and heat production and manufacture of solid fuels.

Source: UNFCCC (2020), *Netherlands: 2020 National Inventory Report (NIR)*, https://unfccc.int/documents/226476.

Energy-related CO_2 emissions

Energy-related CO_2 emissions[1] are by far the largest source of Dutch GHG emissions. From 2005 to 2018, energy-related CO_2 emissions ranged from 150 Mt to 171 Mt and accounted for around 80% of total GHG emissions. In 2018, heating and electricity generation was the largest source of energy-related CO_2 emissions (35%), followed by industries (24%), transport (20%), residential (11%) and services/other (10%). From 2005 to 2018, emissions from residential and commercial buildings (primarily related to natural gas heating) decreased by 18%, transport emissions fell by 10%, and heating and electricity generation emissions dropped by 11%; industry emissions, however, increased by 5% (Figure 3.2).

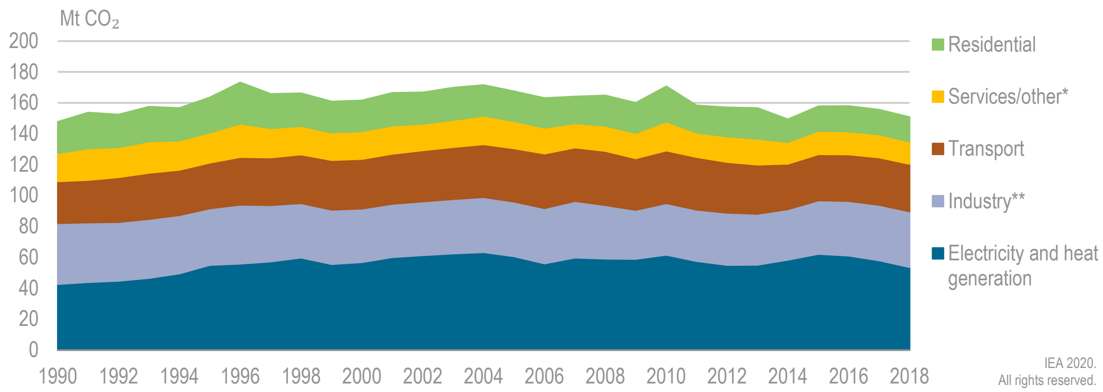
Temperature variations have a significant effect on energy-related CO_2 emissions in the Netherlands as natural gas covers 90% of building heating demand and is used to heat the large number of greenhouses in the agricultural sector. Energy-related CO_2 emissions peaked in 2010 at 171 Mt because of unusually cold weather. Economic activity is also a major emissions driver as the Netherlands has a concentration of emission-intensive industries. Falling economic activity was a key reason for the emissions reductions seen from 2008 to 2014. Emissions from electricity generation are also linked to economic activity and strongly impacted by fuel prices and regional

[1] Energy-related CO_2 emissions includes emissions from heating and electricity generation, energy demand in the industry, transport, residential, and commercial and public service sectors, and excludes non-energy related emissions from agriculture (e.g. emissions from animals and decaying plants) and industry.

electricity trade. A recovering economy and increased coal-fired generation pushed energy-related CO_2 emissions in 2015, after which a notable shift from coal to gas generation reduced emissions.

The overall reduction in energy-related CO_2 emissions from 2005 to 2018 was driven by decreased emissions from natural gas and oil (Figure 3.3). From 2005 to 2018, emissions from natural gas decreased by 16%. A key driver for the decline in natural gas emissions up to 2015 was an increase in gas prices, which led to a market preference for coal-fired electricity generation and the construction of three coal-fired power plants. Since 2015, gas generation has become less expensive than coal-fired generation and market forces have reduced coal-fired generation. As a result, emissions from coal have dropped sharply, leading to an overall emissions reduction, despite increased emissions from natural gas electricity generation. From 2005 to 2018, emissions from oil dropped by 11%, mainly because of a decline in transport demand and improved vehicle efficiency.

Figure 3.2 Energy-related CO_2 emissions by sector, 1990-2018



Energy-related emissions vary notably based on heating demand, economic activity and electricity trade. Energy-related emissions experienced an overall decline from 2008 to 2018.

* *Services/other* includes commercial and public services, agriculture, forestry and fishing.

** *Industry* also includes emissions from coal, oil and gas extraction, oil refineries, blast furnaces and coke ovens.

Source: IEA (2020), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

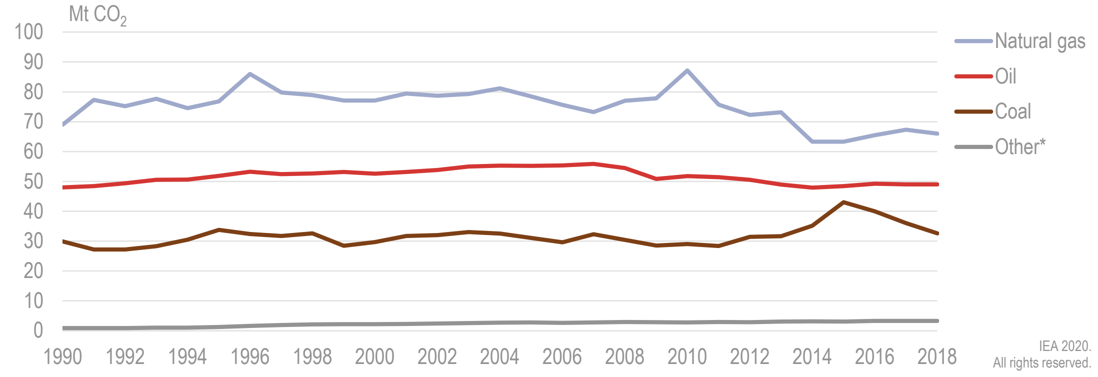
CO_2 emission drivers and carbon intensity

Energy-related CO_2 emissions fell 8% between 2000 and 2018, despite population growth of 8% and gross domestic product (GDP) per capita growth of 18% (Figure 3.4). The decrease in emissions was partly driven by a notable reduction in the energy intensity of the economy (TPES/GDP), which fell 24% from 2000 to 2018. However, the Netherlands has a carbon-intensive energy mix, which has been a drag on emissions reductions. Gas, oil and coal covered 90% of total primary energy supply (TPES) in 2018. Carbon intensity of the energy supply (CO_2/TPES) has declined since 2015, driven partly by a rapid fall in coal-fired generation. However, CO_2/TPES in 2018 was only 2% lower than in 2008.

The high share of fossil fuels in TPES gives the Netherlands a relatively high carbon intensity of the economy (CO_2/GDP) compared to its key trading partners (Figure 3.5).

Although CO_2/GDP fell 28% from 2000 to 2018, many countries have seen more rapid declines. In 2018, the carbon intensity of the Dutch economy was 164 gCO_2/USD, just below that of Belgium and Germany, but significantly above that of the United Kingdom and France.

Figure 3.3 Energy-related CO_2 emissions by source, 1990-2018



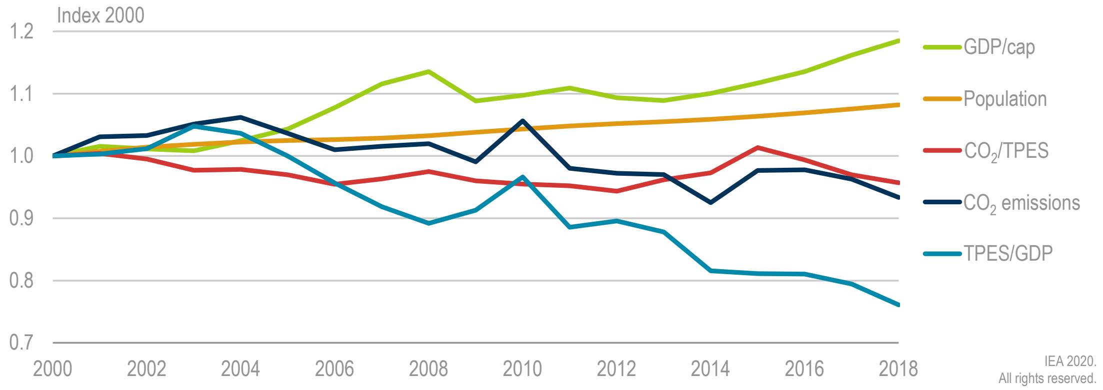
Natural gas emissions are down from 2005, but have recently increased as electricity generation from coal rapidly decreased. Oil emissions are down due to decreasing transportation demand and improved vehicle efficiency.

* Emissions from non-renewable waste.

Note: Data for 2018 are estimates.

Source: IEA (2020), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

Figure 3.4 Energy-related CO_2 emissions and key drivers, 2000-18

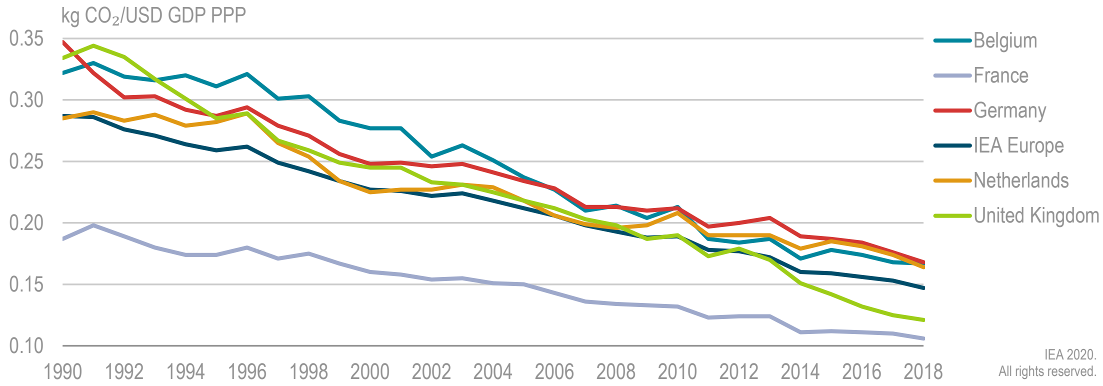


Despite economic and population growth, energy-related CO_2 emissions are slowly declining thanks to reduced energy intensity per GDP. CO_2 intensity of the energy supply remains high.

Notes: GDP = gross domestic product; TPES = total primary energy supply eal GDP in USD 2010 prices and PPP.

Source: IEA (2020), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

Figure 3.5 CO_2 intensity in selected IEA member countries, 2000-18



The Netherlands' CO_2 intensity per GDP (PPP) is falling, but at a slower rate compared to its key trading partners.

Note: GDP in 2015 prices and PPP.
Source: IEA (2020), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

Institutions

The Ministry of Economic Affairs and Climate Policy has primary responsibility over climate and energy policy and the design and implementation of measures supporting the achievement of emissions reduction targets set under Dutch and EU regulations. The Climate Agreement's central focus on emissions reductions has increased responsibilities related to emissions reductions across most of the Dutch government, including for regional and local authorities. The Dutch Emissions Authority (NEA) is the independent authority with responsibility for ensuring that Dutch companies participating in the EU Emissions Trading System (ETS) fulfil their obligations. The NEA also ensures compliance with laws and regulations governing the transport sector, air pollution and fuel consumption (NEA, 2020).

Targets and policy

National and EU laws and regulations, and international agreements set Dutch GHG emissions reductions targets for 2020, 2030 and 2050 and drive the policy measures supporting the achievement of these targets.

Urgenda legal ruling

In 2015, the Hague District Court ruled in the legal case of the Urgenda Foundation against the Dutch state. The ruling states that climate change poses a risk to the rights to life and well-being of residents of the Netherlands and obliges the Dutch state to achieve a 25% reduction in GHG emissions compared to 1990 levels by the end of 2020. The ruling was upheld by the Court of Appeals in 2018 and the Supreme Court in 2019. The ruling is noteworthy as being the first binding national GHG emissions target resulting from a court decision.

The government has implemented numerous measures to support the achievement of the Urgenda target. However, 2019 analysis by the PBL indicated that the Netherlands is not on track to achieve this target. The PBL expects an emissions reduction of 23% in 2020, with an uncertainty bandwidth of 19-26%. In response, the Dutch Cabinet introduced a plan in April 2020 for additional GHG reduction measures that can be implemented quickly, be as cost-effective as possible, and be supported by citizens and companies.

The largest emissions reductions are expected to come from a measure to reduce coal-fired generation as much as possible while maintaining a secure supply of electricity. Additional measures primarily focus on energy efficiency in industry, construction, the built environment and agriculture. The largest measure in terms of funding is an expansion of the 2020 budget for the Stimulation of Sustainable Energy Production (SDE+) renewable support scheme from EUR 2 billion to EUR 4 billion (Government of the Netherlands, 2020a).

Climate Act, Climate Agreement and Climate Plan

The 2017 Coalition Agreement called on the Netherlands to establish GHG emissions reductions as the core of climate and energy policy. The 2017 Coalition Agreement specified targets to reduce GHG emissions by 49% by 2030 compared to 1990 levels and by 95% by 2050. These targets were set as legal requirements in the Climate Act in May 2019. The target covers all GHG emissions in the Netherlands (Government of the Netherlands, 2020b). Dutch GHG emissions were 221 Mt CO_2-eq in 1990. As such, the Climate Act targets require GHG emissions to be less than 113 Mt CO_2-eq by 2030 and less than 11 Mt CO_2-eq by 2050. In 2018, GHG emission were 188 Mt CO_2-eq.

Under the Climate Act, the government is required to develop a Climate Plan every five years that defines climate policy over a ten-year period. The first Climate Plan was adopted by parliament in April 2020 and covers the period 2021-30 (Government of the Netherlands, 2020c). The Climate Plan for 2021 to 2030 contains all of the policy measures developed to meet the targets and requirements of the Climate Act, the 2017 Coalition Agreement and relevant EU directives. The Climate Plan for 2021-30 is based mainly on the measures, targets and goals defined in the 2019 Climate Agreement.

In 2018, the Netherlands began developing the Climate Agreement to define specific measures supporting the achievement of the 2030 and 2050 emissions reductions targets set in the Climate Act. Negotiations to develop the Climate Agreement followed the collaborative Dutch Polder system. Over 100 stakeholders contributed to developing emissions reduction measures focused on five sectors: electricity, industry, the built environment, mobility, and agriculture and land use. Following extensive negotiations between the stakeholders, the Climate Agreement was finalised in June 2019 (MEACP, 2019a). The Climate Agreement defines 2050 carbon neutrality goals for the five sectors and specifies 2030 targets and measures intended to set the country on the path to 2050 carbon neutrality. In 2019, the PBL estimated that Climate Agreement measures would support a GHG emissions reduction of 48.7 Mt CO_2-eq by 2030 in addition to the reduction expected under existing policy.[2]

The Climate Act also establishes a legally binding framework for assessing progress towards policy objectives and updating policy on a regular basis. To support regular assessment of climate policy, the Climate Act requires the PBL to publish an annual Climate and Energy Outlook (KEV). The KEV provides an overview of realised GHG emissions reductions and an estimate of GHG emissions broken down by sector. The KEV must be updated every year and sent to both houses of parliament by 1 November. The KEV does not provide insights on the progress and forecasts on individual emissions reduction measures. Therefore, under the Climate Act, the Dutch Cabinet is required to develop the Climate Policy Monitor, which details progress of policy implementation and climate targets and behavioural insights. Its main function is to detect potential obstacles to implementing the climate policy.

As part of the annual policy assessment process, the Climate Act also requires the Dutch Cabinet to deliver the Climate Memorandum to the parliament every year by 1 November. The Climate Memorandum details the overall realisation of the Climate Plan, including the impact of policies on emissions reductions, national budgets and the financial impact on households, the private sector and local governments. The Climate Memorandum must also define how the findings of the KEV for that year will be considered in evaluating and updating climate policy. The Climate Memorandum is accompanied by the Climate Policy Monitor.

The Climate Act requires that an official progress report be developed every two years after the adoption of the Climate Plan. Based on this report, Cabinet will determine if existing measures must be intensified and/or if additional measures must be defined to keep the country on track to achieve the Climate Act emissions reduction targets. The first progress report will be published in 2021 based on the 2021 KEV and Climate Policy Monitor. The Climate Act requires that the Climate Plan be fully updated every five years through 2045 to ensure that the Netherlands stays on track to the meet the 2050 Climate Act climate neutrality goals. The updated plan must consider if additional emissions reduction measures are needed. Assessment of progress and consideration of new measures will commence in 2023 to support the development of the updated Climate Plan covering the period from 2024 to 2035.

EU and international targets

The EU Emission Trading System (ETS) regulates GHG emissions from large power plants and energy-intensive industries in the Netherlands. The ETS uses tradable emission allowances to drive emissions reductions in ETS sectors across the entire EU plus Iceland, Liechtenstein and Norway. ETS sectors are required to reduce emissions by 21% by 2020 versus 2005 levels and 43% by 2030.

Under the EU Effort Sharing Decision (ESD), non-ETS[3] sectors in the Netherlands have a target to reduce GHG emissions by 16% by 2020 versus 2005 levels. It is expected

[2] The government expects existing policies separate from the Climate Agreement measures to support substantial GHG reductions by 2030: a 158 Mt CO_2-eq reduction excluding LULUCF and 164.9 Mt CO_2-eq reduction including LULUCF (PBL, 2018).

[3] Non-ETS sectors include agriculture, residential, commercial, waste, non-energy intensive industry and transport, excluding aviation within the European Economic Area.

that this target will be achieved. In 2018, non-ETS emissions in the Netherlands were 17% lower than in 2005. The EU Effort Sharing Regulation (ESR) sets 2030 targets for non-ETS emissions reductions in each EU member state. The national targets are designed to support a 40% reduction in EU-wide non-ETS emissions by 2030 versus 2005 levels. Under the ESR, the Netherlands has a target to reduce non-ETS emissions by 36% by 2030 versus 2005 levels.

Each EU member state was required to submit a National Energy and Climate Plan (NECP) to the European Commission (EC) before the end of 2019 detailing plans to achieve national 2030 targets for emissions reductions, energy efficiency and renewable energy. The Netherlands delivered its NECP to the EC in November 2019. The majority of the measures in the NECP are based on the Climate Agreement. Achievement of the 2030 Climate Agreement target would support achievement of the 2030 ESR target.

The Dutch NECP advocates for increasing the 2030 EU-wide emissions reduction target from 40% to 55% (MEACP, 2019b). The 55% target is in line with ongoing discussions related to the European Green Deal (EC, 2020). A higher EU-wide target will require an increase of Dutch emissions reduction targets and measures.

The Netherlands is a signatory to the UNFCCC Paris Climate Agreement and supports the achievement of the EU nationally determined contribution (NDC) to reduce EU GHG emissions by at least 40% by 2030 compared to 1990 levels. In March 2020, the EU communicated a long-term strategy to the UNFCCC for EU-wide carbon neutrality by 2050. The Netherlands pushed for adoption of the EU-wide carbon neutrality goal and aims to support this goal through the Climate Agreement’s 2050 carbon neutrality goals.

Emissions reduction measures

Dutch climate and energy policy includes a wide range of measures to drive emissions reductions across all sectors. These measures include fees, taxes, binding targets and obligations, funding for RD&D and demonstration projects, loans and grants for energy efficiency and renewable energy projects, and subsidies for renewables and emissions reduction technologies.

RD&D

The Netherlands is in the process of aligning its energy RD&D programme to focus on the achievement of the Climate Agreement 2050 carbon neutrality goals. A new framework for research and innovation is being implemented under the Integral Knowledge and Innovation Agenda (IKIA), which defines 13 Multiannual Mission-Driven Innovation Programmes (MMIP) that focus research on emissions reductions across all sectors. The framework is adapting existing RD&D funding mechanisms to support emissions reduction research and new mechanisms are being established (see Chapter 5).

SDE+ and SDE++

One of the most important instruments to drive emissions reductions is the SDE+ support scheme, which uses competitive auctions to award operational subsidies to renewable energy projects. From 2011 to 2020, SDE+ auctions allocated over EUR 60 billion in funding. Projects selected in the auctions receive floating market premiums based on the amount of renewable electricity, gas or heat produced. Projects are eligible for subsidy payments over a period of 8-15 years depending on the type of technology. In 2020, SDE+ will be expanded into the Stimulation of Sustainable Energy Production (SDE++), which uses a similar auction process to award subsidies to a wider set of technologies based on avoided CO_2 emissions, including carbon capture and storage (CCS) and low-carbon hydrogen. The first SDE++ auction will be held in the second half of 2020 (see Chapter 6).

It is expected that payments to projects winning SDE+ and SDE++ support will reach EUR 3.3 billion per year by 2030 (EUR 2.3 billion for SDE+ and EUR 1 billion for SDE++). SDE++ is expected to focus on reducing industrial emissions, but also support projects in electricity, heating and renewable gases, and advanced transportation fuels (Table 2.2).

Table 2.2 Estimated annual support from SDE++ by technology in 2030

Renewable electricity	Renewable heat and green gas	Small-scale renewable heat	Advanced biofuels and renewable synthetic fuels	CO_2 reduction in industry*
EUR 200 million	EUR 135 million	EUR 100 million	EUR 200 million**	EUR 550 million

* Excluding renewables.

** EUR 200 million is the total funding available from 2020 to 2030. The Climate Agreement does not estimate how this funding will be spent on an annual basis.

Regional energy strategies

The Netherlands is developing 31 Regional Energy Strategies to support emissions reductions through the deployment of 35 TWh of onshore renewable electricity generation and a transition to low-carbon heating in the built environment. The strategies are being developed by municipalities, provinces and water authorities in co-operation with social organisations; network operators for gas, electricity and district heating; the business community; and residents. The strategies aim to resolve barriers related to spatial planning, social acceptance, cost impacts, and integration of variable wind and PV generation. The government is providing technical and financial assistance to assist with the development and execution of the strategies through the National Regional Energy Strategy Programme.

Electricity

In addition to SDE+, SDE++ and the Regional Energy Strategies, the Netherlands has several other policy measures aiming to reduce emissions in the electricity sector. The government has developed a highly effective offshore wind policy framework that is driving accelerated deployment and falling project costs. Under this framework, the Netherlands is aiming for 4.7 GW of offshore wind capacity in 2023, and 11.5 GW of capacity and 49 TWh of generation by 2030. A net-metering scheme for small-scale PV is driving strong growth in residential PV deployment (see Chapter 6 for details on the support measures).

In addition to rapidly increasing renewable generation, the Netherlands also aims to reduce electricity emissions through a ban on coal-fired generation, which passed into law in December 2019 and requires that the four coal-fired plants in the Netherlands cease operating, or convert 100% to alternative. The oldest coal-fired power plant (commissioned in 1993) must comply with the coal ban by 1 January 2025. Three coal-fired power plants commissioned in 2015 must comply with the ban by 1 January 2030. Strong reductions in coal-fired generation must also be sought as part of the measures to meet the Urgenda 2020 emissions reduction target (see Chapter 10).

The government has established a carbon pricing mechanism for the electricity sector. Currently, this mechanism acts as a floor price if the ETS price falls below a threshold (EUR 12.30 per tonne in 2020). The government can adjust the price and has indicated that it could be increased above the ETS price if the desired level of electricity sector emissions reductions are not being achieved through existing policy measures.

Industry

To encourage industrial emissions reductions, the government is establishing a carbon levy that will come into effect in 2021. The levy will be paid for emissions above a certain threshold, which will be reduced annually through at least 2030 in line with Climate Agreement targets. Any payments resulting from the levy are separate from payments required under the ETS. The levy is intended to drive emissions reductions beyond those required under the ETS. The government aims to manage the levy in combination with SDE++ support for investments in cost-effective emissions reductions measures, to allow domestic industry to stay competitive. Industry also has requirements to reduce energy demand under the energy efficiency obligation (EEO) programme (see Chapter 4).

Built environment and agriculture

The Netherlands is also seeking to reduce emissions from the residential, service and agriculture sectors, with a focus on reducing natural gas heating in the built environment (including for greenhouses). Key measures include the Natural Gas Free Districts programme, which aims to transition 1.5 million homes from gas to low-carbon heating by 2030. The Gas Act was amended in 2018 to change the obligation for a gas connection into a ban of connecting of new homes and buildings to the natural gas network. There are numerous other support programmes and requirements in relation to heating and overall energy efficiency for the built environment (see Chapter 4).

Mobility

The transport sector was responsible for 20% of energy-related CO_2 emissions in 2018 and is almost completely reliant on oil. In 2018, 93% of domestic transport sector energy demand was covered by oil-based fuels. Support measures for reducing transport sector emissions include a broad policy framework pushing for adoption of zero-emission vehicles (battery electric and hydrogen fuel cell vehicles) for personal, public and freight transport. The framework includes subsidies and tax incentives that encourage zero-emission vehicle purchases and numerous other measures supporting the development of robust infrastructure for electric vehicles and initial deployment of hydrogen refuelling stations (see Chapter 4).

Vehicles with combustion-based engines will have an important role in transport in 2030 and beyond. To reduce emissions from these vehicles, the government is supporting the development of sustainable advanced biofuels. The Netherlands also aims for a broader shift to a more efficient and diverse mobility sector that supports walking, biking, mobility services and other measures to reduce emissions.

Energy and carbon taxation

The Netherlands has a broad energy tax that covers consumption of electricity, natural gas and districting heating. Consumers also pay a surcharge for Sustainable Energy Act levy (ODE), which funds the SDE+ and SDE++ support schemes, and covers the cost of the offshore electricity grid. The rate of the energy tax and the ODE depend on the level of consumption, with much lower rates for large consumers. There is a special reduced rate for gas consumption in agriculture and household self-consumption of electricity is exempt from the energy tax and the ODE levy. Energy products and fuels used to generate electricity are exempt from the energy tax (except coal). The Netherlands is using adjustments in the energy tax and the ODE levy to support emissions reductions. For example, to support the transition to low-carbon heating, the government will increase taxation of natural gas by up to 43% by 2026 (compared to 2019 levels) and lower taxation on electricity.

In May 2020, the government delivered a letter to parliament offering a broad review of how fiscal policy could be adjusted to better support the transition to a low-carbon economy as part of the government-wide operation “building blocks for a better tax system”. The letter identified specific options for “tax greening” to adjust existing fiscal measures or introducing new fiscal measures to drive cost-effective emissions reductions in the five sectors of electricity, industry, the built environment, mobility, and agriculture and land use (Government of the Netherlands, 2020d).

Climate adaptation and resilience

The 2016 National Climate Adaptation Strategy (NAS) defines Dutch climate adaptation policy and calls for new initiatives and a broadening of existing initiatives to address the most urgent climate risks, including flooding and impacts on health and economic productivity from extended heatwaves. The NAS was developed through a participatory process including the government, provinces, municipalities, water boards, research institutions, social organisations and the private sector (MIE, 2016).

Around 20% of the land area of the Netherlands is below sea level and most of the country faces flooding risks. The Delta Programme has the responsibility to protect the Netherlands from flooding, to ensure a sufficient supply of fresh water, and to contribute to achieving climate-proof and water-resilient spatial planning; each of these areas has a specific adaptation action plan. The Delta Commissioner, a special government commissioner, is in charge of the programme. The programme was initiated in 2010 and is updated on an annual basis. The 2020 Delta Programme covers a wide range of water management issues, with an increased focus on understanding the impact of climate change and developing clear options for resilience (Delta Programme, 2020).

In 2018, the Minister of Infrastructure and Water Management and the Delta Programme Commissioner jointly launched a multi-year Sea Level Rise Knowledge Programme, in collaboration with the other Delta Programme partners. This programme is intended to provide greater insight into the probability of an accelerated rise in sea level, and into its potential impact on flooding, inland water levels and spatial planning, and to indicate options for anticipating such developments. The Netherlands is one of the leading countries in the world of water management and has extensive infrastructure for managing inland and coastal waterways and shorelines. The Dutch are leveraging this expertise to assist other countries to develop climate change adaptation strategies and infrastructure in relation to water and sea-level rise.

Climate assessment

The Netherlands has established an ambitious vision for energy transition that places strong emissions reduction targets at the centre of climate and energy policy. The Climate Act adopted in 2019 sets binding targets to reduce GHG emissions by 49% by 2030 compared to 1990 levels and by 95% by 2050. The 2019 Climate Agreement defines overall climate policy and specifies emissions reductions measures aiming to support the achievement of the 2030 and 2050 emissions reductions targets.

The PBL's initial analysis indicates that Climate Agreement measures do not support achievement of the 49% reduction target and would result instead in a 43-48% reduction. However, this assessment did not examine the impact of recent policy changes implemented in relation to the Urgenda ruling and also did not assess vehicle taxation beyond 2025, or the recently adopted zero-emission vehicle subsidies. An updated analysis covering these and other policy measures is expected from the PBL in October 2020 and will provide a more complete estimate of the impact of current policy on achieving the 2030 target. If the updated PBL analysis indicates that there is still a gap in achieving the 2030 target, the government should quickly begin to work with Climate Agreement stakeholders to develop additional measures that support the achievement of the 2030 target and put the Netherlands on a clear path to meeting the 2050 target.

Dutch policy aims to drive emissions reductions in the electricity sector by eliminating coal-fired generation in stages from 2025 to 2030 and steadily increasing generation from renewable sources of energy. The coal ban will likely be the greatest source of emissions reductions from the electricity sector. Care should be taken to ensure that the phase-out of coal generation does not affect security of electricity supply.

Significant emissions reductions are also expected from increasing renewable electricity generation. PBL estimates that Climate Agreement measures would result in at least a 70% renewable energy share in electricity generation in 2030. The renewable share of generation was only 16% in 2018. The government has numerous support mechanisms for renewable energy, but it remains unclear if these are sufficient to drive the rapid acceleration in renewable deployment needed to meet the Climate Agreement targets. The government should monitor electricity sector emissions and be ready to adjust policy if the desired emissions reductions are not realised.

The government is expecting that a significant share of industrial emissions reductions will be realised through SDE++ support for CCS and low-carbon hydrogen. It remains unclear if these emerging technologies will be able to win support through SDE++ or be deployed at the scale needed to support the desired emissions reductions. The results of the first round of SDE++, which will take place in the second half of 2020, should be closely monitored and the government should be ready to adjust policy to support these technologies or explore other routes to help reduce industrial emissions.

If emissions reduction measures for the electricity and industry sectors result in a relaxed market for ETS allowances, the government should consider cancelling emission allowances to strengthen the ETS price signal.

Climate Agreement measures in the mobility sector focus on the adoption of zero-emission vehicles and encourage the use of public transportation, biking, walking and other low-emission mobility options. PBL analysis indicates that these measures are not enough to achieve the desired emissions reductions. To help drive further emissions reductions in the transport sector, the government introduced a subsidy programme supporting the purchase of new and used zero-emission vehicles (with a list price up to EUR 45 000) starting in June 2020. Even if the Climate Agreement goals for zero-emission vehicles are achieved, diesel and gasoline vehicles will continue to be the majority of the passenger vehicle fleet and a significant share of new vehicles sales for years to come. While the government should maintain a focus on rapidly increasing the share of zero-emission vehicles, it also needs to ensure that emissions from traditional vehicles with combustion-based engines are reduced as much as possible.

The government should examine how carbon pricing could be implemented in the mobility sector, including the option of notably increasing vehicle registration fees linked to CO_2 emissions. The government should also closely monitor the various support programmes for advanced biofuels and examine if the current biofuels blending mandate needs to be adjusted or expanded to ensure the desired emissions reductions. The Netherlands should also continue its strong support for a more efficient and diverse mobility sector, including public transportation, walking, biking, mobility services and other measures that reduce emissions.

Dutch policy for reducing emissions in the built environment is focused on simultaneously increasing building efficiency while reducing the demand for natural gas heating. Reduction of natural gas heating is also the key policy for the agricultural sector, where the majority of energy-related emissions come from natural gas heating of greenhouses. Emissions from new buildings will be effectively limited by current efficiency requirements and the ban on connection of new buildings to the gas network. Emissions reductions from existing buildings remain a notable challenge because of the high share of natural gas heating and the low renovation rate. To address these challenges, the government has set an ambitious target to transition 1.5 million existing homes and additional public and commercial buildings to low-carbon heating by 2030 through the Natural Gas-free Districts programme.

The Natural Gas-free Districts programme relies on a variety of low-carbon heating options. Efficient electrification of heating is funded through several mechanisms. Achieving emissions reductions through electrification will require the Netherlands to decarbonise its fossil fuel heavy generation mix. Other options for low-carbon heating include mature technologies that are not widely used in the Netherlands, such as district heating and geothermal heating. Options for grid injection of biomethane and low-carbon hydrogen require notable infrastructure investments. These options have high investment costs and the government has developed a variety of support mechanisms and policies to encourage their development. The government should closely monitor the impact of existing policies and be ready to make adjustments as needed to support investment in low-carbon heating while maintaining affordable heating costs.

The Netherlands has numerous energy sector targets set under EU regulations, many of which are focused on specific areas outside of emissions reductions, including targets for renewable energy, renewable transportation fuels and multiple energy efficiency targets. The government should closely track progress on EU targets to ensure the policy focus on GHG emissions reductions drives emissions reductions measures that also support the achievement of all EU targets.

Current policy includes a mix of CO_2 taxes and levies and indirect taxation of emissions through the energy tax and other fiscal measures. The carbon levy establishes a direct taxation of industrial emissions. A separate carbon pricing mechanism for electricity sector emissions is in place that currently acts as a floor price for the ETS. The vehicle registration tax is determined primarily by a vehicle’s CO_2 emissions. While energy demand in the residential, commercial and agricultural sectors is covered by the energy tax, there is no direct taxation of CO_2 emissions from these sectors. This mixed approach results in different costs for emissions in different sectors, some explicit, others implicit. While this can provide flexibility and tailoring of price signals and incentives in different sectors, it does not necessarily incentivise emissions reductions where they are the most cost efficient. Regular examination of energy and emission taxes and levies to assess their effectiveness in driving the needed emissions reductions in a cost-effective manner will be important. The government could regularly assess and adjust the sectoral coverage of carbon and energy pricing and strengthen the price signal as needed, to keep emissions reductions on the path to achieving the 2030 targets.

In May 2020, the government delivered at letter to parliament on “tax greening”, with detailed options for new and updated fiscal measures designed to send more effective price signals to drive emissions reductions in the five sectors of electricity, industry, the built environment, mobility, and agriculture and land use. The government is encouraged to examine implementing measures identified in the letter as part of an overall effort to develop a more coherent carbon and energy taxation system that clearly supports cost-effective emissions reductions in all sectors.

Climate recommendations

The government of the Netherlands should:

- Closely monitor the impact of the energy transition and climate change on all energy infrastructure and facilitate timely investments that support the achievement of climate policy targets, including for climate adaptation.
- Ensure that the 2019 Climate Agreement GHG emissions reduction measures support cost-effective achievement of EU requirements, including targets for renewable energy and energy efficiency.
- Continue collaborating with energy sector stakeholders to maximise successful implementation of emissions reduction measures and to ensure that expanded or new measures can be efficiently developed as needed to achieve the 2030 emissions reduction target.
- Further develop and seriously strengthen the emissions reduction measures for the mobility sector to ensure that the targeted reductions are achieved.
- Consider a more coherent policy on CO_2 taxation to stimulate costeffective CO_2 reductions across all sectors.

Carbon capture utilisation and storage

The Dutch government sees carbon capture utilisation and storage (CCUS) as a key option to drive emissions reductions, especially in the industry sector. Supporting policy focuses on quickly scaling up carbon capture and storage (CCS) of industrial emissions. However, the government sees CCS as an initial step in the effort to increase industry sustainability. In the long term, the government wants to move away from CCS of fossil fuel emissions towards carbon capture and utilisation (CCU) and CCS linked with bioenergy. The government is providing substantial RD&D funding for CCUS and is offering support for industrial CCS through SDE++.

In May 2020, the Infrastructure Climate Agreement Taskforce (TIKI) delivered a study to the Ministry of Economic Affairs and Climate Policy giving recommendation on developing a Multi-year Infrastructure Energy and Climate Programme. The study details the energy sector infrastructure necessary for achievement of emissions reductions targets (especially for industry) and makes several recommendations in relation to CCS, with a focus on rapidly scaling up CCS in the Dutch industrial cluster. The study will inform the development of the Industry Memorandum 2050, which will be published in 2020 (DNV-GL, 2020). In June 2020, a market reform strategy supporting energy transition was sent to parliament. The strategy aims to establish clear rules and regulations for CO_2 transport and storage to support the development of CCS.

Planned carbon capture and storage deployment

The Netherlands is well positioned for large-scale CCS deployment. The majority of industrial CO_2 emissions come from a few industrial clusters, which reduces the complexity and costs of building a CO_2 transport and storage network. Many of these clusters are located close to the North Sea, which facilitates CO_2 transport and offshore storage in depleted gas fields or in deep saline aquifers. Under the Dutch Mining Act, underground storage of CO_2 is only allowed offshore or in other countries. A 2017 study by EBN and Gasunie estimated that offshore gas fields in Dutch waters could safely store 1 700 Mt CO_2, enough to store Dutch industrial CO_2 emissions for decades. The Netherlands sees the reuse of existing offshore oil and gas infrastructure as a major opportunity to reduce CCS costs. Further studies may reveal additional storage capacity (e.g. in deep aqueous aquifers) although most likely at higher costs than for depleted gas fields (EBN and Gasunie, 2017).

The Netherlands is co-operating with Norway and other countries to explore options for CO_2 storage in Norwegian waters and other areas of the North Sea. A recent change in international regulation of CO_2 transport and storage has greatly expanded the potential for CCS in the North Sea region. Until 2019, international movement of CO_2 for geological storage in subsea formations was banned under the London Convention on the Prevention of Marine Pollution. A 2009 amendment to remove this ban has still not been ratified. However, a proposal from the Netherlands and Norway for provisional application of the amendment was approved by several countries in 2019, removing the legal barrier to international transport of CO_2 for subsea storage in waters of the Netherlands, Norway and the United Kingdom (IMO, 2019).

Two large-scale CCS projects are currently being planned in the Netherlands: the Porthos project in the Port of Rotterdam is the most advanced and aims to build a CCS hub providing transport and storage services to the large number of industrial companies in the port. A consortium of three government-owned companies (EBN, Gasunie and the Port of Rotterdam) is developing the project, which will include compressor stations, dedicated CO_2 pipelines and offshore storage with a capacity of 37 Mt CO_2. The initial phase is estimated to cost around EUR 400 million and will support storage of 2-2.5 Mt CO_2/year. Companies would be responsible for investing in CO_2 capture systems on their installations. Porthos has been recognised by the EU as a Project of Common Interest (Rotterdam CCUS, 2020).

In 2020, the Porthos project will focus on designing transport and storage infrastructure, attaining the needed environmental impact assessment and permits, and securing offtake agreements with companies in the port. These issues must be concluded so that a final investment decision can be taken in 2021 to allow the start of construction. It is expected that the initial system will be operational by the end of 2023 and the Porthos consortium is already exploring the potential for increased transport and storage capacity. The Porthos project is closely linked to the Port of Rotterdam H-Vision project, which aims to convert already existing natural gas-based hydrogen production to low-carbon hydrogen production using CCS (Rotterdam CCUS, 2020).

The Athos project aims to develop a CCS hub providing CO_2 transport and storage to the industrial clusters in the Ports of Amsterdam and IJmuiden. In 2019, the Athos Consortium (TATA Steel, the Port of Amsterdam, Gasunie and EBN) called for expression of interest from potential users of Athos. The consortium aims to publish a Joint Development Agreement in 2020 to provide more details on system capacity and a potential start date (Port of Amsterdam, 2019).

The government see CCS as a key option for the production of low-carbon hydrogen and numerous planned projects look to combine CCS with natural gas-based hydrogen production, especially at existing production facilities (see Chapter 8). Low-carbon hydrogen based on CCS is also being considered for electricity generation. The Hydrogen to Magnum project is examining conversion of the existing 1.3 GW Magnum natural gas power plant to run on low-carbon hydrogen produced from natural gas with CCS, with the CO_2 stored offshore in Norway. The project aims to test the use of hydrogen in one of the plant's three turbines by 2023 and be fully operational on hydrogen by 2030 (Vattenfall, 2020).

Current carbon capture and utilisation deployment

There are already two large carbon capture and utilisation (CCU) operations in the Netherlands. The companies OCAP (Organic CO_2 for Assimilation of Plants) and WarmCO_2 both operate large pipeline networks delivering CO_2 captured from industrial processes to greenhouses to increase agricultural production. OCAP takes CO_2 captured from hydrogen and ethanol production and transports the CO_2 to greenhouse in the western Netherlands. OCAP has been operating since 2005 and currently supplies around 500 000 tonnes of CO_2 per year to approximately 600 greenhouses covering 2 500 hectares (OPAC, 2020). WarmCO_2 has been in operation since 2015 and uses CO_2 captured from industrial processes from the North Sea Port in Zeeland to supply around 55 000 tonnes of CO_2 to greenhouses covering 150 hectares (WarmCO_2, 2020).

Several small-scale CCU pilot projects are in operation. The AVR Duiven project captures around 100 kilotonnes per year (kt/y) of CO_2 from a waste-to-energy plant. The CO_2 is purified, compressed and delivered to greenhouses by truck. The Twence project is also demonstrating CO_2 capture from a waste-to-energy plant, with the CO_2 supporting flue-gas cleaning. The project will capture around 3 kt/y, with a larger demonstration being planned. The HVC Alkmaar project is capturing CO_2 from a biomass power plant and aims to scale-up the plant and deliver the CO_2 to greenhouses.

Support measures

The Dutch government provides support for CCUS through several RD&D programmes. The Top Sector Energy RD&D tender programme includes grants dedicated to CCUS research that cover 50% of the eligible costs for industrial research, 25% of the eligible costs for experimental development and 80% of the eligible costs for research organisations. The percentages covered for industrial research and experimental development are increased by 10% for medium-sized enterprises and 20% for small businesses. The grant is limited to EUR 2 million per project (Government of the Netherlands, 2020e). The Demonstration Energy and Climate Innovation grant scheme (DEI+) supports deployment of CCUS pilot projects. Projects selected for DEI+ funding receive grants covering up to 45% of project costs, with a maximum of EUR 15 million per project (RVO, 2020).

The Mission Oriented Knowledge and Innovation Agenda (IKIA) framework aligns RD&D with Climate Agreement emissions reduction targets. IKIA defines RD&D priorities through 13 Multiannual Mission-driven Innovation Programmes (MMIP). MMIP 6 (Creating circular industrial chains), contains a sub-programme supporting accelerated and cost-effective use of CCS in existing industrial plants through research on optimisation of CO_2 capture, transport and storage and on monitoring and social acceptance. MMIP 6 calls for implementation of at least one industrial CCS demonstration project with a capacity of 2-4 Mt CO_2/year between 2023 and 2025.

Support for industrial CCS projects is available through the cost-competitive SDE++ auctions. CCS projects able to win SDE++ support receive payments based on the amount of CO_2 captured and stored. The level of subsidy depends on the technologies used in each project and accounts for the costs of CO_2 of transport and storage. Subsidy payments are available for 15 years after a project commences operation. The government plans to reduce the level of subsidy in the coming years in line with anticipated CCS cost reductions. Based on an independent study conducted in 2020, the Ministry of Economic Affairs and Climate Policy determined that in the short term, there are no cost-effective alternatives to CCS to achieve the desired level of emissions reductions. As such, SDE++ funding will be available for all industrial applications of CCS.

To ensure that CCS does not limit overall efforts on industrial sustainability, SDE++ funding for CCS is limited to 7.2 Mt CO_2 of industrial emissions reductions through 2030[4] (the Climate Plan indicates that industrial emissions should be reduced by at least 14.3 Mt CO_2 by 2030). In addition, no CCS projects capturing CO_2 emissions from fossil fuels will be able to bid for SDE++ funding after 2035. CCS projects selected in SDE++

[4] SDE++ funding is available for CCS covering an additional 3 Mt CO_2 of emissions reductions specifically related to flue gases from the Tata Steel factory. The gases are used to support electricity generation and as such CCS measures to reduce the associated emissions are classified as reductions from the electricity sector (not the industry sector) under the Climate Agreement. SDE++ funding is not currently available for any other applications in the electricity sector.

auctions before this cut-off date will continue to receive payments for avoided emissions and CCS projects capturing bioenergy GHG emissions or other non-fossil GHG emissions will still be able to bid for SDE++ funding. The government has indicated that SDE++ funding for CCS might be restricted for any industries or processes if cost-effective alternatives to CCS become available.

SDE++ support is not currently available for CCU. Support for CCU is being analysed and will depend on several factors, including the ability to calculate a net CO_2 reduction. Support for CCS targeting negative emissions through direct air capture or in combination with bioenergy is also being considered. The government indicates that support for CCS in the electricity sector could be an option after 2030, but only if existing measures, like the coal phase out and renewable energy deployment, do not result in the desired emissions reductions.

International co-operation

The Netherlands participates in several EU CCUS RD&D programmes, including ERA-NET ACT I and II under Horizon 2020. ACT I started in 2017 with research projects on capture, storage and CCS clusters. The ACT II tender closed in 2019 and supports projects covering the full CCS chain. The Netherlands supports the CCUS Implementation Working Group under the EU SET-plan RD&D programme. The Netherlands (along with France, Italy, Norway and the United Kingdom) is a founding member of the European Carbon Dioxide Capture and Storage Laboratory Infrastructure (ECCSEL), which supports collaboration on CCUS research by enabling access to CCUS facilities and projects in participating countries. The Netherlands collaborates on international CCUS RD&D through the IEA technology collaboration programmes and Mission Innovation (see Chapter 5).

Carbon capture utilisation and storage assessment

The Dutch government is aiming for CCS to play a key role in driving industrial emissions reductions. SDE++ funding for CCS is available for up to 72% of the emissions reductions expected from industry under the Climate Agreement. Dutch industry relies on a number of hard-to-decarbonise processes, including steel, cement, ethanol and chemicals production, as well as oil refining, which makes CCS an attractive option for industrial emissions reductions. However, CCS is an emerging technology and it remains unclear whether CCS can win SDE++ funding or achieve the large-scale deployment needed to drive significant industry emissions reductions in a cost-effective manner.

Several large-scale industrial CCS projects are being planned. The Porthos CCS project in the Port of Rotterdam is aiming to start commercial operations by 2023 and if completed would be one of the largest CCS operations in the world. CCS is also seen as a key option to support low-carbon hydrogen production and several large-scale CCS hydrogen projects are being planned. In 2019, hydrogen production accounted for around 10% of total natural gas demand and resulted in around 7 Mt CO_2 emissions, equal to 5% of total energy-related CO_2 emissions and over a quarter of industry CO_2 emissions.

Near-term policy focuses on scaling up CCS in industrial clusters. However, the government has made it clear that CCS cannot serve as a long-term alternative to increasing the sustainability of industry and has placed several limits on support for CCS. In the long term, the government wants to move away from CCS of fossil fuel emissions towards CCU, and CCS in combination with bioenergy.

The government supports CCUS RD&D through several funding programmes and large-scale CCS projects (including low-carbon hydrogen based on CCS) are eligible for subsidies through SDE++. However, CCUS is still in the early stages of development and faces numerous technical and financial risks. It is not clear if current support measures are sufficient to the drive the level of CCUS deployment envisioned in Dutch policy. In particular, it remains unclear if CCS can win funding under the SDE++ cost-competitive auction system. If the first round of SDE++ in 2020 does not lead to substantial CCS projects, then the government should consider updating and expanding supporting policy.

Scaling up CCUS to the level desired under the Climate Agreement faces challenges that need to be addressed through a coherent and robust policy framework. Such a framework should identify and pursue opportunities for low-cost CCUS, such as natural gas processing, and hydrogen and ethanol production, to provide a strong starting point for future CCUS deployment in the industry sector. Low-cost opportunities can be used to gain commercial experience and reduce costs across the CCS chain and form the basis of CCUS hubs to facilitate the development of CO_2 transport and storage networks.

There are three key areas where a policy framework could help to overcome the challenges CCUS faces in reaching commercial scale deployment. First, for establishing a sound business case, a mix of flanking policies can provide support, including emissions performance standards, green procurement initiatives and carbon pricing mechanisms. The carbon levy on industrial emissions to be introduced in 2021 should prove supportive.

Second, to derisk CCUS investment, the government can consider granting CO_2 volume guarantees for transport and storage operators (in case of delays in the capture projects), and transport and storage guarantees for capture operators (in case of delays in the transport and/or storage projects). Public guarantees covering long-term liability for stored CO_2 or loan guarantees to secure finance might also be needed.

Third, there are significant technical and commercial differences between business models for CO_2 capture (which takes place at individual plants and can have very different requirements) versus for CO_2 transport and storage (which is closer to the role of a network operator and faces issues relating to long-term storage liability). As such, decoupling the CCUS business chain into separate areas for capture and for transport and/or storage can help to reduce cross-chain risks.

Several possible business models for CCUS clusters are available, which differ mainly in ownership and operation of transport and storage infrastructure. Regardless of the exact business model, the government will need to play a leading role, in co-ordination with industry, in the planning, permitting and development of multi-user transport and storage infrastructure, recognising there is a strong public good element to CCUS investment.

Considering the long lead times for CCUS projects, early action is required to deploy the required transport and storage infrastructure, and build the necessary institutional and technical capacity. Close partnerships and co-operation between industry and government is of key importance to support rapid and widespread uptake of CCUS in Dutch industry, as well as sharing project-based experience with other countries to reduce future costs.

CCU is already widely used in the Netherlands to support greenhouse agriculture. There are also potential opportunities for CCU in the industry sector, where captured CO_2 could support a variety of existing chemical processes that rely on CO_2 as a feedstock. CCU RD&D should explore the potential for expanded use of captured CO_2. The government should also examine how CCU can contribute to achieving climate targets. If CCU can play a meaningful role, the government should design a transparent and robust measurement, reporting and verification framework to ensure that CCU emissions reductions are achieved, and examine options for support of CCU.

Carbon capture utilisation and storage recommendations

The government of the Netherlands should:

- Promote research into CCUS technologies that are applicable to Dutch industry.
- Closely examine the results of the first round of SDE++ and make needed policy adjustments if CCS projects do not win the expected level of support.
- Actively promote advanced CCUS projects that support near-term emissions reductions through timely permitting, funding and clarification of legal and regulatory arrangements, including long-term liabilities.
- Continue to engage with industry and other CCUS stakeholders to provide clarity on CCUS strategy, infrastructure, market and financial frameworks and legislation.

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4. Energy efficiency

Key data

(2018)

Total final consumption (TFC): 58.1 Mtoe (oil 42.8%, natural gas 33.6%, electricity 16.0%, district heat 3.4%, bioenergy and waste 2.5%, coal 1.4%) -5% since 2008

Consumption by sector: industry 46.5%, transport 18.8%, services 18.3%, residential 16.5%

Energy consumption (TFC) per capita: 3.4 toe/capita (IEA average 2.8 toe/capita, IEA median 2.4 toe/capita)

Energy intensity (TFC/GDP*): 63 toe/USD million (IEA average: 62 toe/USD million, IEA median 62 toe/USD million), - 14% since 2008

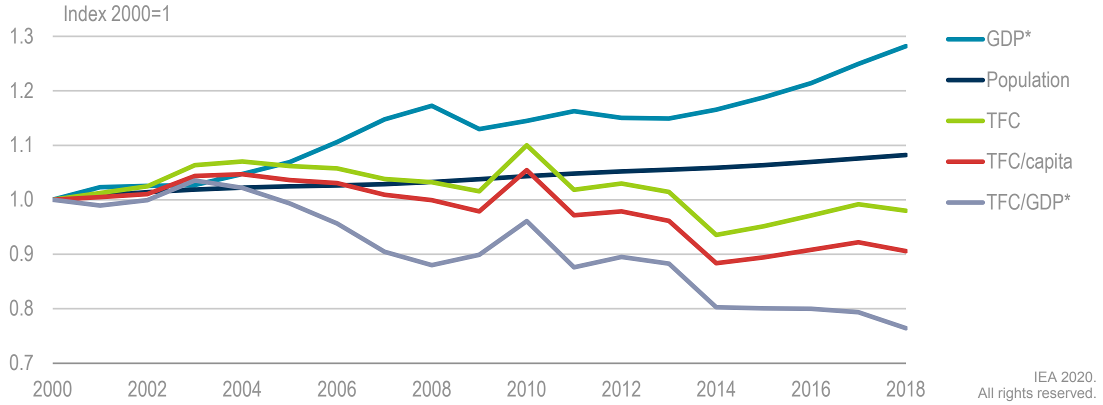
*GDP data are in USD 2015 prices and PPPs (purchasing power parity)

Overview

Total final energy consumption (TFC) in the Netherlands peaked in 2010 at 65.3 Mtoe. TFC declined to 55.5 Mtoe in 2014, but has since increased slightly to 58.1 Mtoe in 2018. The recent increase in energy consumption is driven by a growing population, which increased by 8% from 2000 to 2018, and a growing economy. Gross domestic product (GDP) growth stalled between 2008 and 2014, but has since steadily increased. The Netherlands is showing signs of a decoupling of energy consumption from economic growth. TFC/GDP fell notably from 2010 to 2014 and has declined slightly since 2014.

The EU Energy Efficiency Directive (EED) requires the Netherlands to set 2020 and 2030 energy efficiency targets. 2020 targets and supporting policies are defined in the National Energy Efficiency Action Plan (NEEAP). 2030 targets and supporting policies are given in the National Energy and Climate Plan (NECP). The Climate Agreement focuses on CO_2 emissions reductions, but recognises energy efficiency as a key measure to achieve the 49% emissions reduction target and defines numerous policies supporting energy efficiency. Continued improvements to energy efficiency across all sectors will be crucial for the Netherlands to achieve its energy efficiency and emissions reduction targets in a cost-effective manner.

Figure 4.1 Energy consumption and drivers, 2000-18



Dutch energy demand is at the same level as in 2000 and shows signs of decoupling from economic growth. However, energy consumption has increased since 2014.

* *GDP* data are in billion USD 2010 prices and PPPs (purchasing power parity).

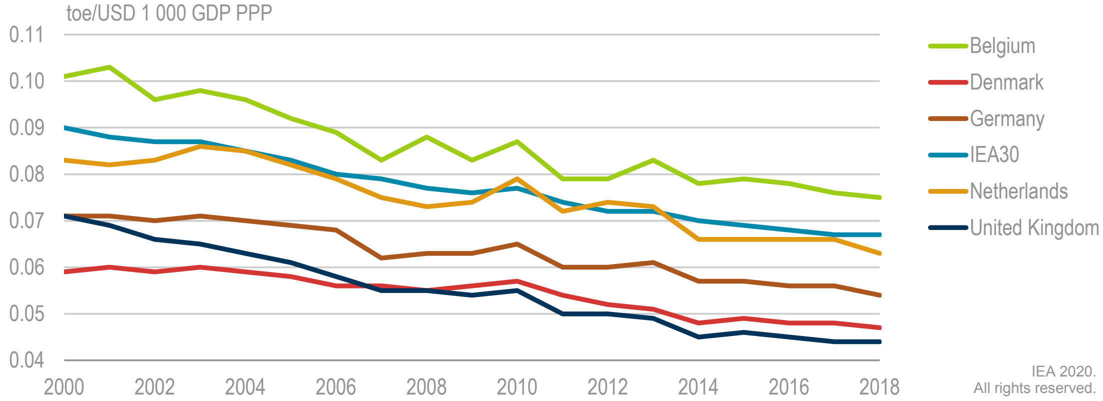
Note: GDP = gross domestic product; TFC = total final consumption.

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Energy intensity per capita and GDP

The Energy intensity of the Netherlands (measured as TFC/GDP) fell by 24% between 2000 and 2018, in line with the decreasing trend seen in neighbouring countries and the IEA as a whole (Figure 4.2). In 2018, the energy intensity of the Netherlands was the 13th highest among IEA member countries, 2% above the median. In terms of energy consumption per capita, the Netherlands ranked the eighth highest (Figure 4.3).

Figure 4.2 Energy intensity in selected IEA member countries, 2000-18



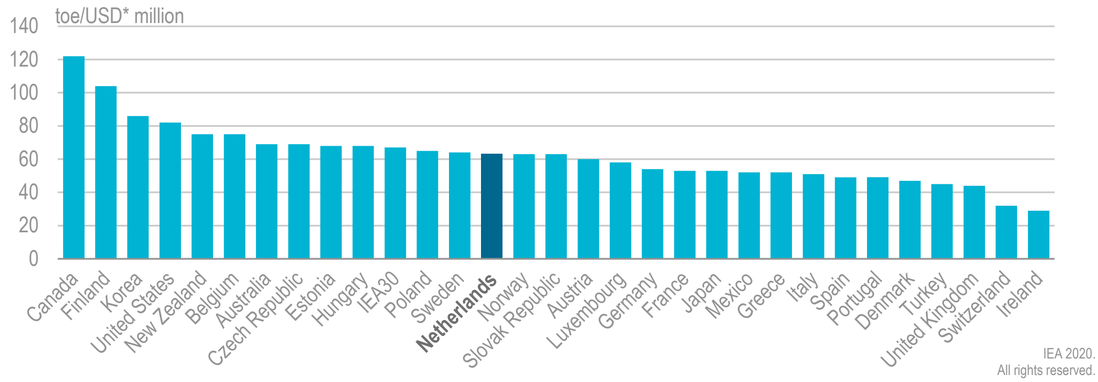
The Netherlands has reduced its energy intensity in recent decades, following the trend of other IEA member countries.

Note: Energy intensity as total final consumption per gross domestic product in purchasing power parity (TFC/GDP PPP).

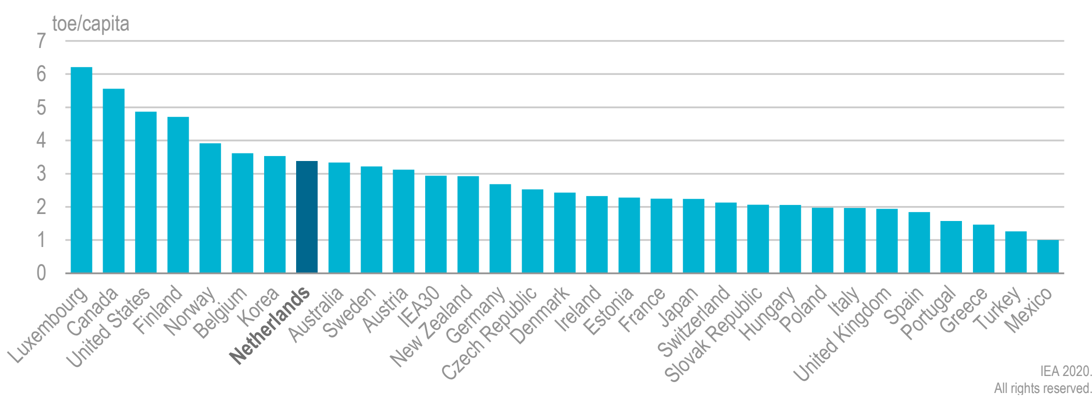
Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 4.3 Energy intensity in IEA member countries, 2018

Energy consumption per GDP (TFC/GDP*)



Energy consumption per capita (TFC/capita)



The Netherlands had the 8th highest energy consumption per capita among IEA countries in 2018 and ranked around the median in energy consumption per GDP.

* GDP data are in billion USD 2015 prices and PPPs (purchasing power parity).

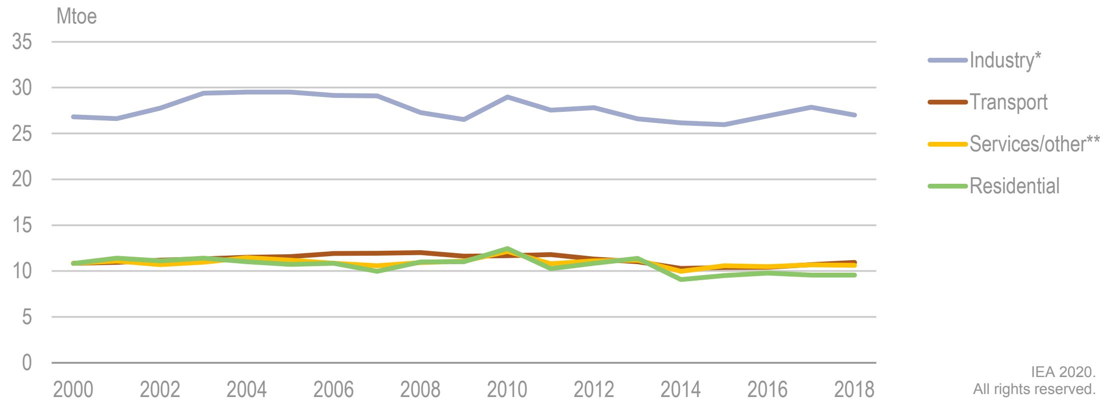
Note: GDP = gross domestic product; TFC = total final consumption.

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Energy consumption by sector

The industry sector is the main energy consumer and the main driver for changes in TFC in the Netherlands. From 2008 to 2018, the industry share of TFC ranged from 44% to 47%. Over the same period, the transport, services and residential sectors all had shares of TFC around 17% to 19%. While demand in the transport and service sectors has been stable, the industry and residential sectors have shown notable demand fluctuations driven respectively by changing economic activity and demand for heating due to yearly temperature variations.

Figure 4.4 Total final consumption by sector, 2000-18



The industry sector is the main energy-consuming sector, with 46% of TFC in 2018, while the transport, services and residential sectors each accounted for around 18% of TFC.

* *Industry* includes non-energy consumption.

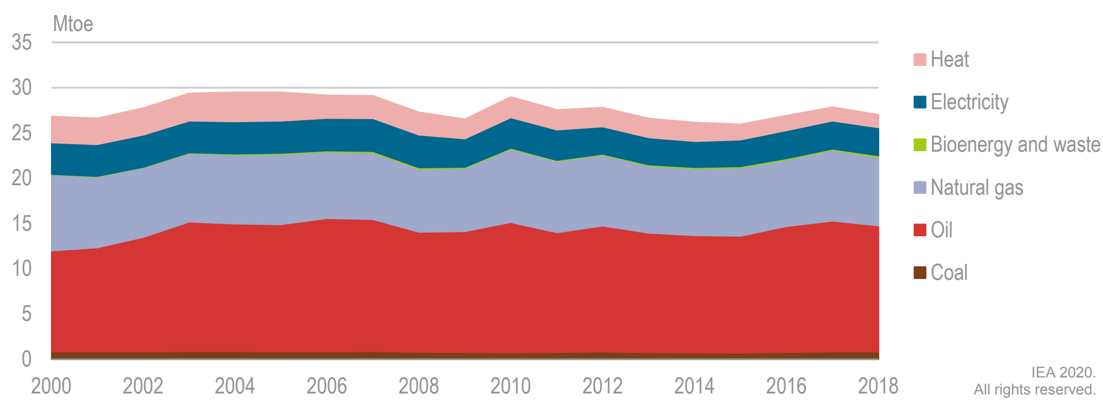
** *Services/other* includes commercial and public services, agriculture, forestry and fishing.

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Industry demand

The industry sector is the largest energy consumer in the Netherlands, accounting for 46% of TFC in 2018 (Figure 4.5). Consumption has fluctuated between 26 Mtoe and 29 Mtoe over the last decade, in line with economic activity. In 2018, the majority of industry demand was for oil (52%), followed by natural gas (28%), electricity (11%), heat (5%), coal (3%), and bioenergy and waste (1%).

Figure 4.5 Total final consumption in industry by source, 2000-18



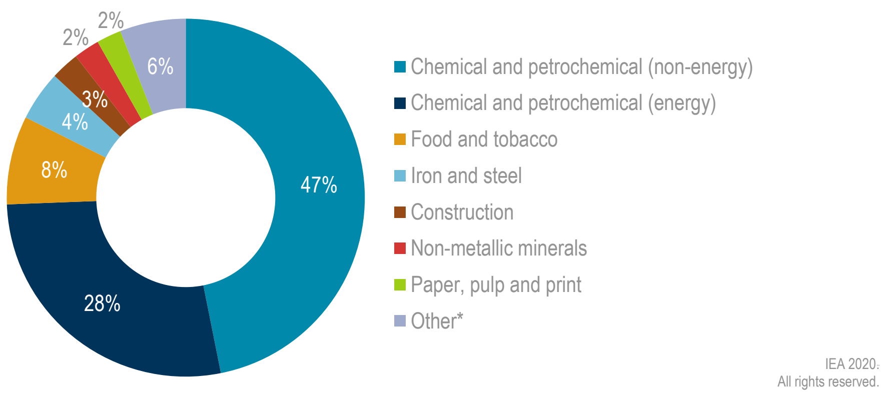
Industry demand peaked in 2010, but has been increasing since 2015 in line with GDP. Industry demand is dominated by oil and natural gas.

Notes: Includes non-energy consumption.

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

In 2018, the chemical and petrochemical sector accounted for 74% of industry demand (47% for non-energy use of feedstocks for industrial processes and 28% for energy purposes) (Figure 4.6). The high share of non-energy use reflects the important role of refining and chemical production in Dutch industry. The food and tobacco sector had the second-largest industrial energy demand (8%), reflecting the important role of agriculture in the Dutch economy. The Netherlands also has notable steel production, accounting for 4% of industrial demand.

Figure 4.6 Industrial total final consumption breakdown by sector, 2018



The chemical and petrochemical sector accounted for 74% of industry demand in 2018, 47% of which was for non-energy feedstocks supporting industrial processes.

* *Other* includes transport equipment, mining and quarrying, wood and wood products, textile and leather, non-ferrous metals, and non-specified (industry).

Note: Includes non-energy, which covers energy carriers such as oil, oil products and natural gas that are used as raw materials for industrial process but are not consumed as a fuel.

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Residential and services demand

In 2018, the residential and services sectors together consumed 20.2 Mtoe; 9.6 Mtoe in the residential sector, 6.8 Mtoe in commercial and public services, and 3.8 Mtoe in agriculture (including small shares from forestry and fishing). The Netherlands has a large agricultural sector, with the second-highest agricultural exports in the world after the United States. The energy demand of the agriculture sector is partly driven by heating a large number of greenhouses.

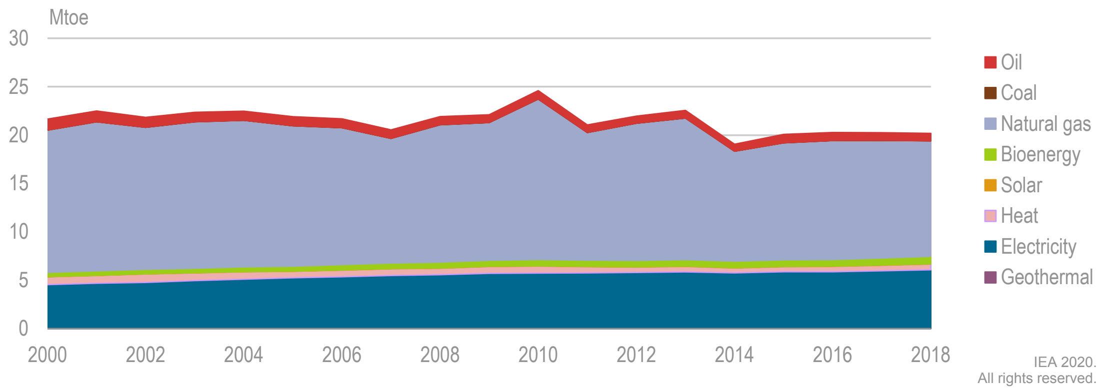
Energy demand in the residential and service sectors is driven by heating demand from buildings (including greenhouses in the agricultural sector). Natural gas is the main fuel for heating in the Netherlands. Annual temperature variations drive fluctuating demand for heating, which is seen as variations in natural gas demand (Figure 4.7).

Despite demand fluctuations tied to heating, it is possible to observe several long-term trends in residential and services energy demand. Improving energy efficiency supported a 7% reduction in the combined demand of these sectors from 2000 to 2018. The role of natural gas has thus been slowly declining. From 2000 to 2013, gas covered 63-68% of total demand, but since 2014, the share has been flat, at around 60%. In contrast, the share of electricity in demand has been steadily increasing, from 21% in 2000 to 30% in 2018.

From 2000 to 2018, oil covered a stable level of around 4% of demand in the residential and service sectors, with a slight increase in recent years. Oil is primarily used as fuel for agricultural equipment and fishing boats (together 66% of residential and services oil demand in 2018). Because of the extensive natural gas network, heating based on oil is uncommon in the Netherlands.

The use of energy from renewable sources (primarily bioenergy and minor shares of geothermal and solar thermal) in the residential and service sectors is small, but has consistently grown, from 2.1% of demand in 2000 to 4.4% in 2018. In contrast, district heating has seen a slow decline, from 3.7% of demand in 2000 to 2.9% in 2018. The Netherlands is aiming to increase the use of both renewables and districting heating (see Box 4.1).

Figure 4.7 Total final consumption in the residential and services sectors by source, 2000-18



Natural gas is the main fuel in the residential and service sectors. Gas demand is linked to fluctuating heat demand, which peaked in 2010 due to unusually cold weather.

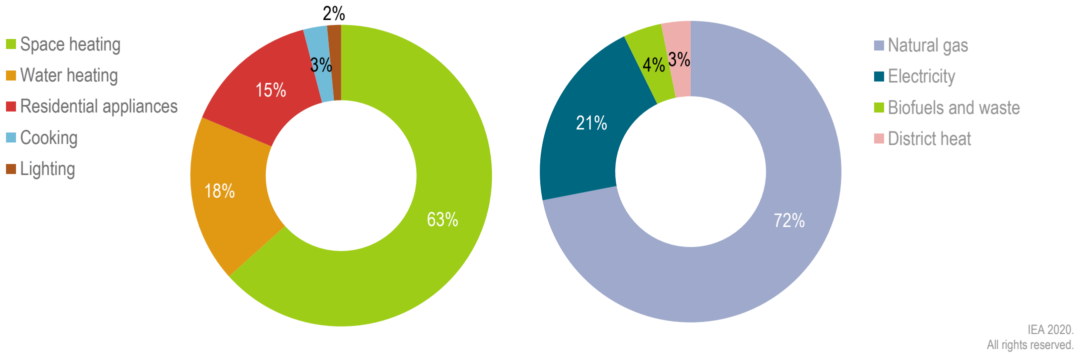
* *Other renewables* includes geothermal and solar, not visible on scale.

Note: The services sector includes commercial and public services, agriculture, forestry and fishing.

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Looking specifically at the residential sector (Figure 4.8), space and water heating accounted for 81% of total energy demand in 2017, followed by appliances (15%), cooking (3%), and lighting (2%). Natural gas was the main fuel (72% of demand), followed by electricity (21%), bioenergy (4%) and district heating (3%). Natural gas covered 88% of residential heating, with a small contribution from bioenergy, districting heating and electricity. Electricity is used mainly for appliances, but electric heating has been growing.

Figure 4.8 Residential energy consumption by use and by fuel, 2017



Space and water heating together accounted for 81% of the total energy demand in the residential sector in 2017. Natural gas and electricity were the main energy sources.

* *Others* includes mainly electric heating and ambient heat (with heat pump) and small shares of oil and solar heat.

Sources: IEA (2020b), *Energy Efficiency Indicators 2020* (database), www.iea.org/statistics.

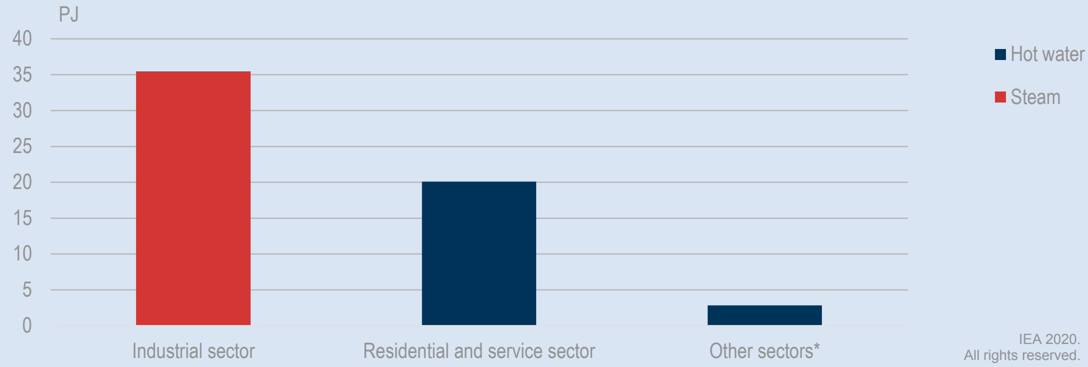
Box 4.1 District heating development in the Netherlands

District heating is supported under the Climate Agreement as a key option supporting the goals of supplying low-carbon heating to 1.5 million buildings by 2030 and of a climate-neutral built environment by 2050. In support of these goals, all municipalities have to develop Transition Visions for heat and the central government is providing EUR 400 million for pilot projects of natural gas-free districts through 2030.

The share of building heating demand covered by district heating has been declining since 2000. However, the number of buildings using district heating grew from 344 000 in 2015 (3.9% of buildings) to 386 000 in 2017 (4.3% of buildings). The Netherlands Environmental Assessment Agency (PBL) expects that 20-30% of homes will be connected to district heating by 2050 (PBL, 2019a). In 2017, district heating production was 58 PJ, with 35 PJ of steam for industry, 20 PJ for heating in residential and service sector buildings, and 3 PJ for heating in other sectors, mainly for heating of greenhouses in the agricultural sector (Figure 4.9).

Availability of cost-effective renewable heating options is essential to support the desired growth in district heating; however, district heating remains heavily reliant on natural gas. In 2017, approximately 68% of district heat production came from combined heat and power (CHP) plants, mainly fuelled by natural gas and some waste incineration. The remaining share of district heating came from biomass boilers, natural gas boilers or other heat sources (e.g. industrial waste heat). Dutch CHP capacity increased from 2007 to 2010, driven by new plants built to cover heating demand in agriculture. Since 2010, due to low electricity prices, almost no new CHP systems have been built and overall CHP production has decreased.

Figure 4.9 Consumption of district heating by sector, 2017



Industry consumed 61% of district heating in 2017, mainly supplied as steam, while hot water was used mainly in residential and commercial buildings plus some in agriculture.

* *Others* includes mainly agriculture.

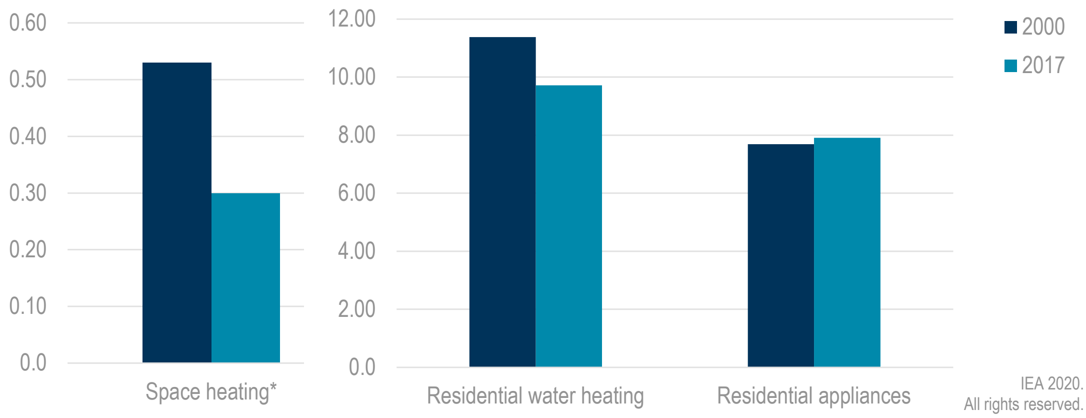
Source: CBS (2018), District Heating reporting Eurostat/EED.

Under the Climate Agreement, CHP use is expected to decline in favour of heat from electricity and direct use of renewable energy. The government does not have a specific CHP incentive policy, but CHP is supported by the Energy-saving Investment Credit (EIA) and natural gas used CHP is exempt from the energy tax. CHP projects using biomass and biogas are eligible for support through the competitive auction-based Stimulation of Sustainable Energy Production (SDE+) support scheme, which will end in 2020. The follow on Sustainable Energy Transition Incentive Scheme (SDE++) support scheme will continue to offer support for CHP from biomass and biogas; however, the government intends to review support for biogas CHP and may change policy to favour upgrading biogas to biomethane for grid injection and other uses (see Chapter 6 for details on SDE+ and SDE++).

Commercial businesses, mainly energy companies, own district heating networks as well as most of the heat production. A small number of independent operators produce heat and sell it to a network. District heating prices are regulated and linked to the price of natural gas, so that the average district heating consumer will pay the same price as a consumer owning a gas boiler. The Authority for Consumers and Markets (ACM) is the regulator overseeing the district heating market. ACM has discussed changes to district heating price regulations in line with the goal to move away from natural gas heating.

Improved energy efficiency in buildings is supporting an overall reduction in heat demand. In the residential sector, energy demand for space heating per square metre of building floor area declined by 43% from 2000 to 2017. Over the same period, energy demand for water heating per dwelling fell by 15% (Figure 4.10). Residential appliances consume the second-highest share of residential energy demand after heating and are a driver for the growing share of electricity demand in the residential sector. While the efficiency of individual appliances has been improving thanks to EU efficiency and labelling standards, total energy consumption by appliances increased by 17% between 2000 and 2017. Correspondingly, energy intensity for appliances in energy demand per dwelling has increased by 3%.

Figure 4.10 Residential energy intensity, 2000 and 2017



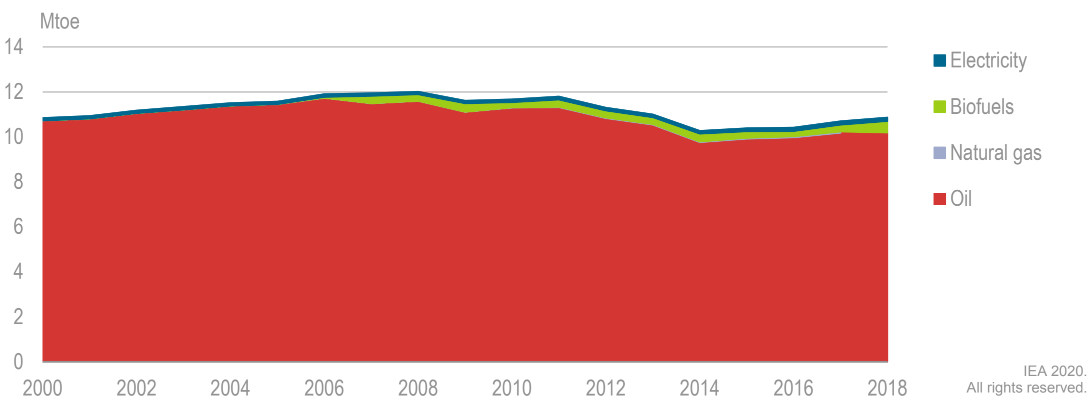
The Netherlands has significantly reduced its energy intensity for space and water heating in residential buildings, while energy intensity for appliances has increased.

* Temperature corrected, GJ/m²: gigajoule per square metre, GJ/dw: gigajoule per dwelling.
Source: IEA (2020b), *Energy Efficiency Indicators 2020* (database), www.iea.org/statistics.

Transport demand

Transport energy demand peaked in 2008 at 12 Mtoe, declined to 10.3 Mtoe in 2014, but has since increased, reaching 10.9 Mtoe in 2018 (Figure 4.11). Oil has historically covered almost all transport energy demand, with a small share of electricity demand coming primarily from rail. Starting in 2006, biofuels have covered a small share of transport demand. In 2018, oil covered 93% of transport demand followed by biofuels (5%), electricity (2%) and natural gas (0.6%).

Figure 4.11 Total final consumption in transport by source, 2000-18

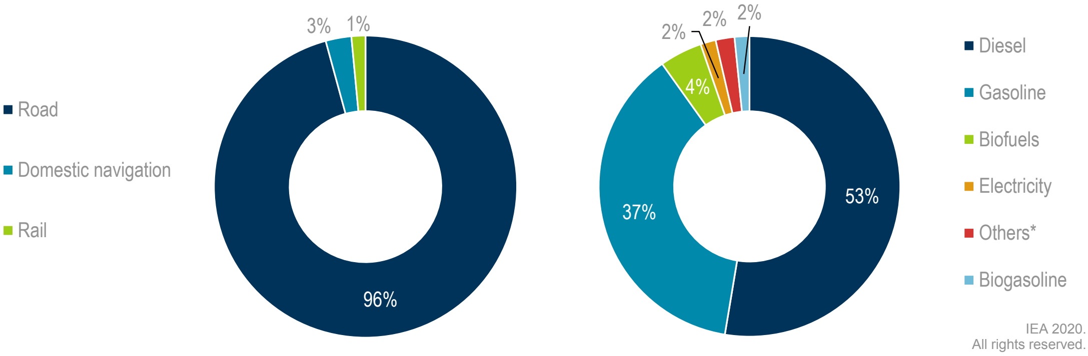


Transport demand is down from a peak of 12 Mtoe in 2008, but demand has been increasing since 2014. Oil is the dominant fuel, but the shares of biofuels and electricity are growing.

Note: Transport sector demand excludes international aviation and navigation.
Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

In 2018, road transport accounted for 96% of transport energy demand followed by small levels of demand from domestic navigation and rail. Diesel (53% of transport demand) and gasoline (37%) are the main transportation fuels while biofuels cover 5% of energy demand (Figure 4.12). Almost two-thirds of road transport demand comes from passenger vehicles (including buses), while freight trucks account for most of the remaining demand.

Figure 4.12 Domestic transport demand by mode and fuel, 2018



Road transport accounts for most transport energy demand. Diesel and gasoline are the main transport fuels, followed by small shares of biofuels in road transport and electricity in rail.

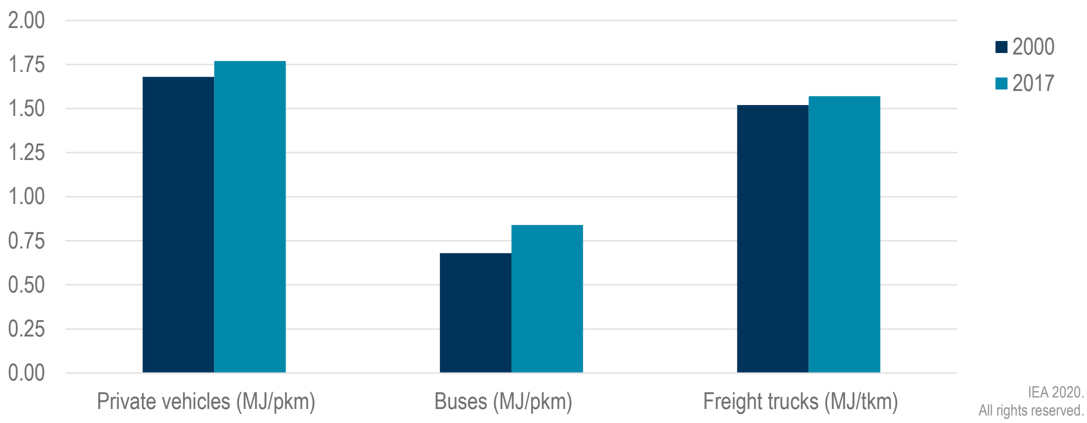
* Includes liquefied petroleum gases, natural gas and a small share of domestic aviation fuel.

Note: Not including fuels for international aviation and international navigation. A minor share of domestic aviation is not visible in the chart.

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

The fuel intensity of the Dutch passenger car fleet increased 5% from 1.7 MJ/pkm (megajoule per passenger kilometre) in 2000 to 1.8 MJ/pkm in 2017 (Figure 4.13). Energy intensity of the bus fleet increased by 24% from 0.68 MJ/pkm in 2000 to 0.84 MJ/pkm in 2017. Dutch freight trucks' energy intensity increased 3% from 1.5 MJ/tkm (megajoule per tonne kilometre) in 2000 to 1.6 MJ/tkm in 2017.

Figure 4.13 Energy intensity in road transport by mode, 2000 and 2017



From 2000 to 2016, energy intensity increased 5% for passenger vehicles, 24% for buses and 3% for freight trucks.

Source: IEA (2020b), *Energy Efficiency Indicators 2020* (database), www.iea.org/statistics.

Electricity accounted for around 2% of transport energy demand in 2018. However, electricity plays an important role in the Dutch transport system, as it is the main source of power for the Dutch rail network. In 2018, electricity accounted for 85% of total energy demand in rail, and in 2017, over 75% of the Dutch rail network was electrified, one of the highest rates of rail electrification in the EU (EC, 2018). Electric vehicles (EVs) are growing rapidly in road transport and the Netherlands is a world leader in EV deployment and charging infrastructure (Box 4.2).

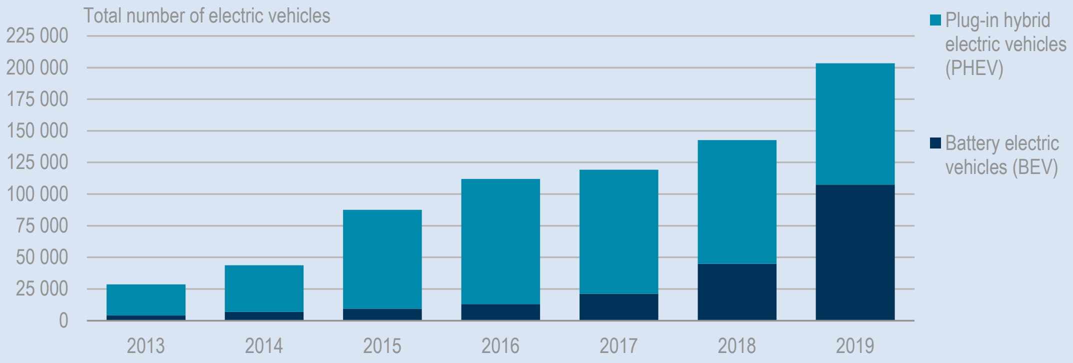
Box 4.2 Electric vehicle market development in the Netherlands

The Netherlands is a world leader in electric vehicle (EV) deployment. In 2019, EVs accounted for 15% of annual passenger car sales (up from less than 7% in 2018). The monthly share of EVs in new car sales reached 54% in December 2019, as financial support for leased EVs halved in 2020 (Inside EVs, 2020). In 2019, the Netherlands had the second-highest share of EVs in new car sales in the world after Norway, where around 50% of new cars sale were EVs. The rate is 11% in Sweden.

In 2019, the Netherlands experienced the largest growth in EV sales to date, with around 60 000 new EVs registered and the total EV fleet growing to over 200 000 vehicles. The Netherlands is also seeing a notable shift in consumer preference away from plug-in hybrid EVs (PHEVs) to fully electric battery EVs (BEVs). The majority of EVs registered in 2018 and 2019 were BEVs and at the end of 2019, BEVs made up the majority of the EV fleet (Figure 4.14).

Looking to 2030, the Netherlands has ambitious goals for 100% of new vehicle sales to be zero-emission vehicles – BEVs or hydrogen fuel cell electric vehicles (FCEVs) – and for 1.9 million zero-emission vehicles in the total vehicle fleet. The government also has a goal for increasing the share of zero-emission public buses; after 2025 all new buses should to be zero-emission. The Climate Agreement estimates that achievement of the target for 100% of new vehicles sales to be zero-emission by 2030 would result in an additional electricity demand of 7.1 TWh, or around 6% of the expected electricity demand in 2030.

Figure 4.14 Dutch passenger electric vehicle fleet, 2016-19



The EV fleet in the Netherlands has rapidly increased, with a growing preference for BEVs.

Source: EAFO (2020), *Vehicles and Fleet, Electricity, Netherlands*, www.eafo.eu/vehicles-and-fleet/m1.

EV uptake is supported by a number of measures, including lower taxes related to company cars. Employees receiving a diesel or gasoline company car must add 22% of the vehicle price to their taxable income. For BEVs and FCEVs, the percentage of the company car price added to taxable income is notably less: 4% until the end of 2019 and 8% as of 2020. EVs also receive reductions in the annual road tax (MRB) and the vehicle registration tax (Bpm). BEVs and FCEVs do not pay the MRB and PHEVs pay only half of the MRB. The government is planning to extend the MRB tax emption through 2024, at which point it will be gradually reduced (Government of the Netherlands, 2020a). BEV and FCEV vehicles do not pay the Bpm and PHEVs pay a lower Bpm than diesel and gasoline vehicles. The Bpm exemption for EVs will also be reduced over the coming years (Ministry of Finance, 2020).

The Netherlands has also introduced new subsidies to increase the uptake of zero-emission vehicles. Since 4 June 2020, newly purchased or leased zero-emission vehicles are eligible for a subsidy of EUR 4 000 and used zero-emission vehicles are eligible for a subsidy of EUR 2 000. To qualify, the vehicle price must be between EUR 12 000 and EUR 45 000, driving range must be over 120 km. There are restrictions on vehicle size limiting the subsidy to smaller vehicles and PHEVs do not qualify for the subsidy. Because of the EUR 45,000 price cap, none of the currently available FCEVs qualify for the subsidy. The Netherlands Enterprise Agency (RVO) administers the programme and maintains a regularly updated list of qualified vehicles. In June 2020, the list contained over 40 BEVs that qualified for the zero-emission vehicle subsidy (RVO, 2020a).

The zero-emission vehicle subsidy programme is currently set to run through July 2025 or until the allocated budget is exhausted. For 2020, EUR 10 million is budgeted for subsidies for new zero-emission vehicles and EUR 7.2 million for subsidies for used zero-emission vehicles. Each resident of the Netherlands is entitled to use the subsidy (new or used) only once. The government is also examining a variety of options to strengthen the market for used zero-emission vehicles in the Netherlands.

The Dutch EV fleet is supported by robust charging infrastructure. As of May 2020, there were over 56 000 semi-public EV charging points in the Netherlands, one of the highest concentrations globally (EAFO, 2020; IEA, 2019). In January 2020, the Metropolitan Region of Amsterdam awarded a contract for the installation of 20 000 EV charging stations (Total, 2020). Under the National Charging Infrastructure Agenda, the government is co-operating with provinces, electricity system operators and other stakeholders to rapidly increase the deployment of charging infrastructure, with the goal of reching around 1.7 million charging points by 2030 (NAL, 2020).

Institutions

The responsibility for energy efficiency policy is divided among four ministries. The Ministry of Economic Affairs and Climate Policy is responsible for general energy efficiency policy and for measures in the industry and energy sectors. The Ministry of the Interior and Kingdom Relations is responsible for energy efficiency in buildings. The Ministry of Infrastructure and Water Management is responsible for energy efficiency in the transport sector. The Ministry of Agriculture, Nature and Food Quality is responsible for energy efficiency in the agriculture sector.

The competent authority for enforcing energy efficiency legislation is in most cases the relevant municipality or, for larger companies, the provincial authority. The Netherlands Enterprise Agency (RVO) is the lead implementing agency for energy efficiency. RVO implements the various energy efficiency programmes and assists companies in complying with energy efficiency requirements. The Rijkswaterstaat InfoMil knowledge centre provides insight in energy efficiency legislation and training for competent authorities.

Targets

European Union (EU) directives are key drivers of Dutch energy efficiency targets and policy. The 2012 EU Energy Efficiency Directive (EED) (2012/27/EU) established a set of measures supporting the achievement of the 2020 target of a 20% reduction in EU-wide energy consumption compared to the business-as-usual projection. The EED requires EU member states to:

- set energy efficiency targets, based on primary or final energy consumption, primary or final energy savings, or energy intensity
- require energy suppliers to realise at least a 1.5% reduction of annual energy demand for final consumers through an energy efficiency obligation (EEO) scheme, or other measures that achieve the same savings
- require large companies to regularly audit energy demand and identify efficiency measures
- provide incentives to support energy audits by small and medium-sized enterprises
- develop a national building renovation strategy and implement measures to improve energy efficiency in public buildings
- ensure that national governments purchase only products, services and buildings with a high energy efficiency performance.

Under the EED, EU member states set indicative national energy efficiency targets to contribute to the EU-wide target. These targets are defined in a National Energy Efficiency Action Plan (NEEAP), which also details the measures supporting the achievement of the target. The EED requires submission of an updated NEEAP every three years along with annual reports on progress towards energy efficiency targets. The Netherlands submitted its fourth NEEAP to the EC in 2017, specifying a 2020 energy efficiency target of not surpassing 52.2 Mtoe (2 186 PJ) of final energy consumption and 60.7 Mtoe (2 541 PJ) of primary energy consumption (MEACP, 2017).

In line with the EED, the Netherlands established an EEO with a target to save 482 PJ cumulatively on final energy consumption from 2014 to 2020. To meet the EED requirements for improving the energy efficiency of public buildings, the Netherlands has chosen the allowed alternative approach requiring that 3% of the total floor area of buildings of more than 250 square metres owned or used by central government is renovated annually.

In addition to EED requirements, the 2013 Energy Agreement for Sustainable Growth set an energy efficiency target requiring an average final energy consumption saving of 1.5% per year through 2020. This target would result in a final energy consumption saving of

100 PJ by 2020 compared to a reference scenario that excludes the energy efficiency measures defined in the 2013 Energy Agreement.

The Netherlands' 2030 energy efficiency targets are derived from the EU Clean Energy Package (CEP). The CEP includes an updated EED published in December 2018, which set an EU-wide 2030 target to increase energy efficiency by at least 32.5% compared to a business-as-usual projection (EC, 2019a). Under the CEP, each EU member state was required to submit a National Energy and Climate Plan (NECP) in 2019, proposing contributions to the EU-wide 2030 targets for energy efficiency, GHG reductions (see Chapter 3) and renewable energy (see Chapter 6). The Netherlands delivered its NECP to the EC in November 2019.

Under the NECP, the Netherlands has set 2030 targets of 1 950 PJ of primary energy consumption and 1 837 PJ final energy consumption. In 2018, primary energy consumption was 2 710 PJ and final energy consumption 2 105 PJ. The initial EC review of the NECPs indicated that the Netherlands' energy efficiency targets support the EU-wide energy efficiency target (EC, 2019a). The review of the NECPs is still ongoing and it is possible that the EC will request additional contributions from EU member states to support achievement of the EU-wide energy efficiency target.

In line with EED requirements, the Netherlands will continue the existing EEO programme with an updated target to save 914 PJ cumulatively on final energy consumption from 2021 to 2030. If achieved, this would cover most of the energy savings required under the 2030 targets. In relation to the EED requirement for improving energy efficiency of public buildings, the NECP states that for the period 2021-30, the Netherlands will continue to use the allowed alternative approach requiring that 3% of the total floor area of buildings of more than 250 square metres owned or used by the central government is renovated annually. The Netherlands will adopt the Sectoral Road Map of the Central Government Real Estate Agency to support achievement of the 3% renovation target. The Road Map was produced in the context of the Climate Agreement and outlines the plan to achieve a low CO_2 real estate portfolio for the central government by 2050. The estimated savings in the Road Map are 1.3 PJ in 2030, which exceeds the savings of 0.2 PJ estimated to result for the 3% renovation rate.

While the Climate Agreement (see Chapter 3) does not contain the 2030 EED/NECP energy efficiency targets, there is some alignment between the Climate Agreement emissions reduction targets and the EED/NECP targets. In 2018, the PBL conducted a study of possible policy measures in order to meet the 49% emissions reduction goal for 2030. These measures were later adopted in the Climate Agreement. The resulting primary and final energy demand levels in 2030, which corresponds to the most cost-effective policy measures to meet the 49% reduction target, where used as the basis for the 2030 energy efficiency targets set in the NECP (PBL, 2018). The NECP does not contain sector-specific energy efficiency targets. However, the Climate Agreement defines indicative emissions reduction targets for the industry, transport, buildings, electricity and agriculture sectors, which aim to support energy efficiency.

Policy and support measures

While the Climate Agreement has shifted energy policy to focus on emissions reductions, it does define a number of policies and support measures for energy efficiency in various sectors. The Netherlands also has a wide range of energy efficiency programmes that are defined outside of the Climate Agreement.

General measures

The Environmental Management Act defines some of the most important energy efficiency measures, including the EEO required under the EED. The Dutch have adopted a broad EEO that is expected to be one of the primary drivers of increased energy efficiency. The EEO requires companies and institutions with an annual energy demand equal to or above 50 000 kWh electricity, 25 000 m³ (cubic metres) of natural gas or equivalent to implement all energy saving measures with a payback period of 5 years or less. To ease enforcement of and compliance with the EEO, the act includes the Recognised Energy Efficiency Measures List (EML), which defines the building components, industrial processes, appliances, equipment and lighting options required under the EEO.

The Environmental Management Act was updated in 2019 to clarify the calculation of payback periods for EEO energy efficiency measures and to update the EML with additional measures (RVO, 2020b). This update also created an energy efficiency notification obligation for companies covered by the EEO. The notification obligation required companies to report implemented energy efficiency measures before 1 July 2019 or 5 December 2019 for companies that also have an EED energy audit obligation (RVO, 2020c). The RVO manages the EEO and the notification obligation programmes and assists companies in complying with these obligations. The RVO also supports companies that are obligated to submit an EED energy efficiency audit with information and tools on EED audit requirements and by running the website used to submit the energy audits to the EC.

The Environmental Management Act will be integrated into the broader Environment and Planning Act, which combines legislation on environment, spatial planning and the natural environment to better allow for integrated assessments. The Environment and Planning Act will include an extension of the EEO programme and the notification obligation through 2030. However, the Climate Agreement stipulates that the EEO will be changed to a CO_2 emissions reduction obligation and the government is considering changing the EEO requirement to implement specific energy efficiency measures with a five-year payback period to a different requirement possibly based on emissions reductions.

The Netherlands has a broad energy tax that covers consumption of electricity, natural gas and district heating. Consumers also pay a Surcharge for Sustainable Energy Act levy (ODE) on top of the energy tax, which funds the SDE+ and SDE++ support schemes. The government plans adjustments to the energy tax and ODE to support various programmes that are at least partly aimed at increasing energy efficiency. To support low-carbon heating (including more efficient heating options like heat pumps), the government will increase taxation of natural gas and lower taxation on electricity.

The Energy Investment Allowance (EIA) is a tax deduction for energy efficiency investments by private companies in sectors including industry, services, transport and agriculture. Individuals, associations and foundations are not eligible for the EIA. Under the EIA, up to 45% of qualifying investment costs can be deducted from the taxable profits on top of the regular depreciation allowed under Dutch tax law. Eligible investments are given in the EML, which is updated annually by the RVO. The EIA budget is set on an annual basis and from 2015 to 2019 varied between EUR 106 million and EUR 166 million. The EIA budget for 2020 is EUR 147 million (RVO, 2020d).

The Environmental Investment Rebate (MIA) and the Arbitrary Depreciation of Environmental Investments (VAMIL) are tax mechanisms supporting investments in environmental technologies by Dutch companies. The RVO maintains a list of eligible technologies, many of which support energy efficiency. The MIA allows companies to deduct up to 36% of capital outlays on qualifying investments from taxable profits in addition to the regular depreciation. The investment costs must be between EUR 2 500 and EUR 25 million. VAMIL allows companies to write off 9% of investments from the same list used for the MIA. Companies can apply for the MIA and VAMIL at the same time, but are not allowed to apply for the MIA and the EIA. The budgets for the MIA and VAMIL are set on an annual basis. The MIA budget was EUR 114 million for 2019 and EUR 124 million for 2020. The VAMIL budget was EUR 25 million in 2019 and in 2020 (Government of the Netherlands, 2020b).

The SDE++ subsidy scheme is designed to support technologies that result in CO_2 emissions reductions (see Chapter 6). SDE++ auctions allow bids from certain technologies that contribute directly to energy efficiency, such as heat pumps or electrification, such as electrical boilers. Many energy efficiency technologies are not eligible for SDE++ support due to limitations on measuring their CO_2 abatement. The Dutch government is currently exploring other options to support energy efficiency technologies that do not qualify for SDE++ support.

In addition to the support mechanisms listed above, which are broadly available to companies in most sectors, the Netherlands also maintains measures and policies that encourage energy efficiency in specific sectors, such as buildings, industry and transport.

Buildings

To promote energy efficiency in buildings, the Netherlands introduced a requirement in 2015 that most homes and other buildings have an Energy Performance Certificate (EPC) issued when they are built, sold or rented. EPCs provide information about the energy efficiency of the home or building and must be issued by a certified advisor. EPCs expire ten years after the issue date. Certain building categories such as historic and religious buildings are exempt from the EPC requirement. Building energy efficiency is also supported by the EU requirement for efficiency labelling on electrical household appliances such as refrigerators and freezers, washing machines, dryers, dishwashers, ovens, lighting, and air conditioners (Government of the Netherlands, 2020c).

To support the emissions reduction goal for the built environment, the Climate Agreement includes an ambition to transition around 1.5 million existing homes from natural gas to low-carbon heating, with a focus on renewable energy (see Chapter 6). Many of these low-carbon heating options would result in energy savings and it is intended that homes transitioning to low-carbon heating will do so as part of a comprehensive renovation process that includes increased insulation and other measures to improve energy efficiency.

The municipality-led Natural Gas-free Districts programme is a key element of the low-carbon heat transition. Under this programme, the government will provide EUR 400 million to support pilot projects executed across entire districts. New heating solutions will be selected based on the characteristics of the district's housing stock and local low-carbon heat resources. The programme has started to identify challenges, build expertise and provide best practices on heat transition to the relevant public authorities. The government is aiming to initiate around 100 district pilot projects by 2028.

As part of the Climate Agreement, municipalities are obliged to adopt a Transition Vision for Heat, indicating how the transition to low-carbon heating and more efficient buildings will be achieved within their jurisdiction. The central government and the Association of Netherlands Municipalities (VNG) will assess the required municipal powers and associated guarantees for consumers and building owners, as well as any necessary changes to legislation. The government will provide EUR 150 million from 2019 to 2021 to help cover the cost to municipalities for their responsibilities in relation to the heat transition. The government is investigating a long-term solution to financing these additional municipal responsibilities.

To support rapid action with regard to the low-carbon heat transition, the Climate Agreement has developed the Starter Motor programme, which aims to switch 100 000 buildings to low-carbon heating by the end of 2023. The incentive scheme for natural gas-free rental housing (SAH) has been developed to drive the Starter Motor programme. Under SAH, housing corporations, private landlords and institutional investors can apply for subsidies for connecting rental homes to heat networks. SAH requires that this renovation result in a complete removal of natural gas consumption from the home. SAH runs from 1 May 2020 to 31 December 2023, with a total budget of EUR 200 million (RVO, 2020e).

Support for energy efficiency in buildings also comes from the Energy-saving at Home Subsidy Scheme (SEEH), which provides subsidies for energy advice from a certified energy performance advisor, possibly in combination with process supervision and/or a multi-year maintenance plan, and for energy-saving measures, including insulation or a comprehensive efficiency package. SEEH subsidies are available to homeowners' associations, housing associations and housing co-operatives. Subsidies can only be used for owner occupied buildings, commercial real estate is not eligible. The SEEH scheme currently runs through 31 December 2022, with a total budget of EUR 14 million (RVO, 2020f).

The National Energy Savings Fund (NEF) was established in 2014 to encourage homeowners to invest in energy efficiency measures. The NEF provides reduced interest rate loans to individual owner-occupiers and homeowners' associations for investments in a variety of energy efficiency measures, which can be combined with investments in residential PV. The maximum loan is EUR 65 000 for individual owners and EUR 5 million for homeowners' associations. Discounted interest rates range from 1.5% to 2.7% depending on the loan amount and duration (10-20 years) and whether it is taken by an individual or association. As of June 2020, the NEF had a budget of EUR 600 million financed by the national government, Rabobank, ASN Bank, the Council of Europe Development Bank and the European Investment Bank. Some municipalities provide additional financing allowing for even lower interest rates. The non-profit foundation SVn manages and implements the NEF loan programme (NEF, 2020; SVn, 2020; EIB, 2020).

In 2020, the government established a Heat Fund within the NEF. The Heat Fund provides low interest loans to individual homeowners and homeowners' associations for investment in low-carbon heating. The Heat Fund also supports projects implementing heat transition of all homes in an entire district. Even under the district approach, Heat Fund loans allow each homeowner to choose their preferred low-carbon heating option. The government has initially contributed EUR 900 million to the Heat Fund and leveraged an additional EUR 300 million in private sector contributions to the fund. Additional public and private contributions to the Heat Fund are expected in the coming years (SVn, 2020).

The Sustainable Energy Investment Subsidy Scheme (ISDE) encourages small and medium-sized enterprises, housing co-operatives and homeowners to invest in solar thermal heating and heat pumps. ISDE offers subsides that cover part of the investment cost with the level of compensation depending on the energy performance of the device installed. ISDE will run through at least 2030 with a budget of EUR 100 million per year. In 2021, ISDE will be expanded to include support for building insulation measures undertaken by homeowners (Government of the Netherlands, 2020d).

The Netherlands is implementing the EU Energy Performance of Buildings Directive, with the introduction of energy efficiency requirements in national building codes, including legal requirements for new construction aiming at Nearly Zero Energy Buildings (EC, 2019b). In addition, the Sectoral Road Map of the Central Government Real Estate Agency was established in the context of the Climate Agreement and defines measures to achieve a low CO_2 real estate portfolio for the central government by 2050. The road map aims for cumulative energy savings of 1.3 PJ by 2030, which is higher than the savings of 0.2 PJ required under the EED 3% renovation target. In the context of the Climate Agreement, similar sectoral road maps have been developed for public real estate including education, healthcare, sports, local government, police, monuments and other areas to give perspectives on actions to make these building more energy efficient to contribute to the 2030 and 2050 emissions reduction targets.

Industry

The Netherlands has voluntary long-term agreements on energy efficiency (MEE and LTA3/MJA3) with companies in the industry sector (and some companies in the buildings and transport sectors). These agreements require four-year energy efficiency plans and reporting of implemented measures. MEE agreements call for improved energy efficiency by energy-intensive companies covered by the EU Emission Trading System (ETS). Initially the MEE called for 22 PJ of energy savings by 2020. In 2017, the MEE agreement program was updated to require companies to deliver an additional 9 PJ of energy savings for a total of 31 PJ by 2020. The additional 9 PJ reduction was divided into reduction targets for each company. If a company does not achieve its energy demand reduction target by the end of 2020 and if the overall 9 PJ target is not met, then any company not meeting its target must pay a levy of EUR 12 per GJ of unachieved reductions. LTA3/MJA3 agreements cover non-ETS companies and call for improved energy efficiency and increased use of renewable energy. The aim of the LTA3/MJA3 agreements is a 30% increase in efficiency between 2005 and 2020.

Companies in the Dutch industry sector have established the regional industrial cluster programme. The programme aims to achieve GHG emissions reductions in line with the Climate Agreement through an integrated approach to the development, financing and use of industrial infrastructure (e.g. for heat, natural gas and hydrogen) and more sustainable use of resources through a variety of measures including energy efficiency.

The industrial cluster programme is an initiative the Confederation of Netherlands Industry and Employers (VNO-NCW) and VEMW, an association of companies with demand for gas, electricity, heat or water. The programme includes the companies that are expected to make the largest GHG emissions reductions in support of the overall industry emissions reductions desired under the Climate Agreement (Shell, Tata Steel, Sabic, DOW Chemicals, Nouryon, Zeeland Refinery, Yara, OCI, BP, ExxonMobil, Air Liquide and Air Products). The programme defines six geographic clusters: Chemelot (south-Limburg), North Sea Canal, Rotterdam, North Netherlands (Delfzijl), Zeeland and Cluster Six, which covers industries outside of the other five clusters and includes companies from the food, glass and paper sectors. The companies in each cluster will develop a co-ordinated action plan detailing specific projects and preliminary requirements to achieve the industrial emissions reductions desired under the Climate Agreement.

To encourage reduction of industrial CO_2 emissions, the government is establishing a carbon levy that will come into effect in 2021. The levy must be paid on industrial emissions above a certain threshold, which will be set by the government to drive emissions reductions from industry in line with the Climate Agreement and beyond what is required under the EU ETS. The emission threshold triggering payment of the levy will be based on EU ETS benchmarks and will be reduced annually until the emission target as set in the Climate Agreement is realised. Although the levy is specifically intended to drive emissions reductions, it should encourage industry to implement energy efficiency measures beyond those required under the EEO.

Transport

The Dutch road vehicle taxation system influences the price of vehicles based on environmental performance and generally results in lower taxes and prices for more efficient vehicles. The annual road tax (MRB) increases with the weight of the vehicle, which generally correlates with fuel consumption. The vehicle registration tax (Bpm) is determined primarily by CO_2 emissions with lower emission (more efficient) vehicles paying a lower tax. The government also requires all new cars and car tyres to carry an energy label that allows consumers to compare energy efficiency between vehicles and tyres (Ministry of Finance, 2020).

The government is supporting the uptake of zero-emission vehicles, including EVs, through targets, reduced taxes, deployment of EV charging infrastructure and other measures (Box 4.2). EVs are, in general, more efficient than diesel and gasoline vehicles, so increasing their use would reduce the energy demand of the transport sector.

The Netherlands is also taking a broad approach to reducing emissions from mobility by encouraging the use of more efficient means of transport for people and goods. Efforts are underway with employers and public transport companies to reduce emissions from commuting by encouraging mobility through public transport, bicycling, walking, carpooling and mobility as a service. The government also supports reduced emissions and improved efficiency of logistics through measures including a 2030 target for at least the 32 largest municipalities to have zero-emission zones for urban logistics and Green Deals for inland waterway shipping and sea shipping, which include various targets to improve the efficiency and reduce the emissions of shipping.

Assessment

The Netherlands has a broad range of energy efficiency programmes that have contributed to reducing energy demand. Total final energy consumption in the Netherlands peaked in 2010. While energy demand has increased since 2014, in line with a growing population and increasing economic activity, the Netherlands is showing signs of a decoupling of energy demand from economic growth. Thanks to improved energy efficiency, TFC/GDP fell notably from 2010 to 2014 and has declined slightly since 2014, even with increasing energy demand. Despite these positive trends, it is likely that the Netherlands will not achieve several 2020 energy efficiency targets.

As an EU member state, the Netherlands has 2020 energy efficiency targets driven by the EU Energy Efficiency Directive (EED). The Netherlands' fourth National Energy Efficiency Action Plan (NEEAP) defines 2020 energy efficiency targets of not surpassing 2 186 PJ of final energy consumption and not surpassing 2 541 PJ of primary energy consumption. In 2017, final energy consumption was 2 107 PJ, 4% below the target; it is expected that this target will be met. Primary energy consumption was 2 702 PJ in 2017, 6% above the target; it is expected that this target will not be met. This is partly due to a lower than expected share of renewable energy that was anticipated for 2020 at the time that these targets were set. Under the 2013 Energy Agreement, the Netherlands defined an additional target aiming for 100 PJ in final energy savings by 2020. Analysis from the PBL in January 2019 indicates that the target will not be met, with additional energy saving estimated to reach 81 PJ with a range of 52-108 PJ. (PBL, 2019b).

In 2019, the government took actions to increase energy efficiency and support the achievement of the 2020 targets. The Environmental Management Act was updated to expand the number of efficiency measures allowed under the EEO, improve EEO payback calculations and introduce an energy efficiency notification obligation requiring a broad range of companies to report implemented energy efficiency measures before December 2019. Under the notification obligation, information was submitted on energy efficiency measures implemented at over 47 000 locations. Despite these additional steps, the government still expects that not all of the 2020 efficiency targets will be met and is examining additional options to support achievement of all of the 2020 targets.

The Netherlands is expected to achieve several important 2020 efficiency targets. It is expected that the EEO will deliver the desired savings of 482 PJ of cumulative final energy consumption by 2020. EEO measures implemented up to 2017 are estimated to have saved 516 PJ and savings should increase further with measures implemented from 2018 to 2020. The Netherlands also expects to achieve the target of renovating 3% of the government's building stock on an annual basis through 2020. Between 2013 and 2017, the final energy consumption of government buildings decreased by 27%.

In line with the updated EED, the Netherlands has defined 2030 energy efficiency targets in its NECP. 2030 targets are for a primary energy consumption of 1 950 PJ and a final energy consumption of 1 837 PJ. An indicative trajectory for these targets from 2021 to 2030 will be developed based on PBL analysis expected in October 2020. The Netherlands has implemented a wide range of policy measures to support the achievement of the 2030 targets. The EEO will be extended with an updated target to save 914 PJ cumulatively on final energy consumption from 2021 to 2030. The

Sectoral Road Map of the Central Government Real Estate Agency supports measures to reduce government building energy demand and aims for cumulative energy savings of 1.3 PJ by 2030. This would exceed the 0.2 PJ of savings required under the EED 3% renovation target.

While the Climate Agreement focuses on CO_2 emissions reduction targets, there is some alignment between these targets and the 2030 NECP energy efficiency targets. A PBL study conducted in 2018 examined measures supporting the Climate Agreement 2030 emission target and the expected energy savings from these measures was used to set the 2030 efficiency targets in the NECP. However, the PBL study was conducted in 2018, and it is not clear which measures considered in the study were incorporated into the final version of the Climate Agreement that was approved in 2019.

The PBL also noted that the study used rough efficiency calculations and was completed in a short time with a model that was not designed specifically to analyse all of the measures supporting the 49% reduction target called for in the Climate Agreement. The government should conduct a new analysis reflecting the measures in the Climate Agreement with a model that can more accurately estimate the impact of these measures in relation to achieving the 2030 energy efficiency targets. The results of this analysis should be used to make policy adjustments as needed.

Industry accounts for about half of total final energy consumption and the energy supply in the Netherlands is heavily reliant on fossil fuels. As a result, energy efficiency improvements in industry have a large impact on total energy consumption and on reducing CO_2 emissions. The government is in the process of ending some energy efficiency measures for industry (long-term agreements on energy efficiency ending in 2020) and introducing other measures aimed more broadly at emissions reduction (carbon levy on industrial emissions starting in 2021). The government should closely monitor the impacts of this policy transition and ensure that new policies continue to encourage broad adoption of energy efficiency measures in industry and other sectors. The government could also consider introducing grants, training and requirements for energy management systems for heavy industry, for example through ISO 50001 certification.

Given that the largest industrial sub-sectors are petrochemical and chemical, the carbon levy could result in a net increase in energy demand, e.g. from enhanced oil recovery in petroleum industries or increased energy demand from carbon capture utilisation and storage and hydrogen substitution. These activities do not necessarily result in reduced industrial energy efficiency; however, they could drive net increases in energy demand that could hamper the achievement of energy efficiency targets, which are set as specific levels of primary and final energy demand.

The Netherlands is taking strong steps to improve energy efficiency in buildings. This includes implementing the EU Energy Performance of Buildings Directive to ensure that new buildings are highly energy efficient. The Netherlands also has numerous measures encouraging energy efficiency renovations of existing buildings. The largest share of energy consumption in buildings is for heating, coming mainly from natural gas. The Netherlands plans to reduce the use of natural gas in buildings, through an integrated approach that combines energy efficiency measures with a transition to low-carbon heating. This transition is supported via numerous measures, including the Natural Gas-free Districts programme aiming for heating and energy efficiency renovation in

1.5 million buildings by 2030. The government is providing financial and technical support to municipalities implementing this programme and has developed a knowledge-sharing platform to share lessons learnt. The objective of the programme is to increase scale, reduce costs, and improve the processes of planning and participation of inhabitants to support a national transition to low-carbon heating.

With the overall shift to focus energy policy on CO_2 emissions reductions, care should be taken to ensure that energy efficiency improvements continue to take place in all sectors. Experience shows that while energy efficiency is often highly cost-effective, it is not always implemented because of specific barriers. For example, many cost-effective energy efficiency measures can be disruptive, as they require a shutdown of industrial or commercial activity or replacement of key equipment that still has a usable lifespan. Effective building renovations often require occupants to temporarily relocate or owners to forgo rental income. In addition, the benefits of energy retrofits do not also go to those making the investments, e.g. the principal-agent problems in rental properties. Energy efficiency specific targets and support programmes that account for these barriers can be effective in unlocking energy efficiency investments.

Recommendations

The government of the Netherlands should:

- ☐ Ensure that the focus on CO_2 emissions reductions does not diminish the implementation of energy efficiency measures, as these measures are often the most cost-efficient way to reduce emissions, but face specific barriers that require targeted policies.
- ☐ Analyse and monitor the impact of all measures promoting energy efficiency and make policy adjustments as needed to ensure that the Netherlands stays on track to meet its 2030 energy efficiency targets.
- ☐ Provide clear guidance on how each sector can contribute to meeting 2030 energy efficiency targets.

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5. Energy technology research and innovation

Key data

(2018)

Government energy RD&D spending: EUR 232.0 million

Share of GDP: 0.29 per 1 000 GDP units (IEA median: 0.32*)

RD&D per capita: 15.08 USD/capita (IEA median: 14.0 USD/capita*)

* Median for the 27 IEA member countries for which 2018 data are available.

Overview

The Netherlands has extensively reworked its energy research, development and demonstration (RD&D) policy framework to drive innovation that supports the Climate Agreement emissions reduction goals. The core of the new energy RD&D programme is the Mission Oriented Integral Knowledge and Innovation Agenda (IKIA) developed in 2019 and fully implemented in 2020. IKIA defines the innovation priorities derived from the Climate Agreement and translates them in to 13 multiannual mission-driven innovation programmes (MMIPs). The 13 MMIPs prioritise energy and climate RD&D based on the potential to contribute to the Climate Agreement 2030 emissions reduction targets and 2050 missions for carbon neutrality across five sectors: electricity, industry, the built environment, mobility, and agriculture and the natural environment.

Since 2008, annual public funding of energy RD&D has ranged between EUR 159 million and EUR 233 million, with an exceptional increase to EUR 378 million in 2010 driven by government efforts to spur economic recovery following the 2008 global financial crisis. In 2018, government spending on energy RD&D was EUR 232 million, the highest level of spending since 2010. Energy from renewable sources and energy efficiency are consistently the two areas that receive the largest amount of funding and together accounted for 61-87% of annual energy RD&D spending from 2008 to 2018. In line with IKIA and the Climate Agreement, the Netherlands plans to significantly expand energy RD&D.

Funding

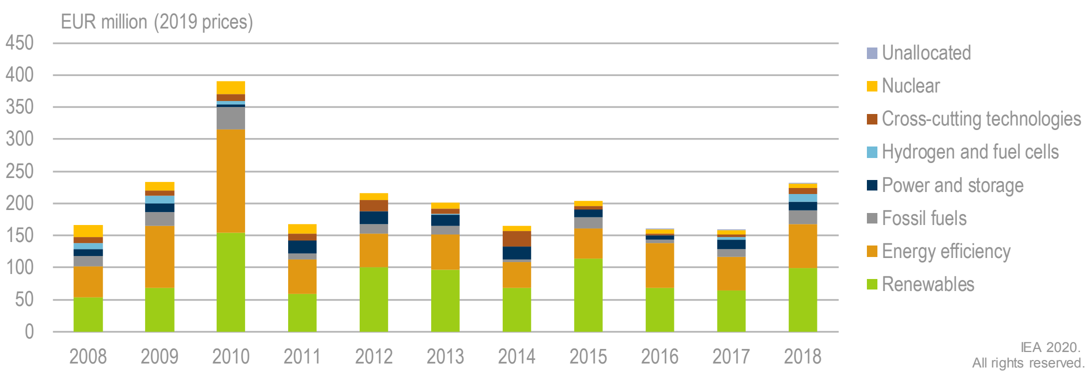
From to 2008 to 2018, annual public funding of energy RD&D ranged between EUR 159 million and EUR 223 million per year, with an exceptional level of EUR 390 million in 2010 driven by higher spending on renewables and energy efficiency as policy makers turned to energy RD&D investments to foster economic recovery following the 2008 global financial crisis. (Figure 5.1). Government energy RD&D funding was 0.029% of gross domestic product (GDP) in 2018, ranking 16th among the IEA member countries (Figure 5.2).

In line with the 2017 Coalition Agreement, the Netherlands established the Climate Envelope budget in 2018. The Climate Envelope receives EUR 285-325 million per year to fund a variety of programmes that support the achievement of the Climate Agreement targets. Around 40% of the Climate Envelope budget is directed towards energy RD&D and thanks partly to this additional funding, government spending on energy RD&D increased to EUR 232 million in 2018, 46% higher than the 2017 budget and the highest level of funding since 2010.

While the public energy RD&D budget has fluctuated, the split between different research areas has remained stable. Renewable energy and energy efficiency consistently received the largest amount of funding, together accounting for 61-87% of energy RD&D budgets from 2008 to 2018. Renewable energy received 43% of the total budget in 2018. Wind power received the largest share, 38% of renewable energy funding, followed by geothermal (22%), solar (21%) and biofuels (17%). Energy efficiency received 29% of total energy RD&D funding in 2018: 40% of this went to research on industry, followed by buildings (25%) and transport (13%).

Fossil fuels received 9% of the total public energy RD&D spending in 2018, roughly half of which went to oil and gas production and conversion; the other half went to carbon capture and storage (CCS). Hydrogen RD&D received 5% of the energy RD&D budget, including a small share for fuel cell research. The remaining energy RD&D spending went to cross-cutting technologies and nuclear power or was unallocated.

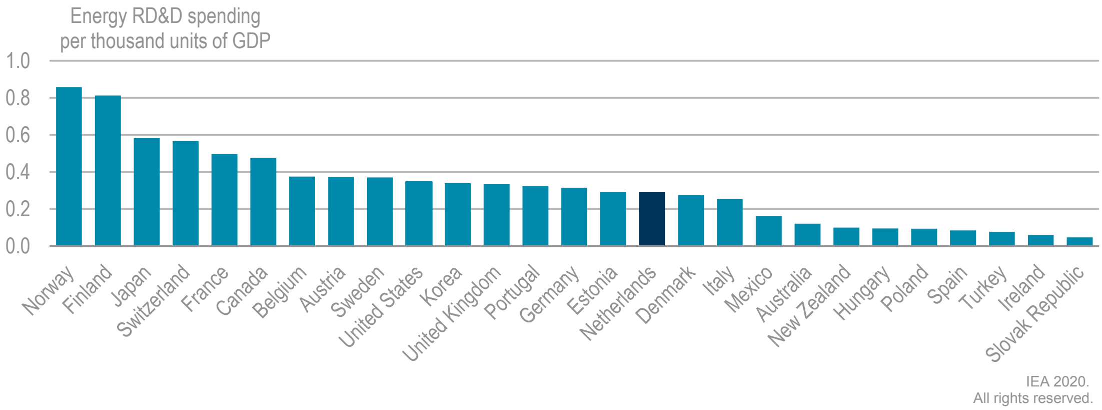
Figure 5.1 National energy RD&D budget by technology, 2008-18



Public energy RD&D funding in the Netherlands has fluctuated over the last decade, but renewable energy and energy efficiency have consistently received the largest share of the budget.

IEA (2020a), *Energy Technology RD&D Budgets 2020* (database), www.iea.org/statistics.

Figure 5.2 Energy-related public RD&D spending per GDP in IEA countries, 2018



The Netherlands ranked around the median among IEA member countries in terms of public energy RD&D funding as a share of GDP.

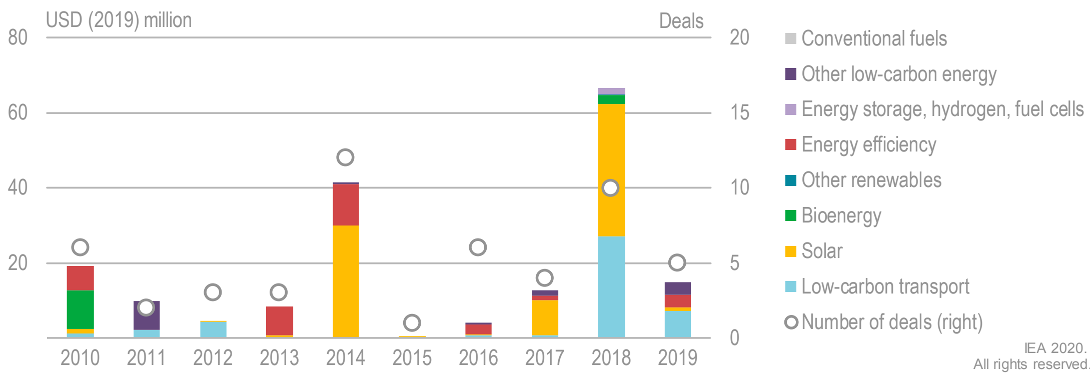
Note: Missing data for the Czech Republic, Greece and Luxembourg.
Source: IEA (2020a), *Energy Technology RD&D Budgets 2020* (database), www.iea.org/statistics.

Data from Statistics Netherlands (CBS) show that public funding for RD&D across all science and technology areas achieves a leverage ratio of 1:2 (each euro invested by the government in RD&D results in EUR 2 of private sector RD&D spending). In 2017, total Dutch RD&D spending was EUR 16.1 billion, with EUR 9.1 billion coming from Dutch companies, EUR 4.7 billion from government, EUR 1.9 billion from the European Union (EU) and foreign companies, and EUR 0.4 billion from non-profit organisations. CBS data do not specify what share of RD&D funding is dedicated to energy (CBS, 2019).

A 2019 study by the Netherlands Enterprise Agency (RVO) estimated that the EUR 721 million in public funding on energy RD&D from 2015 to 2018 spurred private sector investments in energy RD&D of around EUR 600 million. The study noted that this was a rough estimate based on limited reliable data on private sector investments in energy RD&D (RI, 2019).

From 2008 to 2018, most venture capital investment in the Netherlands focused on clean energy technologies, with a predominance of investments relating to solar energy. Venture capital investment in emerging Dutch energy companies reached an estimated USD 130 million in 2018, the highest level of investment in the last decade (Figure 5.3). The latest data available suggest that venture capital investment will be notably lower in 2019, with more diversification across sectors outside of energy.

Figure 5.3 Venture capital investment in Dutch energy start-ups, 2010-19



Source: IEA (2020b), *World Energy Investment 2020*, www.iea.org/reports/world-energy-investment-2020.

Institutions

The Ministry of Economic Affairs and Climate Policy is responsible for innovation policy and funding, including for energy RD&D. IKIA's focus on a broad innovation approach aligned with 2050 missions for carbon neutrality across the five sectors (electricity, buildings, industry, transport, agriculture/natural systems) has increased the involvement of other ministries and institutions in Dutch innovation policy and funding (Table 5.1).

Table 5.1 Institutions supporting IKIA

Institution	Supported IKIA sectors
Ministry of Economic Affairs and Climate Policy	Electricity, buildings, industry and cross-sector co-ordination
Ministry of the Interior and Kingdom Relations	Buildings
Ministry of Infrastructure and Water Management	Industry, transport
Ministry of Agriculture, Nature and Food Quality	Agriculture/natural systems
Ministry of Education, Culture and Science	All five
Netherlands Enterprise Agency (RVO)	All five
Dutch Research Council (NWO)	All five
Netherlands Organisation for Applied Scientific Research (TNO)	All five

Within the Ministry of Economic Affairs and Climate Policy, the RVO is responsible for implementing innovation policy, managing innovation funding, and monitoring and reporting on innovation programmes. The Dutch Research Council (NWO) is an independent body under the authority of the Dutch Ministry of Education, Culture and Science that is responsible for managing a broad portfolio of innovation funding and monitoring and reporting on innovation programmes. The Netherlands is creating a new investment agency (Invest-NL) to invest in innovative, low-carbon technologies with higher risk profiles, with an aim to trigger new investments from the private sector that bring innovative technologies to the market.

The various Dutch institutes for applied sciences and Dutch universities conduct a variety of fundamental and applied research supporting innovation in the Netherlands, in some instances via public-private co-operation. The Netherlands Organisation for Applied Scientific Research (TNO) is the largest independent research, development and consultancy organisation in the Netherlands with a staff of about 3 000 and a total annual turnover of more than EUR 500 million. TNO's primary tasks are supporting Dutch industry (including small and medium-sized enterprises), government and other stakeholders in technology innovation by providing services and transferring knowledge and expertise. The TNO participates in many EU technology development programmes. TNO is not part of the Dutch government; however TNO receives notable funding from the government and part of TNO's research agenda is designed in co-operation with the government.

Policy

Under the Climate Agreement, an Innovation Task Force including stakeholders from the government, research institutes and private companies was created to develop a new RD&D policy framework (IKIA). IKIA's goal is to drive innovation in the Netherlands to support the achievement of the Climate Agreement targets of a 49% reduction in greenhouse gas (GHG) emissions by 2030 and a 95% reduction by 2050 (versus 1990 levels).

The Climate Agreement identifies five missions for carbon neutrality in electricity, buildings, industry, transport, agriculture/natural systems by 2050. It also defines 2030 targets supporting the 2050 missions. Based on the 2050 missions and the 2030 targets, IKIA defines an innovation framework based on 13 MMIPs. The MMIPs are designed to support rapid development of the technologies needed to achieve the 2030 Climate Agreement targets and drive long-term innovation to support the achievement of the 2050 missions for carbon neutrality (Table 5.2).

The MMIPs aim to stimulate research across all technology readiness levels, from fundamental research to the development and market introduction of cost-effective GHG reduction technologies, while taking into account national expertise and human capital, export potential, social circumstances and preferences, and spatial integration issues. Twelve of the MMIPs focus on specific technologies or sectors. MMIP 13 (a robust energy system supported by society) supports the other MMIPs with a horizontal approach to address cross-sectoral challenges to an integrated energy system (see Annex 5.1 for a summary of the 13 MMIPs).

IKIA represents a notable reworking of the Dutch innovation approach from the previous Topsector system. In 2010, innovation policy was combined with enterprise policy and focused on nine Topsectors, with an aim to remove barriers to growth in these sectors. The nine sectors were selected based on being highly export-oriented, performing substantial RD&D in the Netherlands and being sectors where the Netherlands had an established advantage that could be leveraged to drive economic development. Energy was one of the Topsectors, with research focused on solar energy, smart grids, energy efficiency in the built environment/urban energy, offshore wind, new gas, energy and industry, and a bio-based economy.

Under the Topsector approach, private companies, knowledge institutions and the government collaborated through Top Consortia for Knowledge and Innovation (TKIs), which engaged in research at all levels, from fundamental to market-ready innovations (RI, 2018). Many of the key structures, processes and funding mechanisms established under the Topsector approach have been maintained and adapted under IKIA to support the MMIPs.

Table 5.2 Climate Agreement 2050 missions, 2030 targets and aligned

2050 missions	2030 targets	MMIP
A. Carbon-free electricity system	At least 35 TWh of onshore wind and solar generation from systems with a capacity above 15 kW	1. Offshore renewable electricity
	At least 49 TWh of offshore wind generation	2. Renewable electricity generation on land and in the built environment
B. Carbon-free built environment	Natural gas phased out of 200 000 existing homes per year	3. Acceleration of energy renovations in the built environment
	1.5 million homes and 15% of commercial and public buildings natural gas free	4. Sustainable heating and cooling in the built environment (including greenhouses)
	At least 20% of building energy consumption (including electric vehicles) covered by renewables	5. The new energy system in the balanced built environment
C. Raw materials, products and processes in industry will be net climate neutral and at least 80% circular	50% reduction in primary feedstock demand	6. Creating circular industrial chains
	Greenhouse gases from production processes and waste sector reduced to around 36 Mt CO_2-eq	
	Sustainability improvements to the industrial heat system up to 300°C achieved	7. Carbon-free industrial heat system
	Electrification of industrial processes implemented	
	Carbon capture and storage implemented in a cost-effective manner	
	Low-carbon hydrogen production on the road to implementation	8. Electrification and radically redesigned processes
	Bio-based raw materials seen as the norm	
D. Zero-emission mobility of people and goods	Zero-emission vehicles 100% of new sales and 1.9 million zero-emission vehicles in total	9. Innovative propulsion and use of sustainable energy carriers for mobility
	One-third of all mobility energy consumption covered by renewable energy	
	Reduce freight kilometres by 8 billion kilometres	10. Efficient transport movements for people and goods
	A minimum of the 32 largest municipalities will have zero-emission zones for city logistics	
E. Net carbon-neutral agricultural and natural systems	Reductions of at least 1.0 Mt CO_2-eq in methane emissions, 1.0 Mt CO_2-eq from reduced energy demand in greenhouses and 1.5 Mt CO_2-eq through smarter land use	11. Climate-neutral production of food and non-food
		12. Optimal carbon capture utilisation and storage on land and water
MMIP 13: A robust energy system supported by society (cross-sectoral)		

Energy RD&D support

The Netherlands has a wide variety of support measures for energy RD&D. Under IKIA, all energy RD&D support measures are aligned with the MMIPs. Starting in 2018, additional funding for several energy and climate RD&D support measures became available through the Climate Envelope budget. The Topsector Energy programme continues to play a major role in co-ordinating and allocating funding for energy RD&D, especially in relation to research supporting the Climate Agreement's carbon neutrality missions for electricity, industry and the built environment and for MMIP 13, which covers cross-sectoral research and innovation. Topsector energy includes Top Consortia for Knowledge and Innovation that co-ordinate research on offshore wind, new gas, urban energy, energy and industry, and the bio-based economy. Funding for research relating to the carbon neutrality goals for mobility and for agriculture and the natural environment is available through separate schemes supported by the Ministry of Infrastructure and Water Management and the Ministry of Agriculture, Nature and Food Quality. Table 5.3 gives the total budgets for key energy RD&D support schemes.

Table 5.3 Budgets of key energy RD&D support schemes, 2019-23

EUR million

	2019	2020	2021	2022	2023
Demonstration Energy and Climate Innovation grant scheme (DEI+)	34	25	25	25	25
Renewable Energy Scheme (HER)	50	50	50	50	50
TNO research programmes	38	38	38	38	38
Topsector Energy total RD&D budget	38.7	36.9	39	44	44
– Topsector Energy tender scheme	*26.9*	*4.6*	*1*	*	*
– Mission-driven Research, Development and Innovation Scheme (MOOI)	*0*	*21.5*	*21.5*	*	*
– Specific contract research assignments	*6.5*	*4*	*4*	*4*	*4*
– Other (human capital, social innovation…)	*5.3*	*6.8*			
– Not yet allocated	–	–	12.5	40	40
Climate Envelope total RD&D budget	131.5	120	130	160	180
– DEI+ (additional)	*80*	*73.6*	*30*	*45*	*45*
– MOOI (additional)	*40*	*11*	*11*	*	*
– Topsector Energy tender scheme (additional)	*11.5*	*8*	*3*	*	*
– Other	*0*	*27.4*	*	*	*
– Not yet allocated	–	–	*116*	*115*	*135*

* Budget not yet allocated.

In 2019, the existing Demonstration Energy Innovation scheme (DEI) was updated and expanded to align with the Climate Agreement's emissions reduction goals and renamed the Demonstration Energy and Climate Innovation grant scheme (DEI+). DEI+ focuses on pilot and demonstration projects of energy and climate technologies that have the potential for strengthening the Dutch economy in terms of GDP, employment and export by Dutch manufacturers, technical service providers or suppliers (RVO, 2020a).

To qualify for DEI+ funding in 2020, projects must fit under one of the following themes: energy innovation, energy efficiency, renewable energy (including electricity system flexibility, hydrogen and spatial integration), local infrastructure, carbon capture utilisation and storage (CCUS), other CO_2 reducing measures in industry or the electricity sector, natural gas-free houses, neighbourhoods and buildings, or the circular economy. The government updates the qualifying themes on an annual basis. The RVO reviews DEI+ applications and awards funding on a first-come, first-served basis to qualifying projects. Selected projects receive grants covering up to 45% of project costs, with a maximum of EUR 15 million per project.

The Renewable Energy Scheme (HER) supports cost-effective realisation of the 2030 energy sector targets by providing funding to innovative projects that reduce the costs of renewable energy technologies and thereby reduce expenditures under support schemes for renewable energy production. The HER scheme provides grant funding covering technologies eligible for the Stimulation of Sustainable Energy Production (SDE+) and the Sustainable Energy Transition Incentive Scheme (SDE++) support schemes, offshore wind, energy storage, smart grids and other innovative energy technologies (EM, 2020).

HER grant percentages vary from 50% for industrial research to 25% for experimental development and 45% for demonstration projects, with a possible increase of 10-20% for small and medium-sized enterprises. Total funding is limited to EUR 6 million per qualifying project and is awarded on a first-come, first-served basis. Projects should fit into one of the following themes: reducing the production cost of renewable energy, combining the storage and generation of renewable energy, combining smart grid with distributed production of renewable energy, increasing the production capacity of advanced renewable energy technologies through innovation.

The Mission-driven Research, Development and Innovation Scheme (MOOI) is one of the funding instruments of Topsector Energy. MOOI focuses on projects developed by consortia of companies in the fields of offshore wind, renewable onshore electricity, the built environment and industry. To qualify for funding, a project must be carried out by a partnership with at least three companies and include an innovation plan containing SMART (specific, measurable, acceptable, realistic, time-bound) milestones for tracking progress. The subsidy is a maximum of EUR 4 million per project (EUR 7 million for projects in the built environment) (RVO, 2020b).

The Topsector Energy tender scheme uses a tender process to award grants to research and innovation projects in line with the Topsector Energy priorities. The amount of the grants vary as per the HER grants, and also allow for a possible increase of 10-20% for small and medium-sized enterprises. Total funding is limited to EUR 500 000 per qualifying project. In 2018, the tenders committed around EUR 60 million in funding (Topsector and Climate Envelope budget combined) through 19 separate tenders covering a range of energy technologies. From 2020, the budget has been decreased, as most of the Topsector funding has shifted to the MOOI scheme. In 2020, the tender scheme was aligned with IKIA and the MMIPs to focus on smaller short-term projects within the built environment and industry.

The TNO carries out a variety of energy RD&D. TNO consults with the Ministry of Economic Affairs and Climate Policy and the Topsector Energy on an annual basis to determine the distribution of government funding across six research domains: solar, wind, built environment, industry, fuels and feedstocks, embedding, and integration. In 2020, the TNO allocated EUR 38 million of government funding to energy RD&D. TNO can also conducted energy RD&D by participating in research consortia, conducting research with private co-financing and applying for international innovation schemes, such as EU funding.

Energy and technologies for reducing GHG emissions can receive funding that supports commercial deployment through the SDE+ and SDE++ support schemes. SDE+ is the main mechanism supporting renewable electricity, gas and heat. Starting in 2020, SDE+ is being expanded into SDE++, which will continue to support renewables along with a broader range of CO_2 emission-reduction measures. SDE+ and SDE++ both use a competitive auction process to award subsidies as market premiums to qualifying projects that submit least-cost bids (see Chapter 6).

Generic RD&D support

Energy RD&D is also eligible for support through a variety of generic RD&D measures. The main generic RD&D support instrument is the Research and Development Promotion Act (WBSO). WBSO provides tax breaks to companies for RD&D-related expenses, including capital investments and labour costs. The amount of the tax break is based on numerous factors, including the type of spending and the size of the company. The WBSO budget for 2020 is EUR 1.28 billion. Companies that qualify for the WBSO tax break can also reduce tax payments through the Innovation Box, a special tax rate under which qualifying profits are taxed at 7% instead of 25% (RVO, 2020c).

The Innovation Credit provides co-funding to support technology research projects in Dutch companies. The Innovation Credit finances 45% of project development costs for small companies, 35% for medium-sized companies and 25% for large enterprises. Forming partnerships increases funding to 40-50% of project costs depending on the size of the companies in the partnership. The 2020 Innovation Credit budget for technology projects is EUR 30 million. The minimum project size to qualify for Innovation Credit is EUR 150 000. Maximum funding is EUR 10 million per project (RVO, 2020d).

Through the SEED Capital Scheme, private lenders and the government have jointly set-up a variety of investment funds for start-ups, including several funds targeting energy start-ups. These funds provide access to low-interest loans. For 2020, the annual budgets of the various funds supporting energy start-ups ranged from around EUR 4 million to EUR 12 million, with loan limits of around EUR 2 million to EUR 6 million (RVO, 2020e).

The Dutch Venture Initiative (DVI) investment fund improves access to capital for rapidly growing innovative companies in the Netherlands. The fund is managed by the European Investment Fund in conjunction with the Regional Venture Capital Company. DVI-I was set up in 2013 with EUR 203 million in funding; as of 2018, EUR 193 million of this funding had been allocated. DVI-II was set up in 2016 with EUR 200 million in funding to be allocated by 2021 (EIF, 2020).

The Small Business Innovation Research Programme (SBIR) is a flexible procurement method through which the government challenges entrepreneurs to solve specific social issues by developing innovative products and services. The RVO conducts SBIR competitions on behalf of various government departments. Under SBIR companies first compete for funding for feasibility studies; based on these studies, the RVO may award further funding for companies to develop products or services. Each SBIR competition is assigned a specific budget, normally in the range of EUR 100 000 to EUR 10 million. The 2018 SBIR competitions covered a number of energy-related projects (RVO, 2020f).

The Public Private Partnership (PPP) Allowance provides funding to PPPs focused on research and innovation. Qualifying PPPs must involve at least one private company providing RD&D funding to at least one Dutch research institution or Dutch public benefit organisation. Depending a variety of factors, including the type of PPP and the amount of funding provided by the companies involved, the government contributes EUR 0.25 to EUR 0.4 for each euro of private funding; this contribution must go towards RD&D (RVO, 2020g).

The Incentive Scheme for SMEs (MIT) stimulates innovation by small and medium-sized enterprises in a variety of fields, including energy RD&D. Funding is provided for a variety of activities, including feasibility studies and RD&D collaborations. MIT funding is around EUR 16 million per year (RVO, 2020h).

The Dutch Research Agenda (NWA) is an investment programme run by the NWO for innovative and socially relevant research covering all disciplines across the entire innovation chain. The primary aim of the NWA is to build bridges between various scientific fields, between different types of research, and between various national and international programmes. In 2019, the NWA had a budget of around EUR 100 million (NWO, 2020a).

The Knowledge and Innovation Covenant (KIC) 2020-2023 is a co-ordination mechanism that helps various parties form partnerships and co-ordinate funding of RD&D projects. KIC aims to foster public-private co-operation on specific innovation challenges in Dutch innovation policy under four main themes: 1) energy transition and sustainability; 2) agriculture, water and food; 3) healthcare; and 4) security. Under the energy transition and sustainability theme, public parties of the KIC intend to focus around EUR 320 million per year of funding from DEI+; HER; MOOI and the TNO to RD&D supporting the IKIA. Private parties to the KIC intend to focus almost EUR 590 million per year of the Topsector Energy budget towards the IKIA. Under the KIC NWO intends to commit EUR 11 million of its research budget to the energy transition and sustainability (NWO, 2020b).

International collaboration

The Ministry of Education, Culture and Science and the Ministry of Economic Affairs and Climate Policy co-ordinate Dutch participation in the EU Framework Programme for Research and Innovation, which is the main EU funding instrument for research and innovation. The RVO advises Dutch companies and institutions seeking funding from the EU Framework Programme for Research and Innovation. NWO provides funds to help public research institutes cover the costs of applying for funding. Under the EU framework, the Netherlands participates in 9 of the 14 strategic energy technology plan (SET plan) action areas and 7 of the 10 ERA-NETs, which are RD&D funding programmes co-funded by the European Commission (EC) and EU member states on topics defined in the SET Plan. Several of the SET Plan action areas and ERE-NETs focus on energy RD&D, including renewable energy, energy efficiency and CCUS.

The EU is currently preparing Horizon Europe, the next Framework Programme for Research and Innovation for 2021-27, which will replace the current framework programme known as Horizon 2020. Horizon 2020 provided a total of EUR 80 billion in RD&D funding available from 2014 to 2020. Horizon Europe aims to expand funding to EUR 100 billion. The Ministry of Economic Affairs and Climate Policy has co-financed a number of Horizon 2020 programmes and intends to continue co-financing under Horizon Europe (Science Europe, 2020).

The Netherlands participates in 17 of the 38 IEA technology collaboration programmes. The programmes support the work of independent, international groups of experts that enable governments and industries to support programmes and projects on a wide range of energy issues. The experts in these collaborations work to advance the research, development and commercialisation of energy technologies. The Netherlands participates in technology collaboration programmes covering building technology, smart grids, electric vehicles, CCUS, hydrogen, bioenergy, solar technologies, and wind and ocean power.

The Netherlands is also a founding member of the Biofuture Platform, a multilateral initiative that works to support the transition to a low-carbon bio-economy. Through the RVO, the Netherlands participates in the highest decision-making body of this partnership along with Brazil, Canada, India, the United Kingdom and the United States.

Since 2016, the Netherlands has been participating in Mission Innovation, a global partnership of 24 countries and the EC that aims to accelerate clean energy innovation, including efforts to double spending for clean energy research and innovation by 2020. The Netherlands participates in programmes on energy innovation relating to affordable heating and cooling, CCUS, sustainable biofuels, off-grid electricity access, and hydrogen. Under Mission Innovation, the Netherlands pledged to double clean energy RD&D funding to at least EUR 200 million per year from 2016 to 2020. In 2018, Dutch energy RD&D was EUR 214.3 million (using the Mission Innovation methodology for measuring RD&D).

The Netherlands also participates in the Clean Energy Ministerial, a high-level global forum that promotes policies and programmes to advance the deployment of clean energy technologies. The Netherlands participates in the following programmes: the International Smart Grid Action Network, the Multilateral Solar and Wind Working Group, the Electric Vehicles Initiative, the EV 30@30 programme, the CEM Investment and Finance programmes, the Long-Term Energy Scenarios for the Clean Energy Transition Campaign, the Hydrogen Initiative, and the CCUS Initiative (CEM, 2020).

Assessment

The Netherlands has recently developed a new energy RD&D and innovation approach to support the Climate Agreement that is robust, forward looking and inclusive. IKIA, implemented in 2020, is the core of the new innovation approach. It is a comprehensive climate-related energy innovation support framework aligned with the Climate Agreement. It defines 13 MMIPs to address the most pressing innovation challenges that need to be overcome to achieve the Climate Agreement emissions reduction goals. Twelve of the MMIPs focus on sector-specific innovation challenges. The 13th MMIP has a cross-sectoral approach to support a robust and integrated energy system by targeting innovation challenges in the area of energy system modelling; policy choices concerning the energy system as a whole; and the role of energy storage and conversion in the energy system.

IKIA ensures continuity with the previous Topsector energy RD&D policy framework through continuation of successful innovation funding schemes, such as the Demonstration Energy and Climate Innovation grant scheme and the Renewable Energy Scheme.

To drive innovation in support of the Climate Agreement goals, the government aims to increase spending on energy RD&D. In 2018, the Netherlands established the Climate Envelope budget to fund a variety of programmes that support the achievement of the Climate Agreement targets. The Climate Envelope receives EUR 285 million to EUR 325 million per year, around 40% of which is directed towards energy RD&D. Thanks partly to this additional funding, government spending on energy RD&D increased to EUR 232 million in 2018, 46% higher than spending the 2017, the highest level of spending since 2010 and around the median among IEA member countries in terms of public energy RD&D spending as a share of GDP.

With 2030 Climate Agreement goals in mind, the areas of innovation that should be a priority are cost reduction and integration of renewables at a large scale, heating solutions for the built environment and high temperature industrial applications, a sustainable bio-economy, CCUS, and hydrogen. The government should also seek to leverage a higher amount of private RD&D spending. Early-stage funding and grants, when designed effectively, can mobilise private finance.

The Netherlands has been strongly involved in EU energy RD&D collaboration through the Horizon 2020 programme and intends to maintain robust collaboration through the upcoming EU's Horizon Europe RD&D programme. Since the last IEA in-depth review in 2014, the Netherlands has joined a number of international flagship partnerships for energy technology collaboration, notably Mission Innovation, the Clean Energy Ministerial and the Biofuture Platform. The Netherlands is involved in 17 of the 38 IEA technology collaboration programmes. Further opportunities for international co-operation could be explored in areas aligned with Dutch strategic priorities for energy innovation, such as district heating and cooling for smarter cities, materials research, geothermal energy, and clean energy education and empowerment.

The IKIA approach of focusing innovation on Climate Agreement emissions reduction goals is making the co-ordination of Dutch RD&D more complex. IKIA puts multiple players, sectors and topics that traditionally had separate and distinct responsibilities over innovation policy and outcomes under the same co-ordinating structure. This arrangement is especially challenging given the distributed responsibilities and independence of IKIA stakeholders when it comes to funding decisions. The IKIA framework creates a fast-changing and interconnected regulatory environment where changes implemented by one stakeholder influence all of the others. The government should take care when developing IKIA's oversight and management structures to ensure that the framework is delivering on the desired innovation outcomes in an efficient and transparent manner, and provide feedback to adjust policy and innovation processes as needed.

It is not clear if the organisational structure being developed for IKIA supports the multidisciplinary and collaborative research and innovation approach needed for cross-sectoral areas such smart grids, digitalisation and sector integration. RD&D targeting cross-sectoralchallenges supports key aspects of clean energy transitions, including decarbonising transport and industrial processes, and the integration of variable renewables. The government should closely monitor the development of IKIA's structure and the outcomes of the MMIP projects, and make adjustments as needed to ensure that cross-cutting innovation issues are granted adequate funding and visibility.

In the context of the digitalisation of the energy sector, it will be important to identify research topics for key areas, including artificial intelligence, big data, cybersecurity, data collection and access, data-driven services, and interoperability of digital technologies and standards. This could be achieved through a management and monitoring structure that allows relevant MMIPs to collaborate on cross-sectoral research topics in a coherent and efficient manner and by giving MMIP 13 a strong co-ordinating role.

The Netherlands provides substantial RD&D funding for energy technologies and services. However, there appears to be a gap in support policy between RD&D measures and SDE++, the main mechanism supporting commercial deployment. SDE++ uses a competitive auction process that requires new technologies emerging from the RD&D process to compete against established technologies on a least-cost basis.

Many emerging technologies with promising long-term potential for cost-effective CO_2 emissions reductions will struggle to win funding from SDE++. This will limit their ability to achieve the operational learnings and economies of scale needed to increase their competitiveness. The gap between RD&D and commercial support policy could affect a range of technologies and related services needed to fulfil the Climate Agreement targets. Examples include energy storage, low-carbon transport fuels, green hydrogen and CCUS.

Programmes supporting early-stage market deployment of emerging technologies will be key to achieving the Dutch goal of transitioning to carbon neutrality. The supportive environment provided to the offshore wind industry serves as an excellent example of the types of policy measures that could be used to bring other key emissions reduction technologies to market. In addition, financial derisking measures (e.g. guaranteed offtake, capital subsidies, loan guarantees) can help emerging technologies reach commercial scale and allow them to win SDE++ funding and attract the private sector funding needed to compete in the market.

The government recognises that key emerging technologies fall in the gap between existing support for pilots and demos (DEI+) and support for cost-effective carbon emissions reduction (SDE++) and is taking measures to close this gap. For low-carbon hydrogen, the government aims to facilitate the scaling-up process by redirecting part of the funds for hydrogen pilot projects within DEI+. Starting in 2021, it is planned that around EUR 35 million of the DEI+ budget will be redirected to projects aimed at commercial production of low-carbon hydrogen. The Netherlands is also looking at the option of expanding support to commercial scale low-carbon hydrogen projects under the EU programme allowing flexibility in state-aid rules for important projects of European common interest.

Recommendations

The government of the Netherlands should:

- Ensure that the IKIA framework supports effective collaboration between the increased number of innovation stakeholders, to allow for an effective combination of resources and knowledge, especially on cross-sectoral innovation challenges that require a multidisciplinary approach.
- Develop a management, monitoring and reporting structure for the IKIA framework that ensures that research on cross-cutting issues such as smart grids, digitalisation and sector integration can be clearly identified and supported.
- Strengthen feedback mechanisms to ensure that the results of innovation projects can guide policy making and maximise opportunities for national and international innovation collaboration.
- Support early-stage deployment of emerging technologies that have the potential for cost-effective emissions reductions, to stimulate the mobilisation of private funds and bridge the gap from demonstration to large-scale commercial deployment.

Annex 5.1 Summary of MMIPs

MMIP 1: Offshore renewable electricity

MMIP 1 focuses on enabling increased renewable electricity generated offshore. The emphasis will be on offshore wind energy, but the programme is also aimed at long-term development of offshore solar energy. To support successful implementation of large-scale offshore wind energy, MMIP 1 will address innovation challenges related to decreasing costs; increasing deployment; integrating offshore generation; and co-ordinating offshore special planning, safety and ecology.

For integration of offshore generation, close co-operation is envisaged with MMIP 13 on developing solutions for offshore wind farms, such as the storage and conversion of energy offshore. The objectives of MMIP 1 in relation to offshore wind are reducing production costs to a level of 30-40 EUR/MWh by 2030, scaling up to between 11.5 GW and 18.6 GW of capacity by 2030 and approximately 60 GW by 2050, enabling an annual installation rate of 2-3 GW, and integrating very large quantities of offshore energy into the energy system.

MMIP 1 also aims to address challenges in demonstrating technical, ecological and commercial feasibility, and development and testing of concepts for offshore photovoltaic systems, ocean energy and other advanced technologies.

MMIP 2: Renewable electricity generation on land and in the built environment

MMIP 2 supports innovations enabling a carbon-free electricity system by 2050 with an interim 2030 goal for a minimum of 35 TWh of annual generation from PV systems with a capacity greater than 15 kW and onshore wind in the built environment, rural areas and inland waters, taking into account technical, economic, social and environmental factors. MMIP 2 should support cost reductions so that this electricity can be generated at the lowest possible cost (30-60 EUR/MWh by 2030, and around 20 EUR/MWh by 2050).

MMIP 2 also contributes to the mission of a carbon-free built environment by 2050 by supporting innovations for building mounted renewables. Innovations will be aimed at reducing the cost of electricity generation, making new applications available, integration into the built environment (accounting for multiple uses) and integration into the energy system (which will be undertaken in close collaboration with MMIP 13). MMIP 2 also supports sustainability and the circular economy and addresses challenges of accelerating the deployment of renewables in the built environment and on land, while maintaining public support.

MMIP 3: Acceleration of energy renovations in the built environment

MMIP 3 supports innovation of new and significantly lower cost energy options for the built environment to realise the goal of 200 000 energy renovations each year by 2025 and will lead to natural gas being phased out of the built environment in a cost-effective manner by 2050. Innovations should reduce the impact of renovations on building residents and improve comfort and ease of use to increase building owner support for energy renovation. Innovations should increase the use of sustainable materials, automation, digitalisation and integration of installation technologies into building components.

MMIP 3 also aims to facilitate the industrialisation/automation of the production, renovation, construction and installation processes, and to improve supply chains to accelerate the energy transition in the built environment. This will require collaboration between parties that can translate the needs of building users into product specifications, the construction and installation contracting sector, the supply industry and experts that can contribute to shaping broad user acceptance of new technologies and building renovations. MMIP 3 will contribute to growth of the implementation capacity required to realise the Netherlands' renovations goals.

MMIP 4: Sustainable heating and cooling in the built environment (including greenhouse horticulture)

MMIP 4 focuses on technical and socio-economic innovation for the rapid growth of sustainable heating systems. The objective is to improve existing types of devices and systems, which could be market available in less than five years, and to develop new concepts with longer lead times.

MMIP 4 also supports innovation in corresponding services and improved user experiences. In order for consumers to switch away from gas heating in a timely manner, it is crucial for the supply of new heating options to be aligned with user expectations, comfort (noise, thermal) and the ability to pay (affordability). MMIP 4 primarily focuses on the renovation of existing buildings, lowering costs at the systems level and accelerating the development of sustainable natural gas-free heating and cooling solutions.

MMIP 4 has sub-programmes for: 1) quiet, compact, smart, cost-effective heat pumps; 2) delivery, ventilation and water heating systems; 3) smart compact heat battery; 4) smart heating networks; 5) large-scale thermal storage; and 6) geothermal energy.

MMIP 5: The new energy system in the balanced built environment

Connections between heating systems, distributed renewable generation and energy storage provide new opportunities for integrated concepts. MMIP 5 focuses on achieving an integrated energy system in the built environment with optimal alignment of local clean energy demand from businesses and households (comfort, electricity, heating and mobility) with a supply of sustainable energy that is generated locally as much as possible and continuously available.

MMIP 5 does not focus on the components of energy generation, transport and demand, but relates mainly to the relationships between these components (in the built environment, mobility and industry). MMIP 5 also points out the key importance that end-users play in determining the successful operation of integrated systems. The local system issues to be addressed under MMIP 5 are relevant in relation to the entire system issues under MMIP 13.

The sub-programmes guiding research under MMIP 5 are: local system optimisation; control algorithms for saving, energy optimisation and sector linking (within the built environment and greenhouse horticulture); data architecture and trading systems; and flexibility and energy storage.

MMIP 6: Creating circular industrial chains

MMIP 6 focuses on circular industrial value chains and processes, including reuse of materials, feedstocks, components and products and the creation of new materials and products that facilitate a circular economy. Innovations under MMIP 6 should support the 2030 goal for a 50% reduction in primary feedstocks demand and the 2050 mission that value chains will be at least 80% circular. MMIP 6 has four sub-programmes.

Circular feedstocks and products: Knowledge and innovations will be developed for the conversion of CO_2 and CO from process and combustion gases into feedstocks and products (carbon capture and utilisation), plus direct air capture where appropriate. In addition, processes will be developed for pre-processing and chemical recycling of wastes and plastics and for the closure of the non-ferrous metal chains through separation and recycling.

Biomass-based feedstocks and products: Options will be identified for high-quality, distinctive use of biomass to enable supplementing non-fossil carbon into value chains where this cannot be achieved through other means.

Value chains design and supporting business models: To speed up the deployment of value chains with a minimal carbon footprint, research will examine challenges of social acceptance and behaviour and how circular value chains can be clearly embedded in the broader economy.

Carbon capture and storage: Carbon capture and storage (CCS) will be a research focus to enable achievement of the industrial CO_2 emissions reduction target in the short term. All activities will focus on accelerated and cost-effective deployment of CCS in existing plants, for example in the production of blue hydrogen. Key issues include process integration and optimisation of the capture process, transport, storage, monitoring, and social acceptance and systems issues.

MMIP 7: A 100% carbon-free industrial heating system

MMIP 7 focuses on climate-neutral energy and heating systems for industrial clusters and businesses, to support the 2030 target for power-to-heat solutions and the use of sustainable heating sources to reduce CO_2 emissions by at least 5.3 Mt, and achieve energy savings of 93 PJ, as well as the 2050 mission for a carbon-free heating supply at all temperature levels. Research should support the development of efficient processes to drastically reduce heating demand and the use of sustainable sources (renewable electricity, geothermal energy, biomass, sustainable gases and waste heat).

Innovation will focus on accelerated deployment through 2030 of technologies for temperatures up to roughly 300ºC (e.g. heat pumps), with a focus on standardisation, modularisation and development of a project-based approach to design and deployment. MMIP 7 will also target the development of technologies that support a shift in the highest temperature segment after 2030.

The sub-programmes guiding research under MMIP 7 are: reuse, upgrading and storage of heat; deep and ultra-deep geothermal energy for industry; use of climate-neutral fuels; system concepts for heating and cooling; and maximisation of process efficiency.

MMIP 8: Maximum electrification and radically redesigned processes

MMIP 8 supports innovation that will lead to industrial processes that by 2050 are fully climate-neutral, electrified to the maximum extent possible (using renewable energy) and integrated into the energy system in a way that increases overall system flexibility. The interim objectives of MMIP 8 are:

- By 2030, investment costs of large-scale water electrolysis will have fallen to 350 EUR/kW, bringing a hydrogen price of 2.00 EUR/kg by 2030 and 1.00 EUR/kg by 2050 within reach.
- By 2030, cost-effective electrochemical production processes will have been developed for base chemicals and fuels and will be ready for scaling up to bulk processes.
- By 2025, energy-efficient electrically powered processes will be standard technology.
- By 2025, digitalisation of processes will be accepted as best practice and will have been rolled out on a large scale.
- A minimum of three radical breakthroughs in carbon-intensive processes will have been demonstrated on a pilot scale.

Research focuses on developing industrial processes powered with electricity and using climate-neutral circular feedstocks. MMIP 8 will also help to develop the supply of climate-neutral secondary feedstocks, energy carriers, finished products, flexibility and energy storage. Key challenges include cost reduction and scaling up of electric hydrogen production and the development of climate-neutral fuels and gases (in collaboration with MMIP 11).

MMIP 8 aims for the development of new electrical devices and electrically powered processes and the wide-scale use of digitalisation to increase the possibilities for electrification. In parallel, research will be conducted into the social and system implications of industrial electrification, with an explicit emphasis on radical process innovation and disruptive innovations that will have to make a difference beyond 2030. The sub-programmes of MMIP 8 are: production of hydrogen, molecules and innovative renewable fuels; electrical appliances and electrically powered processes; greater flexibility and digitalisation; radically redesigned processes; and social/system implications of industrial electrification.

MMIP 9: Innovative propulsion and use of sustainable energy carriers for mobility

MMIP 9 focuses on innovation in electric vehicles (EVs), both battery electric, fuel cells and renewable transportation fuels, to support the achievement of zero-emission mobility of people and goods by 2050. Interim 2030 objectives are for: 1.9 million zero-emission vehicles, 100% of new passenger cars sales to be zero-emission and that a third of the energy required for mobility will come from renewable energy sources (electricity, hydrogen, biofuels or synthetic fuels).

MMIP 9 aims to further innovation on new battery technologies (cell technology, systems and production), vehicle propulsion systems, smart charging infrastructure and the development of fuel cell for heavy-duty applications (heavy road transport, rail and maritime sectors). Vehicles with combustion engines will still constitute a substantial segment of the mobility system in the decades to come, and as such MMIP 9 (in collaboration with MMIP 6) is focusing on the development, availability and application of renewable fuels with low direct and indirect CO_2 emissions, such as biofuels and synthetic fuels, and on the development of more efficient combustion engines for new and high-grade blends of renewable fuels.

The sub-programmes of MMIP 9 are: zero-emission propulsion technology and vehicles; energy distribution for electric vehicles and ships; distribution of hydrogen and other energy carriers for fuel cell vehicles and vessels; distribution and use of renewable, carbon-containing fuels; and energy-efficient vehicles.

MMIP 10: Efficient transport movements for people and goods

MMIP 10 aims for 8 billion fewer business kilometres (about 8% of commercial transport demand) and the 32 largest Dutch municipalities to have zero-emission zones for city logistics by 2030 and zero-emission mobility of people and goods by 2050. MMIP 10 supports a broad range of research under four sub-programmes.

Knowing why people move: Increasing knowledge of behaviour to enable the development of innovative and effective policy measures and faster implementation of innovations. Research into the behaviour of individuals and companies in terms of mobility, modal choice, transport habits, and adoption of new techniques and services.

CO_2 reduction through new mobility concepts for passenger transport: Development of new mobility concepts and optimisation of the potential contribution of new and existing concepts to CO_2 reduction through kilometre reduction and modal shift. Research on co-operative and automated driving of passenger cars; mobility-as-a-service.

CO_2 reduction through innovations in logistics: Development of new logistics concepts and optimisation of the potential contribution of new and existing concepts to CO_2 reduction through kilometre reduction and modal shift. (The innovations are described in general terms, but the challenges occur in specific logistics chains such as fresh products/building logistics. These can be included as sample implementations of the programmes.) Research on: supply chain redesign; self-organising logistics; use of the Internet of Things, blockchain and advanced data analytics (among others, artificial intelligence).

Transition-supporting knowledge and tools (public perspective) for adaptive programming: Development of knowledge, methods and models for the support of adaptive policy with a view to achieving climate targets in mobility (for MMIPs 9 and 10). Research on development and embedding of objective, policy-supporting knowledge around new technology in the field of vehicles, energy carriers, and mobility concepts and around system issues, disruptive developments and transition management.

MMIP 11: Climate-neutral production of food and non-food

MMIP 11 focuses on reducing GHG emissions (CO_2, methane and nitrous oxide) from the production of food and non-food. This reduction will be achieved in relation to agriculture, soil and land use, and animal production. MMIP 11 research will cover carbon capture and reduction in emissions from agricultural soil and fertilisers, reduction in emissions from peat meadows, and reduction in methane emissions from animal production.

MMIP 12: Optimal carbon capture and utilisation on land and water

MMIP 12 aims at carbon-neutral agricultural and natural systems by 2050 with research supporting:

- the development of 14 000 square km of seaweed production
- increased biomass cultivation with a doubling of photosynthesis
- halving the carbon footprint of biomass consumption through purchasing choices
- 50% of human-consumed protein coming from plant-based sources
- a natural environment that adapts to climate change and captures more carbon each year while maintaining biodiversity and achieving larger biomass harvests.

MMIP 13: A robust energy system supported by society

MMIP 13 is overarching and links the other MMIPs together by focusing on developing knowledge and innovations to enable well-informed decisions on the design, management, governance and transition to a robust and sustainable energy system that fully exploits the sustainability improvements envisioned in the industry, building, agriculture and energy sectors. MMIP 13 has technical, economic and social aspects. Research will cover potential market mechanisms for achieving the lowest possible costs to society and appropriate incentives for energy producers/users, which also offer opportunities for new services and revenue models. MMIP 13 will also support the development of methods and tools which increase citizen engagement, of knowledge and skills to enable the cost-efficient design and management of a (multi-commodity) infrastructure on various levels.

Digitalisation, a key driver of innovation, will be a major focus of MMIP 13. A key theme is the development of different flexibility options and reducing the costs and spatial requirements of these options. Specific attention will be paid to the development of (large-scale) energy storage. MMIP 13 will address the development of knowledge and skills to enable the hybridisation of large-scale (industrial) energy users, and the associated modifications to infrastructure. This may include grid reinforcement; smart use of infrastructure for electricity, gas or heat (multi-commodity systems); or demand-side response. MMIP 13 will also develop knowledge and (social) innovations which will ensure environmental integration which is accepted by all stakeholders, with minimal negative impacts on the living environment and maximum citizen engagement.

The sub-programmes of MMIP 13 are: joint fact-based decisions and implementation, including revenue models; spatial integration; implementation of infrastructure, flexibility, market mechanisms and digitalisation; system level aspects of power-to-molecules; and large-scale energy storage, energy transport and hybridisation of energy demand.

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6. Renewable energy

Key data

(2018)

Renewables in total final energy consumption (TFEC): 3.3 Mtoe/7.4% (IEA median: 15.5% of TFEC)

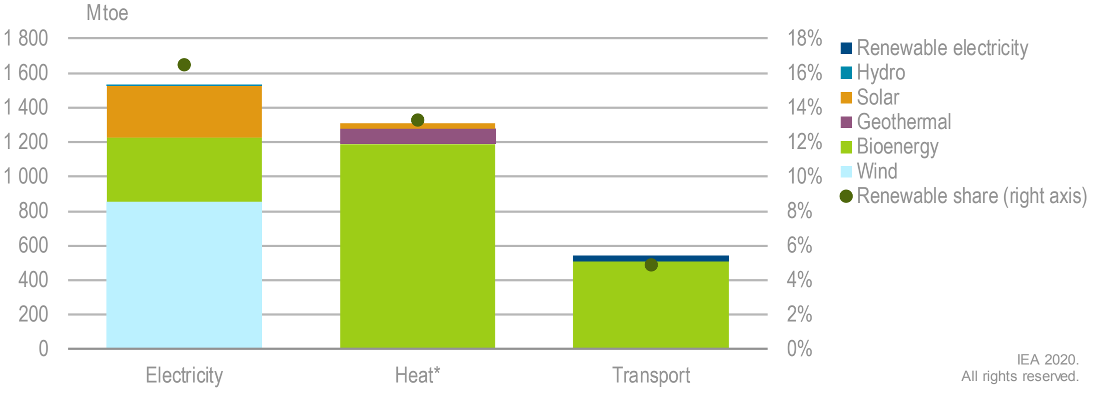
Renewable share: Electricity 16.5%, heat 13.3% and transport 4.9%

Renewables in electricity generation: 18.9 TWh/16.5%; (wind 9.2%, bioenergy 5.1%, solar 3.2%, hydro 0.1%) (IEA median: 33.2% of electricity generation)

Overview

In 2018, electricity from renewable sources of energy covered 16.5% of total electricity demand and accounted for 51% of renewables in total final energy consumption (TFEC) (1.5 Mtoe). Renewable heat covered 13.3% of the heat demand in buildings and industry and accounted for 44% of renewables in TFEC (1.3 Mtoe). Renewable energy in transport lagged behind, covering 4.9% of transport demand and 18% of renewables in TFEC (0.54 Mtoe) (Figure 6.1).

Figure 6.1 Renewable energy in electricity, heat and transport, 2018



Bioenergy is the largest source of renewable energy for heat and transport, while wind power dominates renewable electricity, followed by bioenergy and solar PV.

Notes: Heat includes direct use of renewable energy and renewable district heating in industry, and residential and service buildings (including agriculture). Electricity refers to final electricity consumption, with the breakdown by fuel based on domestic electricity generation. Electricity used for heating is included under electricity due to limitations in data collection.

Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Renewable energy deployment is accelerating in the Netherlands and the country is on track to meet the 2023 target of a 16% share of renewable energy in final energy consumption outlined in the 2013 Energy Agreement. A comprehensive policy framework for offshore wind power deployment and an increase in subsidies awarded through the SDE+ renewable energy support scheme are key factors driving renewables deployment.

A significant increase in renewable energy consumption across all sectors is necessary to deliver the Climate Agreement target of reducing greenhouse gas (GHG) emissions by 49% by 2030 (versus 1990 levels) and the National Energy and Climate Plan (NECP) 2030 target of at least 27% renewable energy in gross final energy consumption. Analysis by the Netherlands Environmental Assessment Agency (PBL) shows that if all renewable energy measures in the Climate Agreement are fully implemented, the renewable energy share would reach 30-32% of gross final energy consumption in 2030. Renewable energy provided just 7.4% of TFEC in 2018.

Renewables are anticipated to provide at least 70% of electricity generation by 2030. The 2019 offshore wind road map and the introduction of regional energy strategies intended to resolve barriers to onshore wind and solar PV, offer pathways to achieve the electricity sector's contribution to emissions reductions, which accounts for over 40% of the total emissions reductions stipulated in the Climate Agreement.

Scaling up renewables to achieve the emissions reductions for other sectors outlined in the Climate Agreement will be more challenging. This includes moving from natural gas to renewable energy in the built environment, increasing the contribution of biomethane and low-carbon hydrogen[1] in heating and industry, and a comprehensive decarbonisation of the transport sector. Achieving these goals requires further policy development and changes to market design to secure investment in the necessary infrastructure, stimulate innovation and remove deployment barriers.

Supply and demand

Renewable energy in TFEC[2]

Renewable energy is steadily increasing in the Netherlands. In 2018, renewable energy consumption was 3.4 Mtoe, a 50% increase since 2008 (Figure 6.2). Bioenergy is the largest source of renewable energy in the Netherlands, accounting for 62% of renewables in TFEC in 2017. The use of bioenergy steadily increased from 0.7 Mtoe in 2000 to 1.8 Mtoe in 2012.

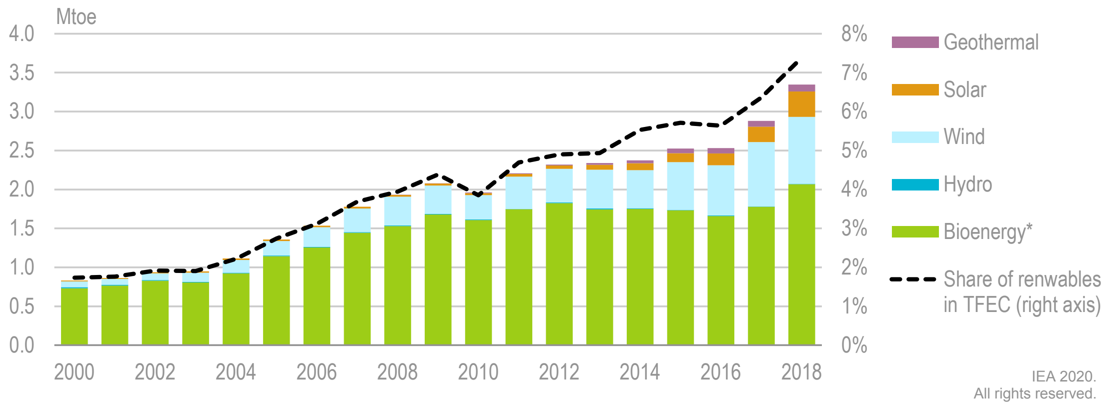
However, between 2012 and 2017, bioenergy consumption stabilised and most of the increase in renewable energy consumption over this period came from growing wind and

[1] Hydrogen production from electrolysis using renewable energy or from natural gas in combination with carbon capture utilisation and storage.

[2] Total final energy consumption (TFEC) excludes non-energy use which is counted in total final consumption (TFC). TFEC provides a more accurarte assessment of the share of energy demand coverd by renewable energy and is better aligned with EU's gross final energy consumption metric, which is used to set EU member state renewable energy targets.

solar PV generation, which together increased from 0.5 Mtoe in 2012 to 1.2 Mtoe in 2017. Growth in direct use of geothermal and solar thermal also made a contribution to the growth of renewables in TFEC. Hydropower has made a small but consistent contribution, but is not expected to grow significantly. Despite recent growth, renewable energy accounted for only 7.4% of TFEC in 2018, the second-lowest share among all IEA member countries and well below the IEA median of 15.5% (Figure 6.3).

Figure 6.2 Renewable energy in total final energy consumption, 2000-18



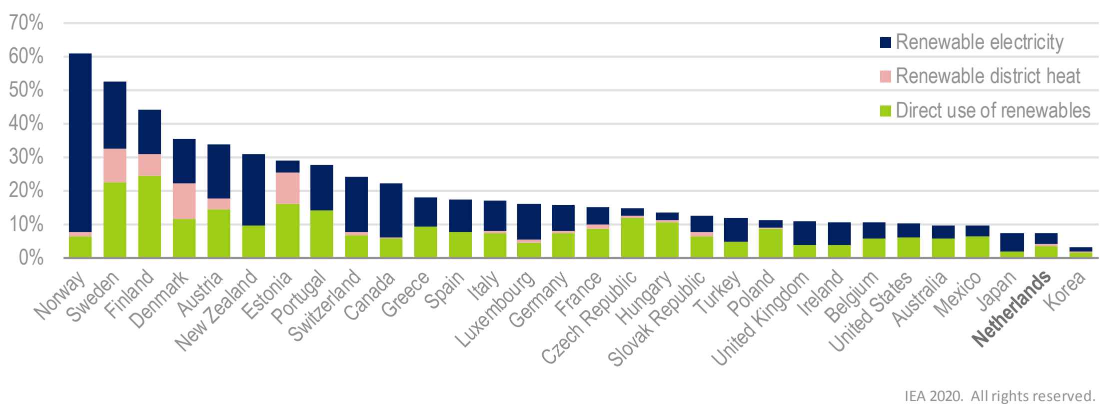
Bioenergy has the largest share in renewables consumption. Wind and PV generation have notably increased in recent years.

* Bioenergy Includes direct use of bioenergy, electricity and district heat produced from solid biofuels and renewable waste, liquid biofuels and biogases.

Note: TFEC = total final energy consumption.

Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 6.3 Renewable energy as share of total final energy consumption in IEA member countries, 2018



In 2018, renewables covered just 7.4% of TFEC in the Netherlands. If all Climate Agreement measures are implemented, renewables could reach 30-32% of consumption by 2030.

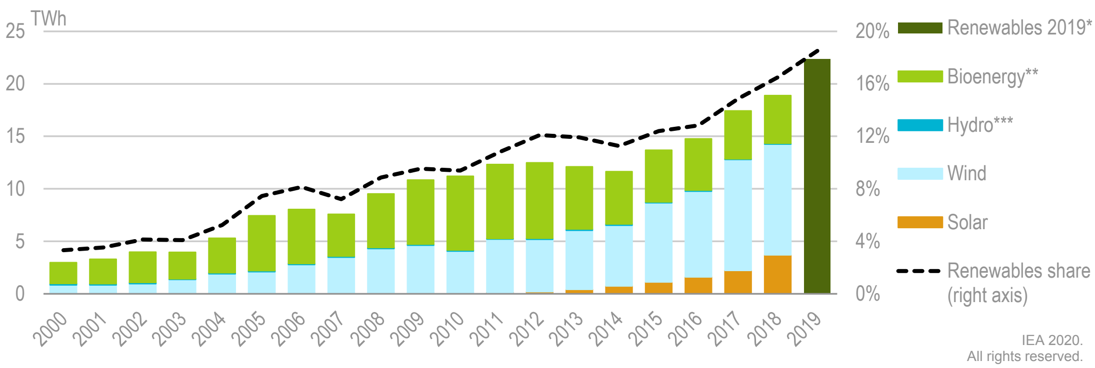
Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Renewable electricity

Renewable electricity generation reached 22.4 TWh in 2019, representing 18.5% of total electricity generation (Figure 6.4). Since 2015, wind power has been the largest source of renewable electricity. Wind power generation more than doubled from around 5 TWh in 2012 to 10.6 TWh in 2018, when it represented around 9% of total electricity generation. The rapid increase in wind generation was aided by offshore wind projects coming on line in 2015 and 2016. In 2018, offshore wind accounted for almost a third of total wind generation. Solar PV generation has also experienced rapid growth, increasing from 0.2 TWh in 2010 to 3.8 TWh and more than 3% of electricity generation in 2018.

Since peaking in 2012 at 7.2 TWh, generation from bioenergy declined steadily, reaching 4.6 TWh in 2018. Since 2018, four large biomass combined heart and power (CHP) plants have started operating, which could lead to an increase in the share of bioenergy in electricity generation. However, in June 2020, Vattenfall announced it was delaying the decision to start construction of what would be the largest biomass CHP plant in the Netherlands until the government finalises a biomass sustainability framework.[3] The sustainability standards set in this framework could have notable impacts on the future level of biomass generation in the Netherlands.

Figure 6.4 Renewable energy in electricity generation, 2000-19



Since 2015, wind and solar PV have driven increased renewable electricity generation. Bioenergy generation has fallen since 2012, but is expected to increase in the coming years.

* 2019 data are from Statistics Netherlands. A breakdown into different technologies is not available.

** *Bioenergy* includes direct use of bioenergy, electricity and district heat produced from solid biofuels and renewable waste, liquid biofuels and biogases.

*** Hydro generation ranged between 0.14 TWh and 0.06 TWh between 2000 and 2018.

Sources: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics; CBS (2020a), *Electricity Production at Record High*, www.cbs.nl/en-gb/news/2020/12/electricity-production-at-record-high.

Despite accelerated growth in renewable generation, the Netherlands ranked the ninth lowest in the share of renewable energy in electricity generation among IEA member

[3] The Dutch Cabinet is working to develop a widely supported sustainability framework for all types of biomass, which it plans to publish in 2020. The Ministry of Infrastructure and Water Management has asked the Social and Economic Council (SER) to issue advice on the framework. The SER's advice on biomass was issued in July 2020 and drew from a PBL study on the availability and optimal application of sustainable biomass in the Netherlands. The SER indicated that the government should prioritise the use of biomass in high-grade applications such as chemical processes, aviation and other areas where biomass is the main renewable option to replace fossil fuels. The SER indicated that the Cabinet should consider both sustainability and the availability of alternative energy sources when determining which biomass applications to support (PBL, 2020; NOS, 2020).

countries in 2018. While limited hydropower resources is one contributing factor, the shares of generation from wind and solar PV are also lower than many IEA countries. The Netherlands is starting to harness its considerable renewable electricity generation potential with significant offshore wind projects in the pipeline and policy measures in place to increase deployment of onshore wind and solar PV.

Renewable energy in transport

Dutch transport sector energy demand remains dominated by petroleum products, mainly gasoline and diesel. In 2018, renewable energy covered just 4.9% of domestic transportation demand. Biofuels used in road transport, principally biodiesel and ethanol, accounted for 94% of renewable energy in transport. Renewable electricity accounted for 6% of renewable energy in transport, primarily in rail transport, with road electric vehicles (EVs) accounting for around 1.4% of renewable energy in transport.

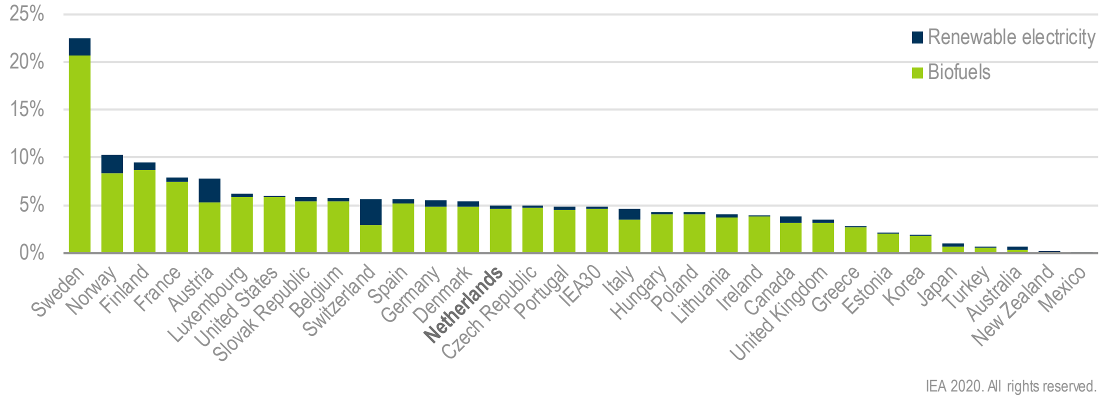
The share of biofuels in total transport energy demand remained stable at around 3% from 2007 to 2017.[4] In 2018, this share jumped to 4.7%. The majority of biodiesel consumed from 2015 to 2017 was produced from waste and residue feedstocks. However, less than 10% of the feedstocks used to produce the biofuels consumed in the Netherlands in 2018 were sourced domestically. Like in most EU member states, a very high percentage of Dutch biofuel consumption (99.5% by energy in 2018) was compliant with EU sustainability criteria (Eurostat, 2020).

The Netherlands is a world leader in EV deployment. In 2019, EVs accounted for 15% of annual passenger car sales with the monthly share of EVs in new car sales reaching 54% in December 2019 (Inside EVs, 2020). In 2019, EVs were 2.3% of the total vehicle fleet, one of the highest shares globally (CBS, 2020b). The Dutch EV fleet is supported by robust EV charging infrastructure. In 2020, there were over 56 000 semi-public EV charging points in the Netherlands, one of the highest concentrations of charging points globally (EAFO, 2020). In January 2020, the Metropolitan Region of Amsterdam awarded a contract for the installation of 20 000 EV charging stations (Total, 2020). Under the National Charging Infrastructure Agenda, the government aims to rapidly increase the deployment of charging infrastructure, with the goal of reaching around 1.7 million charging points by 2030 (NAL, 2020) (see Chapter 4 for more details on EV policy).

The Netherlands ranked among the upper half of IEA member countries in terms of renewable energy in transport demand in 2018, with a renewable share of 4.9% (Figure 6.5). More than half of the IEA countries had a renewable share in transport of 5% or less in 2018. Only Sweden and Norway have surpassed 10%, highlighting the challenge of decarbonising the transport sector.

[4] This share is based on actual energy consumed in transport, without the multipliers for certain biofuels and renewable electricity consumption in transport used to determine compliance with the EU Renewable Energy Directive.

Figure 6.5 Renewable energy in transport in IEA member countries, 2018



Like many IEA countries, the Netherlands has a low share of renewable energy in transport, with a need to increase the use of sustainable biofuels and renewable electricity.

Notes: The renewable electricity share is calculated as the electricity consumed in transport multiplied by the share of renewable energy in domestic electricity generation.
Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Institutions

The Ministry of Economic Affairs and Climate Policy has a broad mandate covering general energy policy, including renewable energy and the energy transition. This includes responsibility over the integrated spatial planning process for large energy projects, including offshore wind farms, onshore windfarms above 100 MW and other renewable projects above 50 MW. In 2018, the ministry issued a road map for the development of offshore wind energy in the Netherlands until 2030. The ministry has joint responsibility for creating, organising and implementing the Regional Energy Strategy programme. The development of less mature renewable energy technologies under the Integrated Knowledge & Innovation Agenda (IKIA) of the Climate Agreement also falls within the ministry's jurisdiction. The Ministry of Infrastructure and Water Management is responsible for policy concerning transport, including renewable fuels and EVs.

The Netherlands Enterprise Agency (RVO) is a department of the Ministry of Economic Affairs and Climate Policy with responsibility for implementing the ministry's policies. The RVO is the main implementing agency for renewable energy policy with responsibility over funding programmes including innovation subsidies, deployment subsidies and tax reduction schemes for both RD&D and renewable technologies. The RVO manages the SDE+ and SDE++ renewable support schemes and monitors public spending on energy innovation.

The Netherlands Environmental Assessment Agency (PBL) is an autonomous research institute within the Ministry of Infrastructure and Water Management. PBL conducts strategic policy analysis in the fields of environment and spatial planning, monitors implementation of national climate and energy objectives, and develops long-term climate and energy scenarios. The agency also publishes an annual Climate and Energy Report (KEV), which estimates the effects of climate and energy policy, including the contribution of renewable energy to the Dutch energy system. The PBL has a role in monitoring the national Regional Energy Strategy programme.

Local and regional authorities are responsible for spatial planning for onshore renewable energy projects. Provinces are responsible for the integrated planning process for onshore wind farms between 5 MW and 100 MW. Provinces currently hold no responsibility over PV projects. Municipalities are responsible for onshore wind farms below 5 MW and solar PV projects below 50 MW. The government is in the process of updating these thresholds, with responsibility for municipalities expanding to cover wind farms up to 15 MW and provinces becoming responsible for PV projects from 50 MW to 100 MW.

Achieving the Climate Agreement targets entails extensive efforts by multiple levels of government. This comprises an enhanced role for municipalities, provinces and water boards. These institutions, in consultation with distribution systems operators, the business community and other stakeholders, are required to produce Regional Energy Strategies for renewable electricity and heating. The Regional Energy Strategies will cover 30 designated energy regions of the Netherlands and must be updated biannually. Municipal governments must also produce a transition vision for heat and co-ordination plans by 2021. These will focus on the switch from natural gas to alternative low-carbon heating sources in the built environment at a neighbourhood level. The national government provides financial support to local governments in executing the Regional Energy Strategies and heating transition plans.

Targets, policies and support schemes

Targets

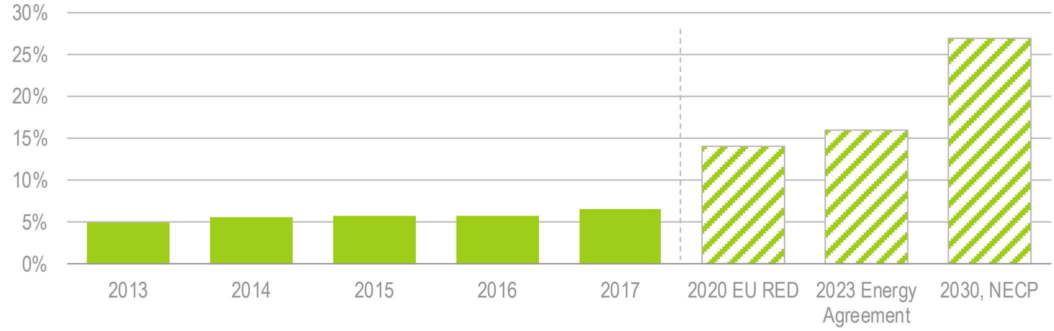
The Netherlands has targets for the share of renewable energy in total energy demand for 2020, 2023 and 2030 (Figure 6.6). The 2020 target comes from the EU Renewable Energy Directive (RED) and requires a 14% renewable share in gross final energy consumption. In 2018, the renewable share of gross final energy consumption was 7.4%. In 2019, PBL analysis indicated that the country would not achieve the 2020 target, reaching a renewable share of around 11.4% by 2020. In response, the Netherlands negotiated an agreement with Denmark for a statistical transfer of renewable energy to ensure achievement of the 2020 renewable energy target.

Under the RED, EU member states at risk of not meeting their 2020 renewable energy target can purchase statistical shares of renewable energy from member states that have exceeded their 2020 target, a physical transfer of energy is not required. The statistical transfer agreement between the Netherlands and Denmark was reached in June 2020 and specifies that the Netherlands will pay Denmark EUR 100 million for a statistical transfer of 8 TWh of renewable energy. The agreement allows the Netherlands to purchase up to an additional 8 TWh of renewable energy statistical credits at a price of 12.50 EUR/MWh before August 2021 to ensure that the Dutch renewable energy share remains in compliance with the 2020 target. The Danish government will use the EUR 100 million to help fund a tender for a low-carbon hydrogen project with technical co-operation from the Netherlands (Euractiv, 2020).

All EU member states also have a mandatory sub-target of a 10% renewable energy share in transport by 2020. The Netherlands is on track to achieve this target, having reached a share of 9.6% in 2018[5] (EC, 2010; PBL, 2019; Eurostat, 2020).

The Dutch 2013 Energy Agreement set a 2023 target requiring a 16% share of renewable energy in final energy consumption. PBL analysis indicates that this target is attainable with the 2023 renewable share estimated between 14% and 17%. The Energy Agreement also included a target of 6 GW onshore wind by 2020. Onshore wind deployment reached 3.2 GW in 2018; however, it is anticipated to fall short of the 6 GW target due to barriers associated with public acceptance, grid constraints and land fees. There is a further target within the Energy Agreement for 4.45 GW of offshore wind capacity by 2023. Current plans for offshore wind projects indicate that this target is achievable (Government of the Netherlands, 2013; PBL, 2019).

Figure 6.6 The Netherlands' renewable share of final energy consumption and targets



The Netherlands has renewable energy targets for 2020, 2023 and 2030. A significant expansion in renewables deployment in all sectors will be needed to meet the 2030 target.

Sources: IEA (2020), *World Energy Balances* (database), www.iea.org/statistics; MEACP (2019a), *National Energy and Climate Plan*, www.rijksoverheid.nl/documenten/rapporten/2019/11/01/integraal-nationaal-energie-en-klimaatplan; Government of the Netherlands (2013), *Energy Agreement for Sustainable Growth,* www.government.nl/documents/publications/2013/09/06/energy-agreement-for-sustainable-growth; EC (2010), *European Union Renewable Energy Directive*, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32009L0028&from=EN.

Under the European Union's 2030 Climate and Energy Framework, member states must submit an NECP covering 2021-30. The NECP must define a national renewable energy contribution that supports the EU-wide target of a 32% renewable share of gross final energy consumption in 2030. The Dutch NECP, submitted at the end of 2019, indicated that the country would reach a renewable share of at least 27% by 2030. The EC has indicated that the 27% share of renewable generation would result in a contribution from the Netherlands that supports the achievement of the EU-wide target (EC, 2019).

The Climate Agreement sets targets for GHG reductions: 49% by 2030 and 95% by 2050 (compared to 1990 levels). The Climate Agreement has no specific target for renewable

[5] EU targets and the 7.4% renewable energy share in gross final consumption and 9.6% renewable share in transportation consumption are based on the EU RED calculation methodology, which includes multiplication of the energy content for certain waste and residue-based biofuels and renewable electricity in transport.

energy, but details a number of measures intended to boost renewable deployment. The PBL's analysis shows that if all of these measures are fully implemented, renewable energy consumption would double and its share would reach 30-32% of gross final energy consumption by 2030 (MEACP, 2019b; PBL, 2019).

Meeting the Climate Agreement emissions reduction targets will require the share of renewables in electricity generation to reach around 70% by 2030. The emissions reduction attributed to the electricity sector in the Climate Agreement translates to 94 TWh of renewable electricity generation by 2030. Of this, 49 TWh is expected to come from offshore wind, with the Netherlands' offshore wind energy road map aiming to deliver 11.5 GW of total offshore wind capacity by 2030 (MEACP, 2019c). Of the 2030 renewable generation, 35 TWh is expected to be deployed onshore, principally as onshore wind and solar PV projects. In addition, there is a 2030 goal for 10 TWh of electricity from small-scale distributed renewable generation, primarily PV. The Climate Act includes a target for 100% CO_2-neutral electricity production by 2050, which will require clear long-term policies to sustain robust deployment of renewable generation beyond 2030 (Government of the Netherlands, 2019).

SDE+ and SDE++ support schemes

The Stimulation of Sustainable Energy Production (SDE+) support scheme is the main policy measure encouraging the deployment of renewables. SDE+ was established in 2011 and supports renewable electricity, gases and heat. In 2020, SDE+ was expanded into the Sustainable Energy Transition Incentive Scheme (SDE++),[6] which supports renewables and a wider range of technologies that reduce CO_2 and other GHG emissions, including methane. SDE+ includes sustainability requirements for biomass, which will be maintained in the transition to SDE++. Since in 2019, renewable electricity projects require confirmation from the relevant network operator[7] showing that sufficient grid capacity is available to support the project before they can be awarded SDE+ funding; this requirement will be maintained under SDE++.

Funding under SDE+ and SDE++ is awarded via competitive technology neutral auctions, which are open to bids from private companies, institutions and non-profit organisations. Under SDE+, projects including biomass and biogas, geothermal, hydropower, onshore wind, and solar PV compete with each other. The final SDE+ auction was held in the first half of 2020. Starting in the second half of 2020, SDE++ auctions will allow bids from renewable technologies along with carbon capture and storage (CCS), waste heat, heat pumps, and low-carbon hydrogen. The technologies eligible to participate in SDE++ auctions will be reviewed annually. It is currently planned that SDE++ auctions will be held once a year (SDE+ auctions were held twice a year).

SDE+ and SDE++ auctions are conducted in phases with the lowest level of financial support offered in the first phase. Once the first phase is closed, if there is still money remaining, additional phases are opened with increased levels of support for each successive phase (up to a limited maximum subsidy) until the total budget for the auction is

[6] A detailed explanation of the transition from SDE+ to SDE++ is available in a letter from the Minister of Economic Affairs and Climate Policy to the Dutch parliament sent on 17 February 2020 and available at: www.rijksoverheid.nl/documenten/kamerstukken/2020/02/17/kamerbrief-over-voortgang-verbrede-sde-en-eerste-openstelling-sde-2020.

[7] Distribution system operators for projects under 100 MW, transmission system operator for projects over 100 MW.

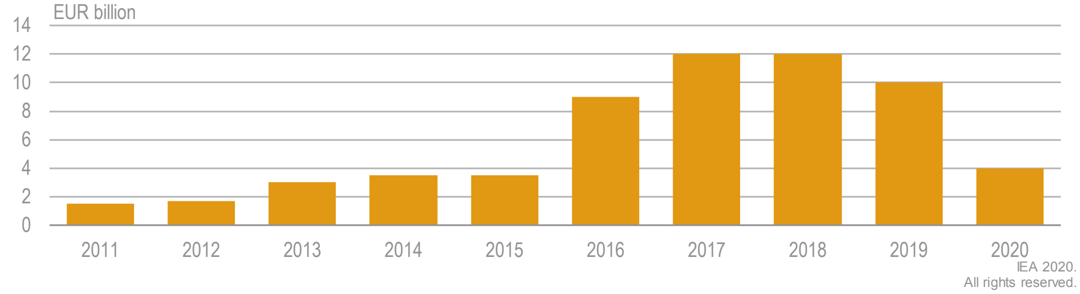
awarded. If the number or quality of project bids is too low for all funding to be awarded, then this budget is rolled over for use in the next auction. This approach gives priority to the most cost-effective project bids. Winning bids that pass a project viability assessment conducted by the RVO are eligible to receive financial support once they start production.

Under SDE+, the level of support was determined via a sliding feed-in premium mechanism designed to cover the difference between the cost of renewable energy production and the relevant corresponding market price for electricity, gas or heat. The level of support under SDE++ covers the difference between the base tariff awarded per tonne of CO_2 equivalent avoided and an estimated market remuneration. Conversion factors determine the CO_2 reduction level for various technologies, with emissions reductions for renewable electricity based on displacement of the expected marginal generation source in 2030.[8]

A project awarded support under SDE+ or SDE++ is required to start operating within a certain number of years after being selected through the auction process. The time limit is based on normal project lead times for the eligible technologies. The period over which a project receieves support payments is technology dependent and ranges from 8 to 15 years from the commissioning of the project.

The subsidy budget available in each round of SDE+ and SDE++ auctions is subject to an annual cap. The annual funding available to SDE+ auctions peaked at EUR 12 billion in 2017 and 2018 (Figure 6.7). In 2020, there was only one SDE+ auction. Support for the spring 2020 SDE+ auction was expanded from EUR 2 billion to EUR 4 billion as part of a package of measures announced in April 2020 to drive increased CO_2 emissions reductions in line with the Urgenda legal case (see Chapter 3).

Figure 6.7 Annual budget available through SDE+ auctions, 2011-19



Funding for the SDE+ renewable energy support scheme significantly peaked at EUR 12 billion in 2017 and 2018. SDE+ supports renewable electricity, heat and gases.

Source: MEACP (2019d), *Support Scheme for Renewables: From SDE+ to SDE++*.

The funding cap for the first round of SDE++ auctions (planned for the second half of 2020) will be EUR 5 billion. To incentivise competition and lower bids, the funding caps for each subsequent round of SDE++ auctions will be adjusted annually based on numerous factors, including the expected subsidy requirements of the technologies

[8] A detailed explanation of the SDE+ remuneration system and the level of support for eligible technologies can be found in Annex 6 of the 17 February letter to parliament: www.rijksoverheid.nl/documenten/kamerstukken/2020/02/17/kamerbrief-over-voortgang-verbrede-sde-en-eerste-openstelling-sde-2020.

allowed to participate in the auction and the progress towards the 2030 Climate Agreement targets. It is expected that total annual payments to projects that won SDE+ and SDE++ support will increase to around EUR 3.3 billion by 2030. The majority of this funding, around EUR 2.3 billion per year in 2030, will go to SDE+ projects. It is estimated that SDE++ support will increase to around EUR 1 billion per year by 2030, with over half of the expected support going to projects reducing industrial emissions (Table 6.1).

Table 6.1 Estimated annual support from SDE++ by technology in 2030

Renewable electricity	Renewable heat and green gas	Small-scale renewable heat	Advanced biofuels and renewable synthetic fuels	CO_2 reduction in industry*
EUR 200 million	EUR 135 million	EUR 100 million	EUR 200 million**	EUR 550 million

* Excluding renewables.

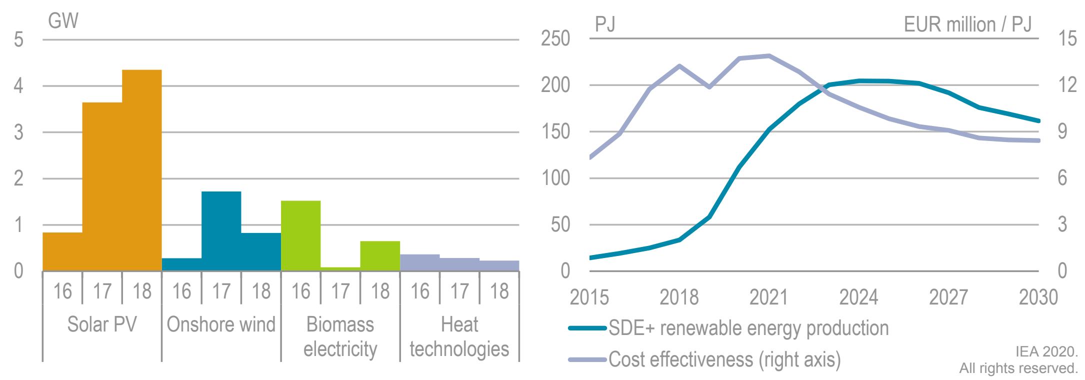
** EUR 200 million is the total funding available from 2020 to 2030. The Climate Agreement does not estimate how this funding will be spent on an annual basis.

Source: MEACP (2019b), *Climate Agreement*, www.klimaatakkoord.nl/documenten/publicaties/2019/06/28/national-climate-agreement-the-netherlands.

Funds for SDE+ and SDE++ are provided by the Surcharge for Sustainable Energy Act levy (ODE), an additional charge on all taxed energy consumption. Until 2020, households provided half of ODE funding; the other half came from businesses. In 2020, the ODE will be adjusted so that two-thirds of funding comes from business and only one-third from households.

In 2018, renewable energy production supported by SDE+ reached 0.8 Mtoe, equivalent to 34 PJ. Production from projects supported by SDE+ is anticipated to increase to around 4.8 Mtoe (200 PJ) per year by 2023, as projects awarded funding from 2018 to 2020 come on line (Figure 6.8). From 2021 onwards, energy production from SDE+-supported projects is anticipated to become more cost effective thanks to a reduction in cost per unit of renewable energy produced, with lower costs from wind and solar PV electricity projects being a key contributing factor.

Figure 6.8 Capacity awarded in SDE+ auctions, 2016-18 and anticipated renewable energy production and project cost effectiveness, 2015-30



SDE+ funding has accelerated the deployment of renewable energy projects. From 2021, energy production from SDE+ projects is anticipated to become more cost effective.

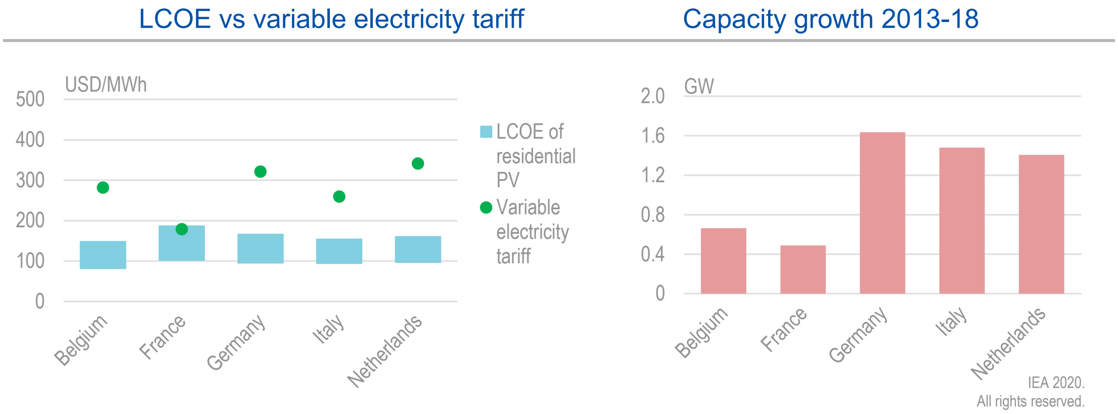
Source: RVO (2020), *Facts and Figures SDE+*, www.rvo.nl/subsidie-en-financieringswijzer/stimulering-duurzame-energieproductie-sde/feiten-en-cijfers/feiten-en-cijfers-sde-algemeen.

Small-scale PV net-metering

The Netherlands supports small-scale PV deployment via a net-metering scheme.[9] The scheme provides energy credits for excess generation injected to the grid at variable retail rates, with annual energy accounting. When PV generation exceeds a consumer's total annual electricity demand, a further value-based price is paid per kWh of PV generation. In addition, residential self-consumption of electricity is exempt from the energy tax and the ODE levy.

The PV net-metering scheme offers attractive economics to households as the levelised cost of electricity for small-scale PV is less than the relatively high Dutch electricity prices (Figure 6.9). Consequently, the Netherlands had one of the highest levels of residential PV deployment in Europe from 2013 to 2018, and the highest deployment in the EU in 2018 with around 600 MW of new PV capacity. In 2019, the residential PV support scheme was extended to 2030. However, after 2023, it is anticipated that net-metering tariffs will be reduced by 9% per year and end completely in 2031.

Figure 6.9 European residential PV market overview



Due to the low cost of residential PV in comparison to Dutch electricity prices and a generous support scheme, the Netherlands is a European leader in residential PV deployment.

Note: LCOE = levelised cost of electricity.
Source: IEA (2019), *Renewables 2019*.

Offshore wind policy framework

The Netherlands has developed an effective policy framework driving accelerated deployment and falling costs of offshore wind projects. The 2013 Energy Agreement introduced a proactive role for the government that includes defining offshore wind deployment zones in the National Water Plan, undertaking site investigations, providing associated data to developers and conducting environmental impact assessments. These steps, and the 2016 decision that TenneT, the electricity transmission system operator (TSO), constructs and pays for grid connection of offshore wind projects,

[9] Support is limited to PV systems with grid connections less than or equal to a 3*80 Amp. The Dutch law distinguishes between small-scale consumers (less than 3*80 Amp) and industry (greater than 3*80 Amp) by their grid connections.

significantly reduce investor risk and facilitate rapid and low-cost deployment (Government of the Netherlands, 2013).

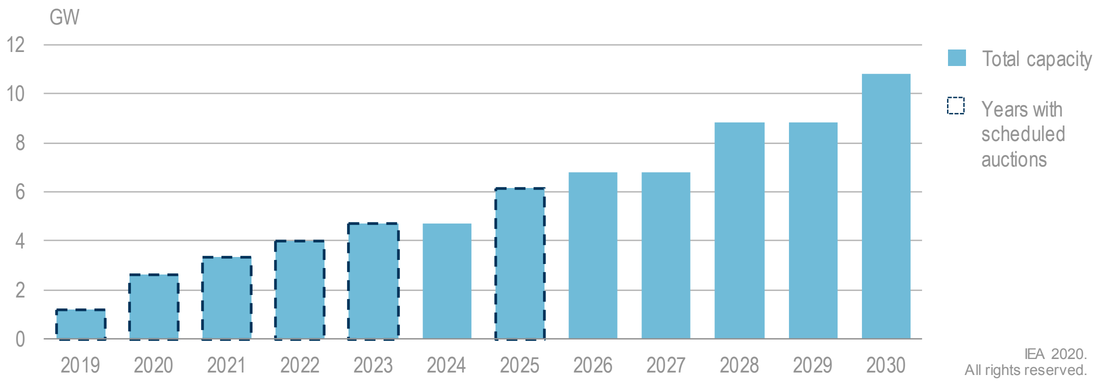
The Energy Agreement defined a project deployment schedule aiming for 4.7 GW of total offshore wind capacity by 2023. In 2016, a competitive offshore wind auction process was created, which is run separately from SDE+/SDE++ auctions. Under the offshore wind auctions process, projects that require the least subsidy (or in the case of a subsidy-free auction, the projects that achieve the highest score on a number of criteria laid down in the Offshore Wind Energy Act) are immediately awarded development permits and consent to operate. Due to the preparatory work undertaken by the government, winning projects can quickly move towards financial close and conclude the necessary contracts with financiers and suppliers to start construction.

In 2016, the Ministry of Economic Affairs and Climate Policy gave TenneT responsibility for the construction and operation of an offshore electricity grid supporting the deployment of offshore wind generation. In comparison to making each wind project responsible for its own grid connection, giving the TSO overall responsibility drives reduced costs through economies of scale, standardised substations and optimised integration with the onshore electricity grid. However, wind project developers do not pay the costs of constructing the offshore grid, which are passed on to electricity consumers via the ODE levy.

The Energy Agreement set a goal to reduce offshore wind generation costs to EUR 75/MWh by 2023 (excluding the cost of the offshore grid). This goal was exceeded in the first auction in 2016 with a winning bid of EUR 72.7/MWh. The 2017 auction delivered an even lower winning bid of EUR 54.5/MWh. The cost for the winning bids for 2018 and 2019 were so low (estimated by the PBL at 40-50 EUR/MWh) that no subsidies were awarded and the winning bids were selected based on project quality, with a heavy weighting given to projects providing clear assurances of timely completion. As a result, the total subsidies needed to reach the 2023 target of 4.7 GW target fell from an initial estimate of EUR 14 billion to around EUR 2 billion.

In 2018, the Ministry of Economic Affairs and Climate Policy issued an offshore wind road map aiming for 11.5 GW of total offshore wind capacity by 2030 (Figure 6.10). The road map extends the existing auction process until 2025 for the established offshore deployment zones and defines a project deployment schedule up to 2030. From 2020, offshore wind auctions will not offer any subsidies. The Climate Agreement adopted the offshore wind road map project deployment schedule, which is anticipated to provide long-term investor clarity and facilitate further cost reductions via innovation and economies of scale. TenneT plans around EUR 8 billion in infrastructure investments to support the projects envisioned in the offshore wind road map (MEACP, 2019c).

Figure 6.10 Projected offshore wind capacity increase and auction schedule to 2030



The offshore wind road map aims for 11.5 GW of total capacity by 2030. This goal is supported by competitive auctions and a strong policy framework that reduces investor risk.

Source: MEACP (2019e), *Offshore Wind Energy Policy and Future Challenges in the Netherlands*.

Renewable transport policies

The EU RED contains a target requiring the Netherlands to reach 10% renewable energy in transport demand by 2020. The main policy measure supporting the achievement of this goal is an annual biofuel obligation set in the Environmental Management Act. The obligation requires that biofuels cover a defined share by volume of a fuel supplier's annual sales.[10] This share is progressively increased on an annual basis (Table 6.2). Suppliers can also meet their obligation by purchasing tickets that are issued to suppliers that exceed their annual obligation. In 2018, the Netherlands introduced a sub-target for advanced biofuels produced from waste and residue feedstocks[11] and established a limit on the share of crop-based conventional biofuels that can be used to meet the annual obligation. The Netherlands Emissions Authority monitors compliance with the obligation.

Table 6.2 Annual biofuel obligation

Target (share by volume)	2018	2019	2020
Total	8.5%	12.5%	16.4%
Minimum advanced biofuel	0.6%	0.8%	1.0%
Conventional biofuel limit	3.0%	4.0%	5.0%

Note: The per cent volume requirements established to meet the 2020 EU Renewable Energy Directive target of 10% renewable energy in transport are higher than 10% because biofuels have lower energy density than fossil fuels.

Source: NEA (2020), *Annual Obligation*, www.emissionsauthority.nl/topics/obligations---energy-for-transport/annual-obligation.

The Netherlands is on track to achieve the 2020 renewable transportation target of 10%. In 2018, the share of renewables in transport demand was 9.6%.[12] The same year, the Netherlands also met its national targets for the minimum share of advanced biofuels

[10] Suppliers delivering less than 500 000 litres of petrol or diesel on an annual basis are exempt from the obligation.
[11] This target is defined in Annex IX, Part A of the EU RED and has been transposed into national legislation.
[12] EU renewable energy targets are based on the EU RED calculation methodology, which includes multiplication of the energy content of certain waste and residue-based biofuels and renewable electricity in transport.

and the limit on the share of conventional biofuels. To help increase the share of biofuels in transport, blends of gasoline with up to 10% ethanol (known as E10) were introduced in 2019.

Under the updated RED, EU member states have a 2030 target for 14% renewable energy in transport with a sub-target requiring a 3.5% share of advanced biofuels. To support the achievement of these targets, the annual biofuel obligation will be maintained through at least 2030. The Netherlands has capped the maximum contribution of crop-based conventional biofuels towards this target at 2020 consumption levels. The remaining share of the 2030 target will have to be met with advanced biofuels produced from waste and residue feedstocks or with renewable electricity.

The Climate Agreement indicates that the transport sector will need to deliver 15% of the CO_2 emissions reductions required to achieve the overall 2030 emissions reduction target. To support transportation emissions reductions, the Climate Agreement sets a target for 100% of new passenger vehicles sales to be zero-emission by 2030. Under the Climate Agreement, zero-emission refers to EVs or vehicles using low-carbon hydrogen. These vehicles do not have direct CO_2 emissions; however, depending on the source of the electricity or hydrogen used to power these vehicles, there could be associated upstream emissions (see Chapter 4 for details on transport policy).

Achieving the desired transport emissions reductions will also require a substantial contribution of up to 60 PJ from renewable fuels. In particular, the Climate Agreement anticipates a role for sustainable biofuels, including biomethane, and low-carbon hydrogen in transport modes such as heavy-duty road freight, aviation and shipping that are more challenging to electrify. To support transport sector emissions reductions, the government will encourage the procurement of sustainable biofuels by public sector shipping companies and the Ministry of Defence.

The Climate Agreement indicates that an obligation for renewable energy in transport will be embedded in the Environmental Management Act. The process of determining the level of this obligation will consider the percentage of renewable electricity in transport and the percentage of renewable fuels. Between 2020 and 2030, the Netherlands will make a total of EUR 200 million available via SDE++ to increase the production of advanced biofuels and renewable synthetic biofuels. The policy mechanisms to allocate this funding are still under development. Tax credits are in place for certain sustainable biofuels and hydrogen-related investments in the transport sector, e.g. subsidies for hydrogen vehicle fuelling stations.

Transition from natural gas to renewable heating in the built environment

To support the emissions reduction goal for the built environment, the Climate Agreement includes an ambition to transition around 1.5 million existing homes from natural gas to low-carbon heating with a focus on renewable energy. This goal entails a transition rate of 50 000 homes per year by 2021 that will progressively increase to 200 000 homes per year by 2030. In addition, the RED includes a target to increase the share of renewable heating and cooling by 1.3% a year through 2030.

The options to transition away from natural gas heating identified in the Climate Agreement include district heating with renewables (e.g. sustainable biomass and deep geothermal), heat pumps, and the delivery of biomethane and low-carbon hydrogen via existing natural gas infrastructure. Non-renewable options such as waste heat are also under consideration. The transition is not intended to increase heating costs. To support this goal, the government will take numerous steps to improve the economic case for transitioning to renewable heat, including increasing the taxation of natural gas by up to 43% by 2026 (compared to 2019 levels), lowering taxation on electricity, providing subsidies through a national heat fund and supporting innovation projects targeting cost reduction of renewable heat.

The transition away from natural gas will occur on a district-by-district basis, with the most appropriate solutions selected according to the characteristics of the housing stock and which low-carbon heat resources are locally availabile. The municipality led Natural Gas-free Districts programme has started to identify challenges, build expertise and provide best practices on the transition away from natural gas to the relevant public authorities. By 2028, there should be around 100 pilot neighbourhoods in the process of transitioning away from natural gas. These pilots and other district-oriented approaches should add up to a total of 1.5 million renovated houses by 2030.

A major revision of the Dutch Heat Act to support the transition away from natural gas heating is under development and set for publication by 2022. The revision will affect market design, heat tariff regulation and emissions reduction requirements and define the roles and responsibilities of municipalities and network operators.

Assessment

Renewable energy will play a significant role in meeting the Climate Agreement target of 49% GHG emissionss reduction by 2030 versus 1990 levles. The PBL's analysis shows that if the renewable energy measures in the Climate Agreement are fully implemented, the renewable energy share would reach 30-32% of final energy consumption by 2030, a significant increase from the 2017 level of just 6.5%. Achieving the 2030 Climate Agreement emission reduction target will require renewable energy to provide at least 70% of electricity generation. The growth in renewable electricity, combined with falling generation from fossil fuels, will lower the carbon intensity of Dutch electricity generation substantially, opening up opportunities for electrification that would support emissions reduction in the harder to abate heat and transport sectors.

The SDE+ auction scheme has been key to increasing the renewable energy share by supporting the deployment of onshore wind, solar PV and biomass projects. In the second half of 2020, the SDE+ will be expanded into the SDE++, which provides funding based on emissions reductions and supports a wider range of technologies. The government should monitor the impact of transitioning to SDE++ and make adjustments as needed to ensure that renewable energy deployment continues at the pace required to meet the Climate Agreement goals.

The IEA commends the Netherlands for delivering a stable legislative and regulatory framework for cost-effective offshore wind deployment, as recommended in the 2014 in-depth review. The framework, including competitive auctions, has significantly reduced investor risk, facilitated low-cost financing and led to a sharp drop in offshore wind project costs. However, there is scope for continued innovation to further reduce the cost of offshore wind turbines, foundations and installation. Under the offshore wind energy road map, capacity is expected to grow from around 2.5 GW in 2020 to 11.5 GW by 2030, which would make the Netherlands a global leader in offshore wind.

Deployment of offshore wind projects further from the coast will likely be necessary after 2030, given the numerous stakeholders competing for use of the North Sea nearer to the coast. As a result, transmission infrastructure will become a larger part of overall project costs. There is space for innovation by TenneT to reduce infrastructure costs. Options include offshore hubs and links with the offshore wind projects of other countries in the North Sea (e.g. Denmark, Germany and the United Kingdom), which could also enhance electrical interconnections. The importance of such innovation will increase if the Netherlands decides to move from paying for offshore electricity infrastructure to recuperating the cost of this infrastructure via grid tariffs, as proposed in the Climate Agreement, or passing grid connection costs to project developers.

Various challenges hinder the deployment of onshore wind and large-scale PV. Onshore wind faces barriers relating to public acceptance, grid connections and land fees. Large-scale PV projects have faced delays from grid constraints, due to the shorter time for PV project deployment compared to the time to deliver supporting grid infrastructure. The government is considering allowing electricity distribution system operators to curtail PV generation during peak production to facilitate faster deployment of large-scale PV projects.

Municipalities, provinces and water boards are required to produce Regional Energy Strategies, which could serve as an effective means to resolve barriers to the deployment of onshore wind and PV. These strategies could provide greater visibility of wind and PV project pipelines to ensure co-ordination with grid investments. However, they will only prove effective if they balance the interests of local communities, project developers and distribution system operators. All of these parties must be represented in stakeholder dialogues during the strategy production process. It is also crucial that these strategies provide a long-term vision to facilitate investments, and are not subject to abrupt or retroactive changes in local policies and requirements.

Under the Climate Agreement, small-scale PV (less 15 kW) is expected to contribute an additional 7 TWh by 2030. The Netherlands net-metering scheme has proved popular. In 2018, over 700 000 households were receiving net-metering payments for generation from their PV systems. A combination of falling capital costs, generation costs substantially below retail electricity prices and the ability to use energy credits on an annual basis is driving residential PV deployment. However, realising a good match between distributed PV generation and electricity consumption that will be beneficial for both consumers and the wider electricity system is challenging in the Netherlands, where peak demand occurs in the winter in the evening and peak PV output occurs in the summer in the middle of the day. Providing incentives for distributed electricity storage could help to address this issue.

The current annual net-metering policies for residential PV do not provide households with an incentive to maximise self-consumption. Therefore, the Netherlands may wish to consider moving to value-based remuneration of PV generation fed into the grid. Under such a policy, PV system owners would gain the most value from their investment if they maximise self-consumption, while excess electricity exported to the grid would be remunerated at a price that reflects the true value it brings to the system. Value-based remuneration of PV generation is possible thanks to the excellent progress on smart meter deployment, with 80% coverage expected in 2020 (see Chapter 7).

The government intends that the gradual reduction of the net-metering support scheme is a first step in the right direction to addressing these issues. To incentivise self-consumption, net-metering will be gradually reduced. Currently, all excess electricity that is exported to the grid can be deducted from the imported electricity. That way, consumers pay less energy tax and ODE levy. After 2031, consumers cannot deduct their exported electricity from their imported electricity, and have to pay tax and ODE for all of the electricity they import. This will encourage consumers to maximise self-consumption. Nevertheless, to protect consumers, they will receive a remuneration for their exported electricity of at least 80% of the agreed electricity tariffs from their energy suppliers. This percentage will, however, be continuously monitored, to review the possibilities of a further decrease of the percentage in the future to stimulate market forces.

Despite encouraging signs for renewables in the electricity sector, an increase in renewable heat is also needed to support the achievement of the Climate Agreement. The built environment accounts for around a quarter of the Netherlands' final energy consumption. However, the built environment's share of the overall CO_2 emissions reduction target of the Climate Agreement is only 7%. This reflects the challenging and costly nature of switching to alternative heating sources in the context of low building renovation rates, high population density, around half of Dutch homes being privately owned and almost 90% of households in the Netherlands having individual gas boilers.

To support emissions reductions in the built environment, the Climate Agreement includes a goal to transition 1.5 million of the country's 7 million homes from natural gas to low-carbon heating by 2030. The principal options identified in the Climate Agreement for transitioning are heat pumps in well-insulated buildings for areas of lower building density, district heating using low-carbon fuels in areas with higher building density and renewable gases delivered via existing gas infrastructure. Municipal governments are required to produce a transition vision for heat that identifies the most applicable heating solutions given the local circumstances.

Ensuring the affordability of the shift to low-carbon heating sources is a core requirement for the Netherlands. The government aims to achieve a balance between the monthly costs of investing in new heating systems and the energy cost savings from these new systems, so that the transition to low-carbon heating does not result in a net increase in living costs. An increase of taxation on natural gas by up to 43% by 2026 (compared to 2019 levels) and a consequent lowering of taxation on electricity will improve the relative economic case for investing in low-carbon heating systems.

It may be challenging to ensure that prices for heat from renewable district heating are competitive with prices for natural gas heating, even considering that the Netherlands has the sixth-highest household natural gas prices of all IEA countries, and the planned natural gas tax increase. This is due to renewable fuel costs still being higher than natural gas in some cases, and the additional need to recuperate the investment in costly new district heating networks where required.

As maximum district heating prices are currently based on natural gas prices, a new price structure will need to be developed. Such a system should allow for flexibility in maximum prices and balance consumer affordability with the need to facilitate investments in district heating infrastructure. The source of funding, e.g. public or private sector investment, for capital-intensive district heating networks is still to be determined. Public ownership, subsidies and public-private partnerships for district heating infrastructure warrant consideration to help renewable district heating play a significant role in the transition away from gas. Scaling up renewable heat in the built environment will also require an increase in the number of suitably skilled heating engineers.

To support emissions reductions from transport, the government has set a target for 100% of new passenger vehicles sales to be zero-emission (powered by renewable electricity or low-carbon hydrogen) by 2030. Good progress in electrification of transport is evident. EVs accounted for 15% of new passenger car sales in 2019. The rapid increase in the share of renewable electricity generation anticipated in the period to 2030, and consequent lowering of the carbon intensity of electricity supply, will enhance EVs' contribution to overall CO_2 emissions reductions. Hydrogen use in transport still has very limited deployment in the Netherlands. In May 2020, the hydrogen fuel cell vehicle fleet in the Netherlands consisted of 251 passenger cars, 13 light duty trucks, 7 heavy duty trucks and 11 buses, and 5 hydrogen vehicle fueling stations. The Netherlands has plans to significantly increase hydrogen use in transport and is supporting deployment of additional hydrogen fueling stations (see Chapter 8).

Achieving the 2030 target for 100% zero-emissions vehicles sales could increase the EV share to around 25% of an estimated 8 million passenger cars in 2030. This would leave an estimated 6 million gasoline and diesel vehicles on the road in 2030. Effective policies are needed to reduce CO_2 emissions from these vehicles in line with the Climate Agreement and support the achievement of the RED sub-target requiring a 3.5% share of advanced biofuels. The Climate Agreement sets an upper limit of 60 PJ of renewable fuels in road traffic by 2030; it is planned that this will be the maximum level required under the annual biofuel obligation. The government should examine whether this upper limit places any restrictions on meeting the emissions reduction and biofuel share targets for the transport sector.

More clarity is required on the policy framework for low-carbon liquid fuels. Although EUR 200 million is proposed to stimulate the production of advanced sustainable biofuels for transport via SDE++ from 2020 to 2030, the requirements for receiving this support are unclear. California's Low Carbon Fuel Standard[13] provides an example of a technology-neutral policy focused on emissions reductions that has stimulated the use of electricity and low-carbon biofuels in transport. The Dutch government is developing a new Vision on Sustainable Fuels, which could serve as an excellent mechanism to ensure that the role of renewable fuels in meeting Climate Agreement targets is fully understood and supported.

The Climate Agreement offers an opportunity for the Netherlands to move to the forefront of low-carbon gas production. In 2017, there was around 840 PJ of natural gas consumption in the country's final energy consumption. The ambition to reduce natural gas consumption creates an opportunity for low-carbon gases such as biomethane and low-carbon hydrogen to play key roles in the energy system. Scaling up the production of low-carbon gases can support the long-term transition away from natural gas and

[13] For further information see: https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard/about.

improve energy security. Renewable gases also offer a solution in hard-to-abate sectors such as high-temperature industrial heat and heavy-duty road freight (see Chapter 8).

IEA analysis shows significant untapped potential for scaling up biomethane production, with Europe's feedstock resource theoretically capable of meeting 20% of EU natural gas demand. Although biomethane production in the Netherlands is currently low, the Climate Agreement contains a goal to realise 70 PJ of biomethane production by 2030. This is equal to 8% of 2017 gas demand, highlighting the significant potential of biomethane to support the desired transition away from gas.

The large agricultural and horticultural sector in the Netherlands produces significant waste and residues suitable for biomethane production via anaerobic digestion and upgrading, which is already a mature technology.[14] Anaerobic digestion produces CO_2 suitable for use in greenhouses and a material called "digestate", which can be used as a fertiliser, providing a circular economy solution. Dutch biogas production via anaerobic digestion has grown rapidly and the government expects capacity to continue to grow in line with the 70 PJ target for 2030.

The transition from SDE+ to SDE++ should boost the prospects of financial support for biogas and biomethane projects, as SDE++ will take into account the ability of these projects to reduce direct methane emissions from the decomposition of agricultural and horticultural waste and residues. In March 2020, the Minister of Economic Affairs and Climate Policy sent a letter to the Dutch parliament on a Green Gas Roadmap that provides a broad range of policy measures aiming to drive increased biomethane production. The letter indicates that SDE++ will be the main support mechanism, but that additional support will come through targeted RD&D, pilot projects, updating of regulations and other measures (see Chapter 8).

Recommendations

The government of the Netherlands should:

- ☐ Ensure that Regional Energy Strategies provide a sufficiently stable outlook for investments in onshore wind and solar PV and balance the needs of local communities, project developers and distribution system operators.
- ☐ Develop a new price structure for renewable district heating that strikes a balance between consumer affordability and facilitating investment in heat network infrastructure.
- ☐ Apply appropriate policy measures to realise the high potential for renewable gas production, both from biomethane and low-carbon hydrogen.
- ☐ Develop a strategy for CO_2 emissions reduction in diesel and gasoline vehicles by clarifying the role of low-carbon transport fuels in the Climate Agreement and how the Netherlands will meet its 2030 EU target for renewable energy in transport.

[14] Gasification of lower moisture content solid biomass feedstocks is an additional means of producing biomethane, although currently at a lower level of technical maturity.

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7. Electricity

Key data

(2018)

Electricity generation (2018): 114.5 TWh (natural gas 51.0%, coal 26.5%, wind 9.2%, bioenergy and waste 5.7%, nuclear 3.1%, solar 3.3%, oil 1.1%, other 0.1%), +6% since 2008

Electricity net imports (2018): 8.0 TWh (imports 26.8 TWh, exports 18.8 TWh)

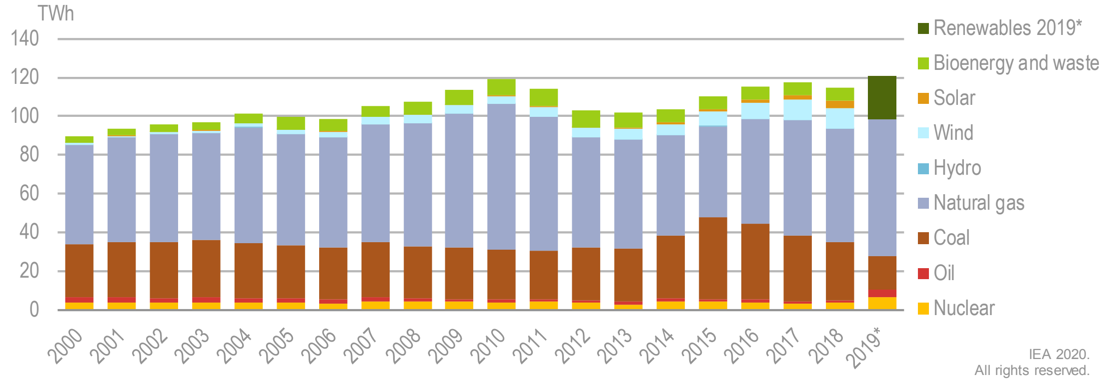
Installed capacity (2018): 35.0 GW

Electricity consumption (2018): 114.0 TWh (services/other 41.1%, industry 31.8%, residential 20.1%, energy 5.1%, transport 1.8%)

Overview

In 2018, fossil fuels covered over three-quarters of electricity generation in the Netherlands (Figure 7.1). Natural gas was particularly important with 51% of generation, followed by coal with 27%. The share of energy from renewable sources increased from 8% in 2008 to 16.5% in 2018, led by a strong increase in wind and solar PV. Estimates from Statistics Netherlands (CBS) show that in 2019, electricity demand reached the highest level ever recorded (121 TWh), with strong increases in natural gas and renewable generation; at the same time, coal-fired generation dropped to the lowest level since 1985.

Figure 7.1 Electricity supply by source, 2000-19



Fossil fuels dominate power generation, but wind and solar power are growing rapidly. Changes in total generation are driven mainly by regional electricity trade.

* 2019 data from CBS estimates and a breakdown into different technologies is not available.

Sources: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics; CBS (2020), *Electricity Production at Record High*, www.cbs.nl/en-gb/news/2020/12/electricity-production-at-record-high.

Under current policy, it is expected that the share of electricity generation from renewable energy will grow at a very rapid pace, from an estimated 18.5% in 2019 to around 70% by 2030. The growth in renewable generation is expected to come mostly from wind (with a large share of offshore wind) and solar PV. Integrating the increasing share of variable renewable generation while maintaining a secure electricity supply requires more flexibility from the electricity networks and markets. The Netherlands is currently in the process of implementing major updates to electricity sector policy and regulations, which aim to accelerate the deployment of renewables and support the development of a highly efficient and flexible electricity system.

Electricity supply and demand

Electricity generation

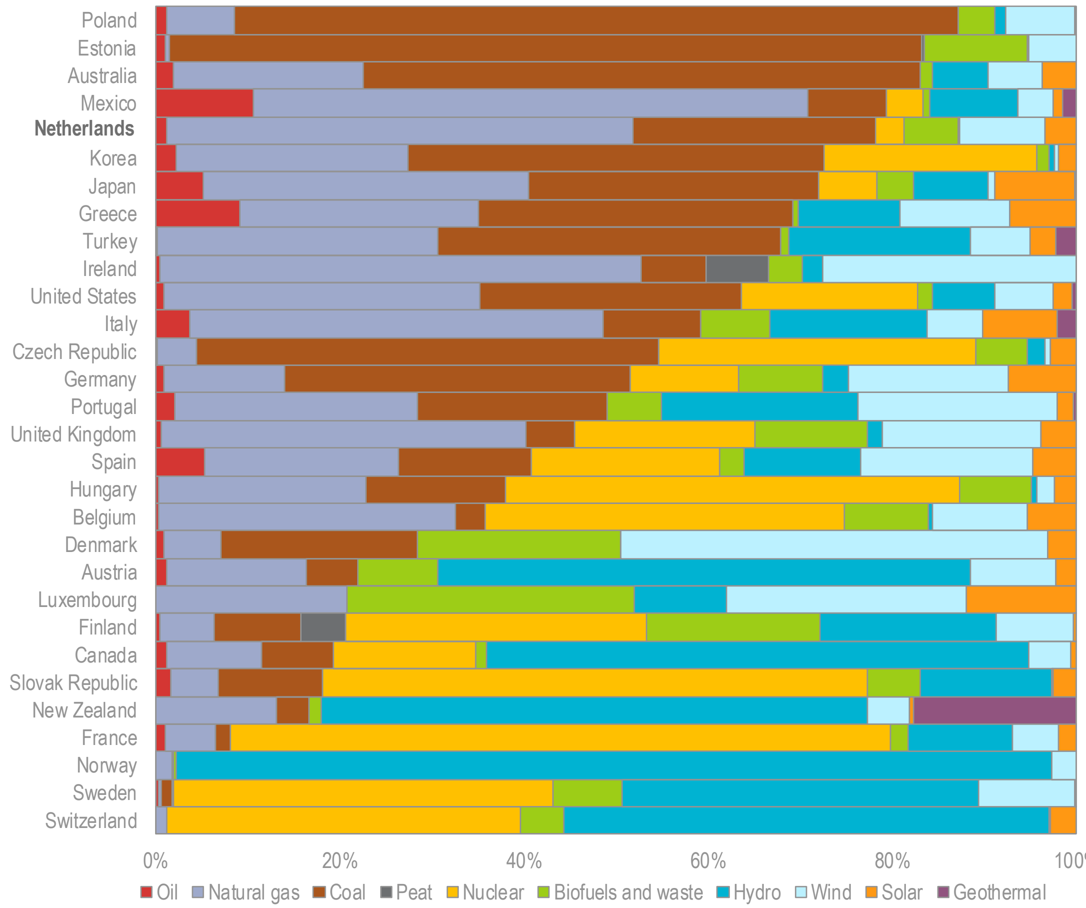
Due to a heavy reliance on natural gas and coal, the Netherlands had the fifth-highest share of fossil fuels in electricity generation among IEA member countries in 2018 (Figure 7.2).The share of natural gas (51%) was the third highest after Mexico (60%) and Ireland (52%). However, the share of fossil fuels in the Dutch electricity mix decreased from 85% in 2008 to 79% in 2018.

In 2018, electricity generation in the Netherlands totalled 114.5 TWh (Figure 7.1). Natural gas was the dominant fuel (51%), followed by coal (26%), wind (9%), bioenergy and waste (6%), solar (3%), and hydro (0.1%). Total generation in 2018 was 6% higher compared to 2008. However, total generation fluctuated significantly over this period, mainly because of changing output from natural gas generation in response to regional electricity trade. The Netherlands has strong cross-border electrical interconnections and a large natural gas fleet that can quickly react to regional price changes. Over the last decade, natural gas power generation has varied between a peak of 75 TWh in 2010 to a low of 47 TWh in 2015 and covered between 43% and 63% of total power generation.

Between 2011 and 2015, there was a shift from gas to coal-fired power generation. Due to price drops for coal and increased natural gas prices, 1.56 GW of new coal-fired generation capacity came on line in 2015 and coal-fired generation peaked that year at 42 TWh, or 38% of total electricity generation. Since then, the trend has reversed and coal power generation decreased to 30 TWh in 2018. Based on the 2017 Coalition Agreement, coal-fired generation will be phased out by 2030 (see Chapter 10).

The share of electricity generation from renewables increased from 8% in 2008 to 16% in 2018. Wind power is the largest source of renewable generation and more than doubled from 4.3 TWh in 2008 to 10.6 TWh in 2018. Offshore wind accounted for around a third of wind generation in 2018 and is expected to be the largest source of new renewable generation through 2030, due to the excellent wind resource in the North Sea and limits to deployment of large-scale onshore renewable projects. Solar PV generation has increased rapidly, from 0.04 TWh in 2008 to 3.2 TWh in 2018, and is expected to be the largest source of new onshore renewable generation through 2030. Hydropower has made a small but consistent contribution, but is not expected to grow.

Figure 7.2 Electricity generation by source in IEA member countries, 2018



The Netherlands has the fifth-highest share of fossil fuels in electricity generation among IEA member countries and the third-highest share of natural gas.

Note: Countries are ranked by share of fossil fuels in electricity generation (from highest to lowest).
Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Since peaking in 2012 at 7.2 TWh, generation from bioenergy declined steadily to 4.6 TWh in 2018. Since 2018, four large biomass combined heat and power (CHP) plants have started operating, which could lead to an increase in the share of bioenergy in electricity generation. However, in June 2020, Vattenfall announced it was delaying the decision to start construction of what would be the largest biomass CHP plant in the Netherlands while the government works to finalise a biomass sustainability framework[1] (NOS, 2020a). The sustainability standards set in this framework could have notable impacts on the future level of biomass generation in the Netherlands.

[1] The Dutch Cabinet is working to develop a widely supported sustainability framework for all types of biomass, which it plans to publish in 2020. The Ministry of Infrastructure and Water Management has asked the Social and Economic Council (SER) to issue advice on the framework. The SER's advice on biomass was issued in July 2020 and drew from a PBL study on the availability and optimal application of sustainable biomass in the Netherlands. The SER indicated that the government should prioritise the use of biomass in high-grade applications such as chemical processes, aviation and other areas where biomass is the main renewable option to replace fossil fuels. The SER indicated that the Cabinet should consider both sustainability and the availability of alternative energy sources when determining which biomass applications to support (PBL, 2020; NOS, 2020b).

The Netherlands has one nuclear power plant: the Borssele reactor in the southwest of the country. From 2008 to 2018, generation from the Borssele plant was relatively steady at around 3.5-4 TWh per year. Over the same period, the share of nuclear power in total electricity generation slowly declined from around 4.5% to 3.1%. The Borssele plant is expected to close down by 2033 (see Chapter 11).

Electricity capacity

In 2018, the Netherlands had 35 GW of installed electricity generation capacity. Table 7.1 gives the historical and expected evolution of the Dutch electricity generation fleet. Installed capacity is estimated to increase to around 59 GW by 2030, driven by the deployment of renewables, primarily solar PV and offshore wind. Of the 16.6 GW of wind capacity expected in 2030, 11.5 GW are planned to come from offshore wind. Coal-fired capacity will be phased out by 2030. The one nuclear power plant in the Netherlands is currently required to end operations in 2033. Natural gas generation capacity is expected to decrease slightly as the share of renewable generation increases.

Table 7.1 Installed electricity generation capacity by type, 2005-30 (GW)

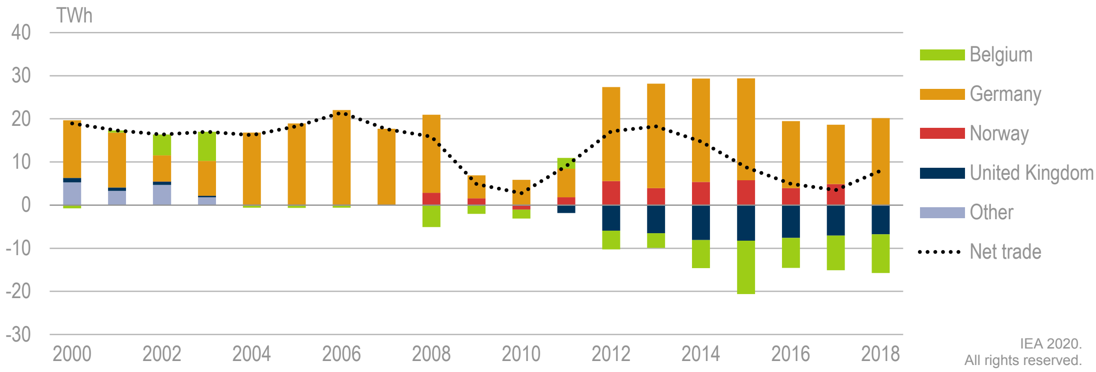
	2005	2010	2015	2020	2025	2030
Natural gas	10.3	14.1	17.7	17.1	16.4	15.4
Coal	9.5	8.9	11.2	4.1	3.4	0.0
Nuclear	0.4	0.5	0.5	0.5	0.5	0.5
Wind	1.2	2.2	3.4	6.4	12.6	16.6
Solar PV	0.1	0.1	1.5	9.0	19.2	26.1
Biomass and waste	0.5	0.8	0.9	0.5	0.5	0.4
Hydro	0.04	0.04	0.04	0.04	0.04	0.04
Total	**21.9**	**26.6**	**35.2**	**37.6**	**52.7**	**59.0**

Source: MEACP (2019a), *National Energy and Climate Plan*, www.rijksoverheid.nl/documenten/rapporten/2019/11/01/integraal-nationaal-energie-en-klimaatplan.

Electricity trade

In 2018, the Netherlands had interconnections with Belgium, Germany, Norway and the United Kingdom, importing 26.8 TWh and exporting 18.8 TWh, amounting to net imports of 8.0 TWh. The largest net imports in 2017 came from Germany (20.2 TWh), followed by Norway (3.5 TWh), while net exports went to Belgium (9.0 TWh) and the United Kingdom (6.7 TWh). In September 2019, the Netherlands expanded its interconnectivity through the subsea COBRA cable to Denmark. Cross-border electricity flows between the Netherlands and its trading partners have fluctuated over the past two decades, reflecting variations in generation costs, regional supply-demand dynamics, and the ability of the well-interconnected and flexible Dutch generation fleet to quickly respond to market conditions (Figure 7.3). Because of the planned increase in renewable generation capacity, it is expected that the Netherlands will shift from its historic status as a net importer to a net exporter of electricity in the early 2020s.

Figure 7.3 Electricity net imports and exports by country, 2000-18



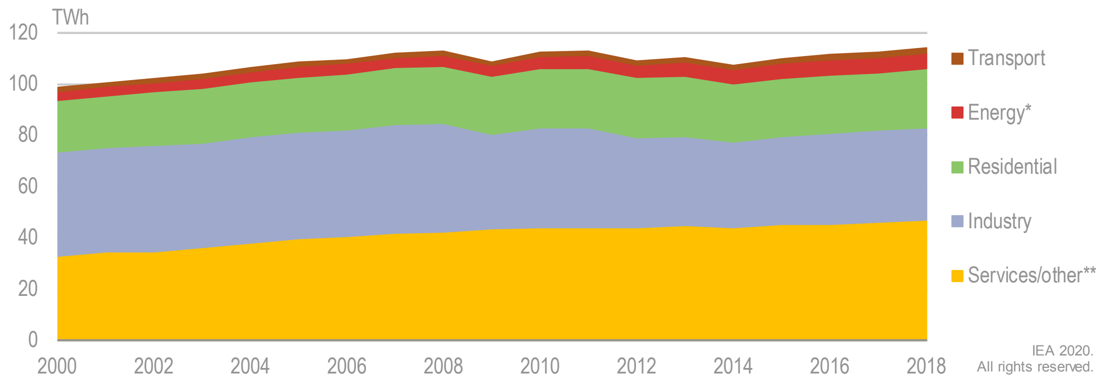
The Netherlands is well interconnected with its neighbouring countries and has a generation fleet that can quickly respond to regional market conditions.

Source: IEA (2020b), *Electricity Information 2020*, www.iea.org/statistics.

Electricity demand

In 2018, total electricity demand was 114.0 TWh (Figure 7.4). The services/other sector was the largest consumer (41%), followed by industry (32%), driven by chemical and petrochemical demand. The remainder of demand came from the residential (20%), energy (5%) and transport (2%) sectors. Transport demand came from electrified rail (76%) and electric road transport (24%). The latest IEA estimates from 2017 show that demand for electric heating in residential and services buildings was around 1% of total electricity demand. Total electricity demand steadily increased from 2000 to 2008, fluctuating between a low of 107.3 TWh in 2014 to 114 TWh in 2018. Over this period, industry was the only sector to experience decreasing demand, falling from 42 TWh to 36 TWh, due to the post-2008 economic crisis. CBS estimates show that electricity demand reached an all-time high of 121 TWh in 2019.

Figure 7.4 Electricity demand (total final consumption) by sector, 2000-18



The Netherlands' overall electricity consumption has been relatively stable in the last decade, except for a decline in the industry sector.

* *Energy* includes petroleum refineries, coal mines, oil and gas extraction, coke ovens, and blast furnaces.

** *Services/other* includes commercial and public services, agriculture and forestry.

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Institutions

The Ministry of Economic Affairs and Climate Policy is responsible for the formulation and implementation of energy and climate policy. Within the ministry, the Directorate-General for Climate and Energy has responsibility over policy covering the electricity sector. The Ministry of Finance owns the TenneT holding company, which has two subsidiaries. TenneT TSO B.V. is the Dutch electricity transmission system operator (TSO) and also owns and operates the offshore electricity grid connecting Dutch offshore wind generation to the onshore grid. TenneT GmbH is one of the four German TSOs. TenneT TSO B.V. and TenneT GmbH jointly own and operate four cross-boarder electrical interconnectors linking the Netherlands and Germany. The seven Dutch electricity and gas distribution system operators (DSOs) are owned by Dutch provinces and municipalities.

The Netherlands Authority for Consumers and Markets (ACM), established in April 2013, is the independent regulatory authority for the electricity, gas and district heating markets. The ACM works to protect the rights of consumers and businesses. The Energy Regulation Unit within ACM deals with competition, market transparency, and regulation of the wholesale and retail electricity markets. The ACM supports consumers through a dedicated website and publishes information on electricity markets. ACM has authority to approve TSO and DSO investment plans to ensure relevant and efficient investments that are in accordance with legislation and support affordability, security of supply and secure networks. Investments above EUR 200 million require approval by the Ministry of Finance.

Policy

The Netherlands is in the process of implementing numerous policies that affect the electricity sector. The main policy goals are defined in the Climate Agreement and aim to drastically reduce CO_2 emissions from electricity generation by transitioning the Netherlands from its current reliance on natural gas and coal-fired generation to renewable energy, primarily wind and PV. Dutch policy also focuses on supporting secure and efficient grid operations while increasing system flexibility, integrating a growing share of variable renewable generation, empowering electricity consumers and complying with EU directives on electricity markets.

Climate Agreement

Under the Climate Agreement, the electricity sector has been allocated the largest 2030 emissions reduction indicative target, 20.2 million tonnes, or 41% of the total emissions reductions. Meeting this target will require the share of renewables in electricity generation to reach at least 70% by 2030. In 2018, renewable energy covered just 15.7% of electricity generation. The 2030 emissions reduction target translates into 84 TWh of annual electricity generation from renewables, 49 TWh of which is expected to come from offshore wind and 35 TWh from onshore generation, principally onshore wind and PV (an additional 7 TWh is expected from small-scale PV). The Dutch Climate Law includes a target for 100% CO_2-neutral electricity production by 2050, which will require a clear long-term policy to sustain robust deployment of renewable generation beyond 2030 (MEACP, 2019b; Government of the Netherlands, 2019).

To support transport emissions reductions, the Climate Agreement sets a target for 100% of new passenger vehicles sales to be zero-emission by 2030. Under the Climate Agreement, zero-emission refers to electric vehicles (EVs) or vehicles using low-carbon hydrogen. Achieving this goal will result in a significant increase in electricity demand and will have notable impacts on the operation of the electricity grid, especially the distribution level for EV charging. The Climate Agreement estimates that achievement of the target for 100% of new vehicles sales to be zero-emission by 2030 would result in an additional electricity demand of 7.1 TWh, or around 6% of the expected electricity demand in 2030.

To support the emissions reduction goal for the built environment, the Climate Agreement includes an ambition to transition around 1.5 million existing homes from natural gas to low-carbon heating, with a focus on renewable energy, including heat pumps, district heating with renewables and green gases (e.g. biomethane and low-carbon hydrogen) delivered via existing natural gas infrastructure. It is likely that the gas transition policy will lead to a significant increase in electricity demand for heating that could also have effects on the electricity system.

Support schemes

To support the ambitious goals for renewable electricity generation, the Netherlands has a well-funded auction process to award subsidies to renewable energy projects (SDE+). In 2020, this programme is being expanded (SDE++) to cover a broader range of CO_2 reduction options. There is also a separate auction process for offshore wind and a net-metering scheme for small-scale PV. Onshore renewable generation will be encouraged through Regional Energy Strategies that facilitate co-operation between key stakeholders to remove deployment barriers (see Chapter 6).

Coal phase out

Reduction in emissions from the electricity sector is also being driven by a policy to phase out coal-fired generation, which accounted for 26.5% of electricity generation in 2018. On 11 December 2019, the Netherlands passed a law requiring the end of the use of coal in electricity generation. Older plants with an efficiency of less than 46% must stop using coal by 1 January 2025. Newer plants with efficiencies of greater than 46% must stop using coal by 1 January 2030. At these dates, the plant must have fully converted to alternative fuels or it must shut down (see Chapter 10).

Nuclear plant closure

Electricity generation in the Netherlands will also be affected by the planned closure of the Borssele nuclear power plant. Borssele is the only the nuclear reactor in the Netherlands providing electricity to the grid. In 2018, it accounted for 3.1% of total generation. The plant has been in operation since 1973 and is required by law to stop operating by 31 December 2033 (see Chapter 11).

Carbon floor price

The 2017 Coalition Agreement required introducing a carbon price for electricity generation. Initial plans called for a national tax on emissions from electricity in addition to payments already required under the EU Emission Trading System (ETS). In 2018, analysis was conducted comparing a national and regional carbon price for electricity and showed that unilateral introduction of a national carbon price would have adverse effects on the Dutch electricity system (mothballing of natural gas plants, carbon leakage due to increased electricity imports and negative adequacy reserve margins after 2025). A regional price was shown to have more manageable impacts and led to a higher overall reduction in emissions from electricity. In response to these findings, the Netherlands adopted a more conservative national carbon price that takes into account risks to security of supply. The price will be introduced in 2020 at a margin under the ETS price, with the result that payments will only be triggered if the ETS price drops below the national carbon price. The Netherlands continues to push for the adoption of a carbon floor price for electricity generation at the regional and EU level, and if such pricing is introduced, the government indicates that the national carbon price could be increased to align with a regional or EU carbon floor price.

EU Clean Energy Package

The EU Clean Energy for all Europeans Package (CEP) entered into force on 4 July 2019. The CEP includes a broad range of measures pushing for a more integrated and efficient energy system, with a particular focus on electricity. Implementation of the CEP will impact the Dutch electricity system and markets (EC, 2019). The CEP calls for additional integration of the European electricity markets, including a 2025 requirement that a minimum of 70% of the capacity of critical network elements[2] must be available on the market. In addition, the CEP calls for a comprehensive review of wholesale market bidding zones that takes into account the physical configuration of the European electricity network. Under the CEP, system operators must refrain from pushing internal congestion to the border. Other impacts of the CEP are discussed in the relevant sections of this chapter.

The CEP regulates the implementation of capacity remuneration mechanisms (CRMs) by bringing national CRMs under a common EU-wide assessment of generation adequacy. Generation adequacy concerns need to be identified, against reliability standards, by regional resource adequacy assessments with the goal for investment decisions to be driven mainly by robust price signals in the electricity wholesale and ETS markets. The Netherlands currently does not have plans to introduce CRMs. The Netherlands has indicated that CRMs could be part of the solution if evidence of unacceptable risks to the security of electricity supply are identified.

New Energy Law

The Netherlands is in the process of developing a new Energy Law to modernise outdated electricity and natural gas regulations, support implementation of the Climate Agreement and the EU CEP, and prepare for future developments such as hydrogen. Public consultations on the new Energy Law were planned for Q2 2020, aiming for a proposal to parliament in Q1 2021, and the law entering into force by January 2022. The main changes planned for the electricity sector under the new law are:

- A revision of the legal duties of the electricity system operator, most importantly:

[2] A critical network element is any network element which is significantly impacted by cross-zonal electricity trade. Critical network elements include overhead lines, underground cables, transformers and other equipment and are not limited to infrastructure that physically cross bidding zone boundaries.

- a duty to procure flexibility instead of grid reinforcement when efficient
- a duty to manage and provide access to smart meter data
- elimination of the current ex ante price monitoring undertaken by the ACM in retail markets
- clear rights and responsibilities for aggregators, active consumers and energy communities
- financing of offshore grid investment through grid tariffs (currently the TSO pays the full cost of the offshore grid and is compensated with funding from the ODE levy).

- The government plans the following policies to address grid constraints:
  - adjust regulations to support more proactive investment by the TSO and DSOs
  - make room for experimentation to support innovative market and technical solutions
  - extend responsibility for congestion management to the DSOs
  - reduce N-1 redundancy requirements for network connections of new generators to allow for faster network expansion and more transmission and distribution capacity
  - adapt the SDE++ support scheme so that support for renewable electricity generation is limited to projects where there is enough transmission and/or distribution capacity available for the project to deliver renewable electricity to the grid while avoiding congestion
  - encourage municipal and provincial decision makers to consider electricity network transmission and distribution capacity in their planning processes.

The new Energy Law will also make changes so that the electricity market delivers clear price signals to all market participants and drives the development of an efficient and flexible system, including through demand-side response (DSR) and innovative energy services. Supporting measures in this area include:

- a new obligation for the DSOs to implement a second round of residential smart meter deployment from 2021 to 2023 (in 2018, around 54% of households had a smart meter)
- developing a framework for smart meter data access and management
- developing a regulatory framework allowing and incentivising the DSOs to procure flexible services from all market parties, including through distributed generation, DSR and energy storage
- developing a framework in national regulations to create a marketplace that supports transparent and efficient procurement of non-frequency ancillary services
- enabling contracting of multiple suppliers, aggregators or energy service companies at single grid connection points with capacity less than 3*80 Amps, which are mostly residential connections.

Outside of the implementation of the Energy Law, the government also plans to conduct a broad analysis of environmental fiscal policy in 2020. This analysis may include an examination of the double taxation for energy storage. Currently, energy storage is considered as both a consumer and a producer of energy and is taxed when taking and returning energy. This presents a notable barrier to developing economically viable business models for energy storage, notably battery storage.

International co-operation

The Netherlands supports more effective operation of its electricity system and markets through a variety of international and regional co-operation mechanisms, including the

Pentalateral Energy Forum (PLEF) with Austria, Belgium, France, Germany, Luxembourg and Switzerland. A key example of PLEF co-operation are the generation adequacy assessments carried out by the TSOs of PLEF countries in 2015 and 2018 (PLEF, 2018a). The Netherlands also co-operates on energy market and security issues through the Benelux Union with Belgium and Luxembourg (Benelux, 2018) and on offshore wind through the North Sea Region with Belgium, Denmark, France, Germany, Ireland, Luxembourg, Norway and Sweden (EC, 2016).

The Dutch regulator AMC co-operates with other European regulators through the Agency for the Cooperation of Energy Regulators (ACER) and the Council of European Energy Regulators (CEER), on the development of framework guidelines and network codes and the implementation of the internal electricity market. The Dutch TSO TenneT co-operates with other TSOs through a number of institutions. EU-wide co-operation is co-ordinated through ENTSO-E and covers a wide range of planning and operational co-operation, including ten-year development plans for grid infrastructure and assessments of EU-wide electricity security and many other areas.

Electricity system

The Netherlands has an extensive electricity grid that is interconnected with Belgium, Denmark, Germany, Norway and the United Kingdom. TenneT TSO B.V. is the TSO responsible for the construction, maintenance and operation of the high-voltage network (110-380 kV) that delivers electricity to large consumers and DSOs. TenneT co-ordinates with the TSOs of the countries linked to the Netherlands to construct, operate and maintain cross-border interconnectors. TenneT TSO B.V. is also responsible for the construction, maintenance and operation of the offshore electricity transmission system that links Dutch offshore wind generation to the onshore grid. There are seven DSOs, which construct, operate and maintain the medium- and low-voltage grid (below 110 kV) to deliver electricity to most consumers. Around 90% of electricity demand comes from consumers connected to the grid at voltages below 110 kV. The TSO and DSOs are unbundled and cannot own companies generating or selling electricity.

The onshore electricity transmission and distribution system is financed through regulated grid tariffs. The offshore transmission system is currently financed directly by TenneT, with these costs covered by funding from the ODE levy. Under the new Energy Law, it is planned to transition financing for the offshore grid to regulated tariffs. The allowed revenues for TenneT (both as the TSO and offshore grid operator) and the DSOs are regulated by the ACM through benchmarking against the TSOs and the DSOs in neighbouring countries. The ACM and the Ministry of Finance also regulate infrastructure investments by the TSO and the DSOs. Table 7.2 gives the historic annual revenues and estimated future infrastructure investments for TenneT and the seven DSOs.

Table 7.2 Transmission and distribution system operators' yearly revenue and estimated future investments

	Historical annual revenue (EUR million per year)	Estimated investments 2019-28 (EUR million)
Distribution system operators (combined)	2 500-3 000	14 000 (through 2030)
TenneT (onshore grid)	500-600	7 000
TenneT (offshore grid)	Around 100	6 000

Source: MEACP (2019c), *Electricity Markets*.

Transmission system

In 2019, the Dutch transmission system had a total of over 22 500 km of lines operated at 110 kV, 150 kV, 220 kV and 380 kV; more than 450 substations; 9 cross-boarder interconnectors; and a rapidly expanding offshore grid (Figure 7.5). The majority of generation capacity in the Netherlands is connected to the transmission system, while a growing capacity of small-scale PV is connected at the distribution level. Many large industrial consumers are connected directly to the transmission system, while the majority of electricity consumers are supplied through the distribution system.

Since the last in-depth review in 2014, the Netherlands has continued to upgrade and expand the electricity system. In October 2019, TenneT completed the construction of the Randstad Ring, one of the largest onshore projects ever undertaken by TenneT. The Ring links the Randstad region (the four main cities of Amsterdam, Rotterdam, Utrecht and The Hague, and the surrounding area), which is home to the majority of the Dutch population and is one of the most densely populated regions in Europe. The ring also provides transmission capacity for offshore wind generation (TenneT, 2020).

In 2018, TenneT commissioned a new interconnector between the Netherlands and Germany. In 2019, TenneT and Enegrinet (the Danish TSO) started operation of a new high-voltage direct current (HVDC) subsea interconnector. With these projects completed, TenneT operates nine cross-border electrical interconnectors in co-operation with the TSOs of the interconnected countries. Six of these interconnectors are two-circuit 380kV AC overhead lines, four to Germany and two to Belgium. Three of the interconnectors are HVDC subsea cables (Table 7.3). In 2019, total interconnection capacity was 7.05 GW (TenneT, 2019a; ENTSO-E, 2020a).

Table 7.3 The Netherlands' HVDC subsea electrical interconnectors, 2019

Name	Links to	Rating	Capacity	Length	Commissioned
NorNed	Norway	±450 kV	0.7 GW	580 km	2008
BritNed	United Kingdom	±320 kV	0.7 GW	260 Km	2011
COBRA	Denmark	±450 kV	1.0 GW	325 km	2019

Source: ENTSO-E (2020a), *ENTSO-E Transmission System Map*, www.entsoe.eu/data/map.

As a result of expanding renewable generation capacity, especially from offshore wind, the Netherlands expects to be become a net exporter of electricity in the early 2020s, with increasing net exports through 2030. In line with this and the likelihood of increased electricity trade across Europe, TenneT is examining options to expand both internal transmission and interconnector capacity. Long-term projects are under consideration for new 380 kV lines between Maasvlakte and Noord-Brabant and between the northern and western part of the Netherlands. Additional overhead line interconnection capacity to Belgium and Germany is being studied and there is a project under consideration for a second interconnector to the United Kingdom with 1-2 GW of capacity that will also examine the potential for interconnection through offshore wind infrastructure (ENTSO-E, 2019a). The Dutch National Energy and Climate Plan (NECP) indicates that cross-border interconnector capacity is expected to grow from 7.05 GW in 2019 to 10.8 GW in 2025 (MEACP, 2019a).

TenneT also operates the offshore transmission system, which has been rapidly expanding. From 2008 to 2017, the Netherlands had only two large-scale offshore wind farms with a total capacity of 0.2 GW. In 2017, the 0.6 GW Gemini offshore farm became operational. As of March 2020, Gemini is the third-largest offshore wind farm in the world (Gemini Wind Park, 2020). In 2018, TenneT started installing two 0.7 GW offshore substations for the 1.4 GW Borssele offshore wind farm. One of these stations was completed in 2019 and the second will be commissioned in 2020 (TenneT, 2019a). TenneT plans to expand the offshore transmission system to support 3.5 GW of offshore wind capacity by 2023 and 11.5 GW by 2030. Between 2027 and 2030, TenneT is aiming to connect 4 GW of offshore wind using high-voltage direct current cables to increase the efficiency of delivering wind generation to the onshore grid (TenneT, 2019b).

TenneT is also part of the North Sea Wind Power Hub consortium, which includes Gasunie (the Dutch gas TSO), TenneT GmbH (one of the German TSOs), the Port of Rotterdam and Energinet (the Danish TSO). The consortium is developing and evaluating technical concepts for a modular hub-and-spoke approach to facilitate large-scale offshore wind deployment. This approach aims to combine offshore wind connection and cross-border interconnection functionality, connect offshore wind farms from one country to demand centres in another, and convert electricity into gas, including low-carbon hydrogen, as an alternative means of transporting the energy from wind generation. The optimal hub-and-spoke project size is foreseen to have around 10-15 GW of offshore wind capacity and a first project could be operational in the early 2030s (NSWPH, 2020).

Figure 7.5 Electricity transmission infrastructure, 2019

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: TenneT (2019c), *Gridmap Netherlands*, www.tennet.eu/company/news-and-press/press-room/grid-maps.

Distribution system

The seven DSOs in the Netherlands are Coteq, Enduris, Enexis, Liander, Rendo, Stedin and Westland Infra, all of which operate both electricity and gas networks. Figure 7.6

gives the coverage of the medium- and low-voltage networks operated by the DSOs. The distribution networks supply electricity to most consumers in the Netherlands. However, under the Climate Agreement, it is foreseen that the electricity distribution networks will support many new activities, including supplying a growing demand from EVs and electric heating, and supporting distributed generation and DSR.

Due to a successful support scheme for small-scale PV, the Dutch distribution system was connected to over 1.4 GW of PV generation in 2018. The Climate Agreement target for 7 TWh of additional PV generation from systems with capacities of less than 15 kW should drive continuing expansion of PV capacity at the distribution level.

To support DSR, better integration of distributed generation and other flexibility measures, the Netherlands aims for 80% of households to have a smart meter by 2020. The DSOs are responsible for smart meter deployment and own the meters and associated data. A first round of smart meter deployment started in 2015 and, by 2018, around 5.2 million smart meters had been deployed, covering 54% of Dutch households. All customers with a smart meter are given a detailed monthly consumption and cost overview by their energy supplier and 25% of all households have access to an app that registers real-time electricity load (RVO, 2019).

The new Energy Law under development includes several measures supporting DSR, distributed generation and other new services that will impact the electricity distribution system. The envisioned measures include the DSOs implementing a second round of smart meter deployment from 2021 to 2023 and the development of a framework for smart meter data access and management.

The Netherlands is a world leader in EV deployment and charging infrastructure. In 2019, EVs accounted for 15% of annual passenger car sales, with the monthly share of EVs in new car sales reaching 54% in December 2019 (Inside EVs, 2020), as an attractive fiscal package ended that month. Achievement of the Climate Agreement target for 100% of new passenger vehicles sales to be zero-emission by 2030 will increase electricity demand and could have impacts on the operation of the electricity grid, especially at the distribution level. Smart charging that controls the timing and level of charging is a key measure that can help to mitigate the impacts of EV charging on the grid. The Netherlands is working to ensure that smart charging becomes the standard for all EVs.

Figure 7.6 Electricity distribution system operator networks, 2019

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: Netbeheernederland (2019), *DSO Map*, www.netbeheernederland.nl/_contentediting/files/files/EN_Elektriciteit-2019-Legenda.pdf.

The Dutch EV fleet is supported by robust EV charging infrastructure. In 2019, there were over 50 000 EV semi-public charging points in the Netherlands, one of the highest concentrations of charging stations globally (EAFO, 2020). In January 2020, the Metropolitan Region of Amsterdam awarded a contract for the installation of 20 000 EV charging stations (Total, 2020). The Netherlands is also a leader in the deployment of smart charging infrastructure. TenneT and several DSOs co-operate with ElaadNL, the Dutch knowledge and innovation centre for smart charging infrastructure, to determine how smart charging can limit the impact of EVs on the grid (ElaadNL, 2020).

Pilot projects in the Netherlands are demonstrating how EVs can be used as DSR assets supporting flexible operation of the electricity system. In May 2019, Amsterdam, Vattenfall and the DSO Liander announced that 462 EV charging stations in the city will be converted to a smart charging network linked to local residential PV generation with the aim to reduce the need for additional grid investment (Vattenfall, 2019). In September 2019, the Ministry of Infrastructure and Water Management announced a EUR 5 million grant to install 472 vehicle-to-grid (V2G) chargers in 21 municipalities. V2G infrastructure allows EV batteries to help balance loads on the grid network (see Chapter 4 for EV policy).

Wholesale market

The Netherlands is part of a wholesale electricity market that links over 20 European countries. This market has been consistently expanded and more tightly integrated as part of the ongoing project to create a single European internal electricity market. The wholesale market manages day-ahead and intraday electricity trading between interconnected European bidding zones. Most bidding zones are correlated with national borders and the Netherlands is a single bidding zone (ENTSO-E, 2020b).

Buyers and sellers of electricity (market parties) trade through wholesale market exchanges operated by nominated electricity market operators (NEMOs). NEMOs are responsible for accepting buy and sell bids from market parties, matching bids according to the results of the algorithms that run the markets, publishing the realised wholesale prices for each bidding zone and clearing the contracts resulting from trading. NEMOs can choose which bidding zones to operate in and compete with each other for bids from market parties. As of March 2020, Epex Spot and Nord Pool are the NEMOs active in the Netherlands for both the day-ahead and intraday markets (Next Kraftwerk, 2020).

NEMOs are also responsible for developing and maintaining the algorithms, systems and procedures supporting the day-ahead and intraday markets. The TSOs co-operate in the development of these algorithms. Approval is required from national regulators for any new market products used in the algorithms. The algorithm EUPHEMIA operates the day-ahead market and is designed to maximise economic efficiency. Under single day-ahead market coupling (SDAC), NEMOs and the TSOs work to expand and better integrate the market for day-head electricity trading. As of March 2020, 95% of EU electricity consumption was coupled through the day-ahead market (ENTSO-E, 2020b).

Following the decision of ACER of 17 November 2016, the European electricity transmission grid was divided into capacity calculation regions (CCRs). CCRs are regional groupings of bidding zones that use a common capacity calculation methodology for their day-ahead and intraday electricity markets, with the aim to improve market operations. As of the 2019 ACER decision on CCRs configurations, there are 11 CCRs. Because of its central location in Europe and numerous cross-boarder interconnections, the Netherlands is part of three CCRs Core, Channel and Hansa[3] (ACER, 2019).

The day-ahead market is in the process of transitioning to flow-based market coupling, which is intended to replace net transfer capacity coupling and aims to improve the operation of the day-ahead market (ENTSO-E, 2020b). Since 2015, flow-based market coupling is used within the Central Western European (CWE) region, consisting of the bidding zones of the Netherlands, Germany-Luxembourg, Belgium, France and Austria. Net transfer capacity is still used for trading between the CWE and the bordering bidding zones. The Core flow-based market coupling project aims to extend flow-based market coupling to include the biddings zones of Croatia, the Czech Republic, Hungary, Poland, Romania, the Slovak Republic and Slovenia. Initial testing to realise this broader use of flow-based market coupling began in March 2020 and full operation is planned to start in Q2 or Q3 of 2021 (ENTSO-E, 2020c).

NEMOs and the TSOs also co-operate on European single intraday coupling to support continuous and more efficient intraday electricity trading between all bidding zones (ENTSO-E, 2020d). The XBID intraday trading platform was launched in June 2018 with coverage of Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Latvia, Lithuania, Norway, the Netherlands, Portugal, Spain and Sweden. XBID allows for continuous matching of bids across all linked bidding zones as long as transmission capacity is available. In November 2019, XBID coverage was expanded to link intraday trading between 17 EU member states. An expansion of XBID to include Greece and Italy is planned for Q4 2020 (ENTSO-E, 2020e).

European-wide intraday coupling is a key component for completing the European internal electricity market. The continuous intraday trading supported by XBID increases optimisation of generation, especially from variable wind and PV, and enables demand response products to develop. TenneT's 2018 Annual Market Update noted increased renewable generation was likely a key factor for the 63% increase in intraday trading seen in the Netherlands from 2016 to 2017, while increased renewable generation and the launch of XBID likely contributed to the 49% increase in Dutch intraday trading from 2017 to 2018 (TenneT, 2019a).

Efficient day-ahead and intraday markets are highly effective at maximising the economic outcomes of electricity trading. However, given the zonal bidding design of markets in Europe, they do not completely account for the physical reality of electricity flows within the grid and the impacts of changing levels of demand and supply. Changing levels of supply are increasingly relevant because of increasing wind and PV generation. Balancing markets operated by the TSOs are used to address any imbalances resulting from a mismatch in supply and demand or grid congestions (lack of transmission capacity). In the future there will be pan-European balancing platforms.

TenneT runs the balancing market in the Netherlands as part of its real time management of the grid and uses a system of balancing responsibility to keep the supply

[3] The Core capacity calculation region connects the wholesale bidding zones of Austria, Belgium, Croatia, the Czech Republic, France, Germany-Luxembourg, Hungary, the Netherlands, Poland, Romania, the Slovak Republic and Slovenia. The Channel capacity calculation region links the bidding zone of France, the Netherlands and the United Kingdom through existing subsea cables. With the 2019 deployment of the COBRA subsea cable, the Netherlands became part of the Hensa capacity calculation region, which connects the bidding zones of Denmark, Germany-Luxembourg, the Netherlands, Poland and Sweden.

and demand of electricity in check. Market parties are responsible for informing grid operators of their planned electricity generation and consumption needs. The DSOs inform TenneT on the actual levels of generation and consumption. Redispatch is a common balancing market product used to address imbalances between planned and actual demand and supply.[4]

A market-based redispatch system is used in the Netherlands, in which market participants provide bids for upward or downward redispatch that can be activated by TenneT. Another balancing market product in the Netherlands is restriction contracts. These concern tailor-made contracts with generators who voluntarily agree to not generate above or below a certain limit for a specific period, in turn for a negotiated compensation.

TenneT's annual redispatch costs have grown from EUR 15 million in 2015 to EUR 50 million in 2018. To help reduce these costs, TenneT and the DSOs Stedin, Liander and Enexis launched the GOPACS (grid operator platform for congestion solutions) in 2019. GOPACS aims to reduce grid congestion, increase grid reliability and lower grid operating costs. When congestion is expected on the grid, the GOPACS platform sends out a request for reduced generation or increased consumption in the affected area. To maintain the national supply-demand balance, GOPACS simultaneously issues requests for a market party outside of the congestion area to increase generation or reduce consumption.

Based on the requests sent by GOPACS markets, parties place bids through an intraday market platform. GOPACS performs a check on the bids to ensure that they do not cause problems in other places in the grid. If no issues are detected, the network operators pay the price difference between two matching bids and the congestion situation is resolved. GOPACS is currently using the ETPA intraday market platform. There are discussions to connect additional market platforms and the DSOs Enduris, Coteq and Rendo are investigating participation in GOPACS (GOPACS, 2020).

Wholesale market bidding zone review

Under the CEP, the TSOs of the countries participating in the European market submitted plans for revised bidding zone configurations in October 2019 as part of a broad review of bidding zone configurations. The purpose of this review is to investigate whether alternative bidding zone configurations increase economic efficiency and cross-border trade opportunities, while maintaining the security of the electricity grid.

Regulation (EU) 2019/943 on the internal market for electricity prescribes that bidding zone borders should be based on structural congestions in the transmission grid. The final configurations of the alternate bidding zones resulting from the review will be decided by the national regulators (or by ACER if regulators cannot reach agreement) by 2021. Based on this configuration, the TSOs will make a joint recommendation to the governments of the countries participating in the review. Governments will then have six months to decide whether to maintain or amend the current bidding zone configuration (TenneT, 2019b).

[4] With redispatch, TSOs such as TenneT request generators or consumers in congested area to decrease feed-in (generation) or increase offtake (consumption) of electricity to alleviate the projected congestion (downward redispatch). In order to maintain the balance of demand and supply, generators or consumers outside of the congested area are requested to increase feed-in or decrease offtake (upward redispatch).

TenneT has identified an alternative bidding zone configuration that would split the single Dutch bidding zone into three bidding zones (Figure 7.7). A major reason for this configuration is that the Dutch transmission grid often has large electricity flows from the north to the south. Even though TenneT is investing an increase in transmission capacity, planned upgrades could be insufficient to ensure compliance with the 2025 requirements that a minimum of 70% of the capacity of critical network elements must support cross-border trade (especially given the plans for large increases in renewable generation and the transition to becoming a net exporter). TenneT intends to use the bidding zone review to determine if alternative configurations support the achievement of this target, while also improving market efficiency, security of supply and achievement of the Climate Agreement targets (TenneT, 2019b).

Figure 7.7 TenneT alternative bidding zones proposal

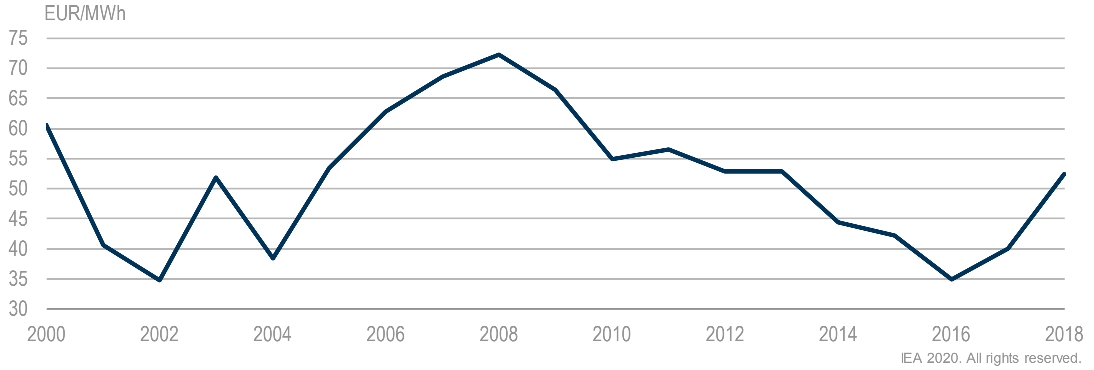
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: TenneT (2019b), *TSOs Propose Methodology, Assumptions and Alternative Configurations for the Upcoming European Bidding Zone Review*, www.tennet.eu/news/detail/tsos-propose-methodology-assumptions-and-alternative-configurations-for-the-upcoming-european-biddi.

Wholesale market prices

Day-ahead wholesale market electricity prices in the Netherlands' bidding zone are down from historic highs exceeding 70 EUR/MWh in 2008, but have been increasing since 2016 (Figure 7.8). Average annual day-ahead prices in the Netherlands increased 33%, from 39.3 EUR/MWh to 52.5 EUR/MWh from 2017 to 2018. Over the same period, the CWE region average price only increased by 24%, from 40.8 EUR/MWh to 50.7 EUR/MWh. There has also been notable price volatility in the day-ahead market. In 2017, day-ahead price varied from around EUR 25 to over EUR 60 per MWh. In 2018, prices and volatility increased with a range from around EUR 30 to almost EUR 80 per MWh (TenneT, 2019a; PBL, 2019).

Figure 7.8 Day-ahead wholesale electricity prices in the Netherlands, 2000-18



Wholesale electricity prices are down from historic highs, but have been increasing rapidly since 2016, driven by higher costs for natural gas, coal and higher ETS carbon prices.

Note: Data for 2000-18 are based on annual averages in the day-ahead wholesale electricity market.

Source: PBL (2019), *Climate and Energy Outlook 2019*, www.pbl.nl/sites/default/files/downloads/pbl-2019-klimaat-en-energieverkenning-2019-3508.pdf.

Key factors for higher wholesale prices in the Netherlands from 2016 to 2018 were increasing fuel cost for gas and coal, which are the dominate fuels for electricity, and higher carbon prices under the EU ETS. Natural gas prices in the Netherlands increased 22% from 2016 to 2017 and 30% from 2017 to 2018 to reach EUR 22.3 per MWh. Gas prices were high in the spring of 2018 because of sustained cold weather and low gas stocks. Gas prices remained high during the remainder of 2018 because of required injections to increase stocks levels. Hard coal prices increased by 41% from 2016 to 2017 and 5% from 2017 to 2018, reaching EUR 11.2 per MWh. In September 2018, prices of EU ETS emission allowances reached a 10-year record high of EUR 25.2 per tonne CO_2. The main reason for this price increase was the ETS Market Stability Reserve, which came into force in January 2019 and led to cuts in the number of EU ETS emission allowances (TenneT, 2019a).

Retail market

The Netherlands has an open and competitive retail electricity market and scores well on many metrics for market competitiveness. However, there is still a high concentration of market share among energy suppliers and there are still barriers to the development of the innovative energy services needed to support the Climate Agreement goals of active consumers and energy communities.

The Netherlands is among the countries with the highest retail switching rates in Europe. The number of retail customers that switched suppliers increased from around 700 000 (12.6% of customers) in 2012 to 1.6 million (20% of customers) in 2019. An ACM survey shows good awareness among Dutch retail customers on the benefit of switching suppliers. Of the consumers consulted in the survey, 78% noted that a lower price was their main reason for switching suppliers, while 17% noted they switched because they wanted renewable energy. The survey also noted that 87% were satisfied with the process of switching suppliers and 28% expected to switch again within the next three years (ACM, 2019).

The number of electricity suppliers active on the retail market steadily increased from just 9 in 2004 to 59 in 2018; in 2019, the number dropped slightly to 57. However, the three largest energy suppliers – Essent (RWE), Vattenfall (Nuon) and Eneco – accounted for over 70% of retail electricity sales in 2018. This is an improvement from 2012, when the three largest suppliers held 83% of the retail market. In 2012, the Netherlands had an HHI[5] just above 2 300. Since 2016, the Dutch HHI has been below 2 000. In 2018, the Netherlands was one of only seven countries with an HHI of less than 2 000 out of the 21 European countries surveyed in the Council of European Energy Regulators' annual report (CEER, 2019).

The CEP includes provisions for active consumers and the DSOs as neutral market facilitators. Under EU rules, consumers have the right to generate, store, consume and sell self-produced electricity to organised markets, either individually or through aggregators. Supporting consumers in realising these rights requires a significant reform of distribution tariffs and the creation of a regulatory regime for energy storage and new market rules for distributed generation, storage, smart metering and DSR. The CEP also aims to facilitate increased use of demand response and distributed renewable generation by expanding the role of close to real-time price signals and clarifying the roles and improving the incentives for aggregators.

To support the development of active consumers, the Netherlands is pushing for broad adoption of smart meters. In line with this effort, the Netherlands allows consumers to purchase dynamic time-of-use pricing contracts, which are enabled by smart meters. These contracts allow consumers to act as market parties that can utilise flexible capacity (both DSR and distributed generation) to reduce their electricity cost and contribute to system security.

As of March 2020, very few retail electricity consumers had contracts with dynamic time-of-use pricing enabled by smart meters The are several reasons for this: many consumers are not yet equipped with a smart meter required for market participation and even those with a smart meter do not have the additional systems that can automate DSR and flexible use of distributed generation. In addition, many consumers may not be interested in dealing with the complexities of active market participation;

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[5] The Herfindahl-Hirschman Index (HHI) is another common indicator of retail market competition. The HHI ranges between 0 for an infinite number of small firms (maximum competition) and 10 000 for one firm with 100% market share (no competition). Based on EU guidance, an HHI above 2 000 signifies a highly concentrated market with a small number of firms.

reaching these customers will likely require energy services that provide clear benefits with minimal impact.

Current regulations for aggregators and a lack of clear frameworks for the use of smart meter data and the provision of distributed flexibility services greatly limit the business case for companies to develop innovative energy services that would appeal to a broad range of consumers. However, despite these barriers, some pilot projects offering distributed flexibility services to support electricity grid operations are being undertaken.

TenneT has been conducting pilot projects examining how distributed resources including renewable generation, energy storage and a variety of DSR resources support grid operations, including through participation in the ancillary service markets. In 2017, TenneT conducted a pilot project showing that distributed resources including batteries, heat pumps, residential water boilers and EVs could be aggregated to supply frequency control services to the grid through the Frequency Containment Reserves market (TenneT, 2018a). The Netherlands is also developing a retail market for the energy consumption management services enabled by smart meters (EVM market). Milieu Centraal (an energy and environment foundation established by the government), in co-operation with Energie Nederland (the association of Dutch energy suppliers) and the Dutch DSOs, runs a website[6] offering consumers that have a smart meter information on contracting energy consumption management services (Milieu Centraal, 2020). In 2018, ten companies offered energy consumption management services through the website and 20% of the 5.2 million households with a smart meter had installed some form of energy consumption management system (app, website, smart thermostat or in-home display) to manage their electricity consumption. Market parties in the energy sector have agreed that all consumers with a smart meter should be served by the EVM market. In 2018, only 4% of consumers were receiving services from an energy consumption manager, the same share as in 2017. A 2018 study by the Netherlands Enterprise Agency (RVO) indicates that the lack of growth of the EVM market results from a failure to communicate options for energy consumption management when a smart meter is deployed and low awareness of energy services among consumers (RVO, 2019).

Retail market taxes and prices

The Netherlands has a broad energy tax that covers consumption of electricity, natural gas and districting heating. Consumers also pay a Surcharge for Sustainable Energy Act levy (ODE), which funds the SDE+ and SDE++ support schemes, and covers the cost of the offshore electricity grid. The rate of the energy tax and ODE depend on the level of consumption, with much lower rates for large consumers (Table 7.4). Household self-consumption of electricity is exempt from the energy tax and the ODE levy. Energy products and fuels used to generate electricity are exempt from the energy tax (except coal).

[6] www.energieverbruiksmanagers.nl.

Table 7.4 Energy tax and ODE rates for electricity, 2019 and 2020

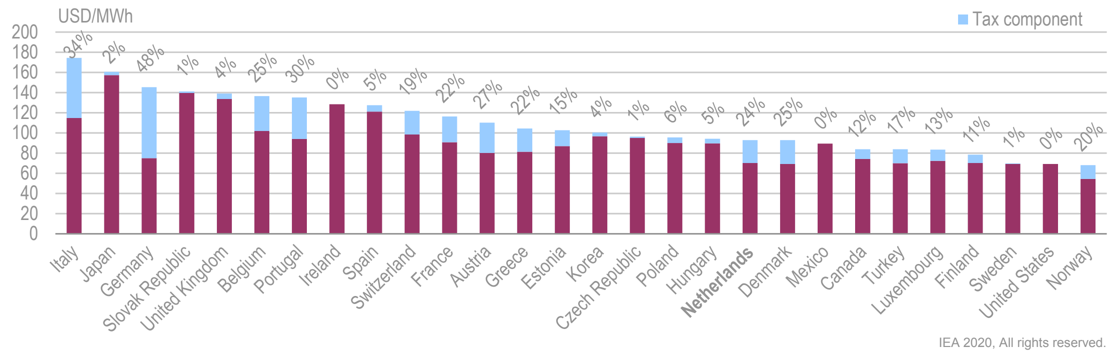
Consumption Bracket	2019			2020		
	Rate (EUR/MWh)					
	Energy tax	ODE	Total	Energy tax	ODE	Total
0-10 MWh	9.863	1.89	11.753	9.77	2.73	12.498
10-50 MWh	5.337	2.78	8.117	5.083	3.75	8.828
50 MWh to 10 GWh	1.421	0.74	2.161	1.353	2.05	3.406
More than 10 GWh	0.058	0.03	0.086	0.055	0.04	0.095

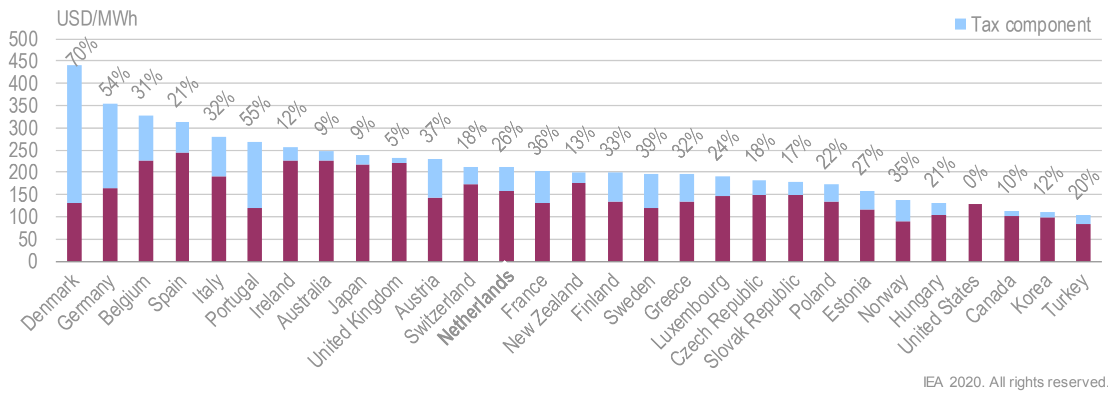
Source: Government of the Netherlands (2020), Environmental Tax Rates Tables 2020, www.belastingdienst.nl/wps/wcm/connect/bldcontentnl/belastingdienst/zakelijk/overige_belastingen/belastingen_op_milieugrondslag/tarieven_milieubelastingen/tabellen_tarieven_milieubelastingen.

Up to 2020, households provided half of ODE funding with the other half coming from businesses. In 2020, the ODE will be adjusted so that two-thirds of funding comes from business and one-third from households. To support renewable heating, the government will increase the taxation of natural gas by up to 43% by 2026 (compared to 2019 levels) and lower taxation on electricity.

Retail electricity prices are not regulated. However, suppliers must submit all prices to the ACM for review and the ACM has the power to oblige suppliers to lower them. In 2017, the Netherlands imposed for the first time retroactive maximum tariffs for two electricity products of one supplier. It is intended that this *ex ante* price monitoring will be ended under the new Energy Law in 2021. In 2018, the electricity price for Dutch industry was USD 93 per MWh, slightly lower than the IEA median of USD 102 per MWh (Figure 7.9). This was despite a relatively high tax component of 24% of the total price, the seventh-highest tax rate among IEA member countries. Dutch households paid USD 210 per MWh for electricity, close to the IEA median value of USD 200 per MWh. Tax accounted for 26% of the total, which was slightly higher than the median tax rate of IEA member countries (22%).

Figure 7.9 Electricity prices in IEA member countries, 2018





Both industry and household electricity prices in the Netherlands were around the IEA median level, with slightly higher tax components than IEA average tax rates.

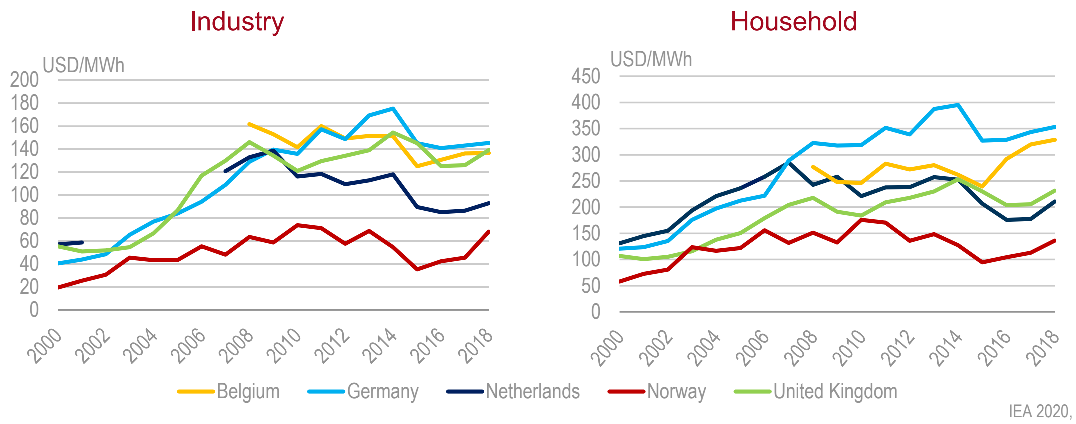
* No tax information available for the United States.

Note: Industry electricity prices in 2018 are not available for Australia and New Zealand

Source: IEA (2020c), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

Dutch retail electricity prices for industry and households declined notably from 2009 to 2016, when prices started to increase, especially for households (Figure 7.10). Among electricity trading partners, the Netherlands has maintained the second-lowest retail price for industry since 2010, while household prices have been the second lowest since 2014.

Figure 7.10 Electricity prices in the Netherlands and its trading partners, 2000-18



Industry and household electricity prices in the Netherlands have declined since 2010. Despite recent increases, they are still the second lowest among trading partners.

Note: Industry data is unavailable for the Netherlands (2002-06), Belgium (2001-07), and household data for Belgium (2001-07)

Source: IEA (2020c), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

Security of supply

The Netherlands maintains a secure electricity supply both in terms of generation[7] and interconnector capacity.[8] Peak electricity demand reached a high of 19.1 GW in 2010 and declined slightly to 18.6 GW in 2017. In 2018, total generation capacity was 32.4 GW, well above peak demand, and included over 25 GW of dispatchable generation. Generation capacity is complemented by robust electricity import capacity. With the completion of the COBRA HVDC cable in 2019, total interconnector capacity reached 7.05 GW.

However, from 2016 to 2018, performance in some key metrics declined, with slightly less onshore grid availability and an increase in interruptions and electricity not transported (Table 7.5). The reasons for this included a notable outage in August 2018 near Tilburg, where at least 100 000 households and hundreds of companies had no electricity for 22 minutes to one hour. Another interruption occurred in April 2018, near Amsterdam. Although the outage was resolved within a couple of hours, impacts lasted through the next day because of knock-on effects at Schiphol airport (TenneT, 2019c).

The CEP provides a clear framework for security of supply by emphasising a regional rather than a national approach. Co-ordinated and harmonised regional adequacy assessments, as mandated by the CEP, are crucial to take consistent decisions. The CEP also calls for the creation of regional co-ordination centres by July 2022. Based on

[7] The Netherlands does not have a set standard for generation adequacy. However, TenneT's yearly Adequacy Assessment uses the Ministry of Economic Affairs and Climate Policy's accredited four hours loss load expectation as the criterion for security of supply. Medium- and low-voltage grids are not considered in this criterion, while demand/supply adequacy is treated as a copper plate between bidding zone and there are no limitations regarding fuel availability.

[8] The Netherlands has already exceeded the EU targets requiring interconnector capacity that allows at least 10% of domestic electricity generation to be transported to neighbouring countries by 2020 and 15% by 2030. In 2019, Dutch interconnector capacity was 20.2%. The NECP indicates interconnection capacity will be 18.3% in 2030.

Regulation EU 2019/941 on risk preparedness in the electricity sector, a methodology will be developed to carry out seasonal as well as short-term adequacy assessments, namely monthly, week-ahead and at least day-ahead. Using that methodology, ENTSO-E will carry out the seasonal adequacy assessments (winter and summer) and regional co-ordination centres will carry out the week-ahead to at least day-ahead adequacy assessments.

The Netherlands is co-operating with Austria, Belgium, France, Germany, Luxembourg and Switzerland through the Pentalateral Energy Forum to develop a regional approach to security of supply in line with the requirements of the CEP. The electricity and gas TSOs in these countries are supporting this effort. The aim is to develop regional scenarios and mitigation measures by early 2021 and an analysis of co-operation and assistance later in 2021. This effort could also feed into the regional co-ordination being incorporated into the national risk preparedness plans of the participating countries by 2022.

Table 7.5 Key security of supply metrics, 2013-18

Metric	Units	Network level	2013	2014	2015	2016	2017	2018
SAIFI*	Events per year	220/380 kV	0	0	0.124	0	0	0
		110/150 kV	0.011	0.011	0.055	0.013	0.072	0.091
SAIDI**	Minutes per year	220/380 kV	0	0	12.2	0	0	0
		110/150 kV	0.28	0.5	0.8	0.08	7.44	6.26
Grid availability***	Per cent (%)	Onshore	99.9999%	99.9999%	99.9975%	99.9999%	99.9986%	99.9988%
		Offshore	****	****	****	92.0%	97.8%	94.5%
Failures	Number	220/380 kV	34	19	13	51	29	17
		110/150 kV	54	66	52	70	46	48
Outages		220/380 kV	2	0	2	0	0	1
		110/150 kV	7	4	14	6	11	16
Electricity not supplied	Per cent (%)	220/380 kV	0.0291%	0%	0.3516%	0%	0%	0%
		110/150 kV	0.0077%	0.0076%	0.0139%	0.0056%	0.1015%	0.1107%
Electricity not transported	MWh	220/380 kV	303	0	3 669	0	0	0
		110/150 kV	80	77	145	59	1 072	1 184

* System Average Interruption Frequency Index.

** System Average Interruption Duration Index.

*** Availability for the TenneT grid in the Netherlands and Germany.

**** Measurements of offshore grid availability started in 2016.

Sources: TenneT (2019d), *Our Performance in 2018*; TenneT (2015), *Integrated Annual Report 2015*.

In 2018, TenneT invested EUR 2.3 billion in expanding and maintaining the Dutch transmission grid to support a secure supply of electricity. In September 2018, TenneT signed an agreement for a black-start facility at the Enecogen gas power plant in the Port of Rotterdam. In the event of a black out, this facility can be used to restore operation of the high-voltage grid. With this agreement TenneT has three black-start facilities available in the Netherlands to support a stable and reliable electricity supply.

There have been some project delays impacting the expansion of network capacity. For example, in October 2018, the Wintrack II contract was terminated by TenneT because of conflicts with the contractor. This led to delays in the construction of new high-voltage pylons running on two tracks: Eemshaven-Vierverlaten and Borssele-Rilland (TenneT, 2018b).

Looking to 2030, a number of trends could create challenges in maintaining security of electricity supply. Under the Climate Agreement, variable renewable energy (VRE) generation will increase from 12% in 2018 to close to 70% by 2030. VRE capacity is expected to reach around 30 GW in 2030, while peak demand is expected to stay at around 18-19 GW. At the same time, natural gas generation will decline, coal-fired generation will stop by 2030 and the Borssele nuclear plant will be shut down in 2033. The Netherlands is also expected to transition from being a net importer to a net exporter of electricity.

The CEP aims to improve the integration of electricity from VRE. This includes a goal to make system-friendly deployment of renewables the norm by phasing out priority dispatch for renewables and mandating technology-neutral balancing requirements for large-scale renewable projects. New wind and large-scale PV projects are also to include monitoring and communication systems that give grid operators close to real-time information. Many of the market and regulatory changes called for under the CEP (better market integration, higher availability of interconnectors, better bidding zone configurations, smart meters, time of use pricing, DSR, energy storage, aggregator) will also assist with secure VRE integration, especially at the distribution level.

The Netherlands is taking steps to address these challenges, with plans to expand transmission, distribution and interconnector capacity. TenneT is considering several large projects to boost transmission capacity, especially in relation to delivering high levels of VRE generation to Dutch consumers and the European market. The NECP indicated that interconnection capacity will reach 10.8 GW in 2030. At the same time, numerous efforts are underway to develop regulations and markets that allow for more flexible operation of the electricity grid to limit the need for large-scale network investments. Regional energy strategies are now required to help local and regional governments develop clear plans in collaboration with DSOs, other regional stakeholders and local inhabitants for maintaining security of supply and are especially relevant given the high levels of PV generation and new demand sources expected to be connected at the distribution level.

A 2018 report prepared for the Ministry of Economic Affairs and Climate Policy analysed security of supply of the electricity system through 2030. The analysis included a reference case based on a level of VRE deployment in line with the Climate Agreement. Emphasis was placed on the impact of the coal-fired generation ban, but the study also looked broadly at the performance of the system, including an examination of security of supply in terms of: the adequacy reserve margin; the utilisation of import capacity in peak demand hours; and the contribution of imports to residual load in peak demand hours (Frontier Economics, 2018).

The report concluded that even with the coal ban, the Netherlands maintains a strong security of supply. In 2030, the adequacy reserve margin remained positive, the utilisation of interconnectors increased by one-third in peak demand hours and the import contribution in peak demand hours grew from 29% (reference case) to 44% (with the coal ban). The report foresees that due to increased renewable energy generation, the Netherlands will become a net exporter of electricity around 2023, with increasing net exports through 2030. This is still the case with the coal ban; however, with lower exports. Reference case net exports would be 39 TWh in 2030 while with the coal ban they would be 22 TWh.

VRE generation is expected to grow across Europe. At the same time, many countries are planning to reduce dispatchable generation capacity. Notably, Germany – the Netherlands' largest electricity trading partner – is rapidly expanding VRE generation while phasing out nuclear and coal. The Netherlands is at the heart of the European electricity system, with interconnections to numerous bidding zones and capacity calculation regions. As such, Dutch security of supply will be affected by regional and European-wide issues.

The Netherlands is at the forefront of international co-operation on energy security and works through regional and European-wide organisations to support regional analysis of security and supply. In June 2017, the Ministers for Energy of the PLEF countries signed a memorandum of understanding committing to implement key measures to improve regional co-operation on electricity emergency response (PLEF, 2018b). In line with this memorandum, the Netherlands participated in a PLEF electricity crisis exercise in June 2018, which simulated a Europe-wide security of supply problem. The exercise showed a need for co-ordination mechanisms for government decisions and communication, and transparency in the preparation phase and during a crisis (Benelux, 2018).

In December 2015, European TSOs and ENTSO-E signed a multilateral agreement on participation in regional security co-ordinators (RSCs), which help the TSOs to co-operate on security issues. The agreement requires ENTSO-E members to participate in RSCs or to contract five essential services from RSCs. The agreement ensures that RSCs develop in a harmonised, interoperable and standardised way under ENTSO-E's co-ordination, standards and methodologies (TSCNET, 2020). The RSCs support the TSOs in operating their grids by providing the following mandatory services according to EU legislation: establishing a common grid model; co-ordinated security analysis; co-ordinated capacity calculation; outage planning co-ordination; short- and medium-term adequacy forecasts; consistency check of the TSO system defence and restoration plans; and reporting on RSC co-ordination actions. In addition, the RSCs are working on an early warning system to identify and mitigate potentially critical network situations.

Tennet co-operates with 13 TSOs from 10 European countries through joint ownership of TSCNET, one of three European RSCs. With the completion of the COBRA cable to Denmark in 2019, TenneT also co-operates with the TSOs of the Nordic RSC.

Assessment

The Climate Agreement is the driving document for realising the energy transition in the Netherlands and defines a critical role for the electricity sector, which has been allocated 41% of the total emissions reduction target. To achieve this, the Climate Agreement foresees the following key trends for the Dutch electricity sector from 2018 to 2030. The electricity sector will significantly reduce its carbon intensity through a rapid increase in VRE, notably from offshore wind and PV; a ban on coal-fired generation; and a decreasing, but key, contribution from natural gas generation. Increasing electrification of transportation and heating will be offset by improvements in energy efficiency. Annual electricity demand is projected to be stable at around 120 TWh. Electricity trading is expected to increase (both imports and exports), while increasing generation from domestic renewables will result in the Netherlands transitioning from a net importer to a net exporter of electricity. Flexible operation of the electricity system will be key to manage increasing VRE generation, maintain security of supply and control system costs.

The Climate Agreement aims for at least 70% of generation to come from renewables by 2030. The majority of this is expected to come from VRE, with total wind and PV capacity reaching around 30 GW in 2030. At the same time, peak demand is expected to stay close to the current level of 18-19 GW. It is also foreseen that electricity networks will support new activities, including supplying growing demand from EVs and electric heating, and supporting distributed generation and DSR. These trends present notable challenges to the DSOs and TenneT, the TSO. Regulations should make it possible for the system operators to implement innovative solutions, support flexibility, and take into consideration future electricity demand and supply trends to develop a more proactive and diversified approach to network development and management.

The EU CEP entered into force in 2019 and places numerous requirements on EU member states and their system operators to support the development of more integrated and flexible electricity systems and markets. The Netherlands aims to introduce a new Energy Law in 2021 to address the requirements of the CEP, and more broadly to modernise outdated electricity and natural gas regulations in support of the Climate Agreement. The new Energy Law will include a variety of measures to support more flexible, efficient and interconnected electricity networks and markets.

While developing and implementing the new Energy Law and other policy measures, the Dutch government should ensure that regulations and markets allow for a wide variety of options supporting increased flexibility, electrification of transport, heating and other sectors, and VRE integration.

Options include promoting system-friendly deployment of VRE generation, establishing a clear role for DSR, and allowing for innovation by energy service companies and aggregators. Electricity markets should value all of the system services needed to maintain security and provide flexibility, including availability, time and location of generation, and the ability to provide ancillary services likes frequency and voltage control. Markets should be open to viable technologies and ensure that the providers of needed services are compensated in a competitive and non-discriminatory manner. The costs of technologies and services supporting flexibility are also strongly dependent on network tariffs and a strong emphasis should be placed on developing effective tariff models that do not act as a barrier to market participation.

Energy storage, through batteries and other options, is a key technology that can support system flexibility, VRE integration and reduce the need for grid investments. Currently, energy storage is considered as both a consumer and a producer of energy in the Netherlands and is taxed both when taking off and returning electricity to the grid. This presents a barrier to developing viable business models. The government should rapidly define a clear legal and regulatory status for energy storage, including batteries, and develop a fair tax treatment that unlocks the valuable contribution storage can make.

Regional Energy Strategies are now required as part of a comprehensive spatial planning process to support the achievement of 35 TWh of new onshore renewables generation by 2030. The Regional Energy Strategies bring together local communities, project developers and the DSOs to address key barriers, for example, aligning wind and PV deployment with grid investments. Effective Regional Energy Strategies could require changing the role of the DSOs from primarily ensuring secure supply at low cost to also taking into account CO_2 emissions reductions and other considerations. The government should consider whether it is necessary to formally revise the role of the grid operators as a consequence of the focus on CO_2 reductions in the Climate Agreement and the involvement of the DSOs in local and regional planning.

In support of developing a more flexible system, the Netherlands has deployed 5.2 million smart meters and plans another round of deployment from 2021 to 2023. Data from smart meters can be used to create new business opportunities such as DSR from enterprises with flexible electricity consumption, and residents with electric heating and EVs. Transparent and open data management and access can create opportunities for new market services, which also require new capabilities from the grid operators. Clear regulations on smart meter data are needed to ensure that the DSOs, the TSO, consumers and energy services companies can work together constructively. It is also important that the ACM is given a clear role and the needed capacity to oversee smart meter data and the new services and markets they enable.

Time-of-use pricing enabled by smart meters can also support system flexibility by encouraging consumers to take an active role in managing their consumption and providing market opportunities for energy service companies. Although time-of-use pricing is allowed in the Netherlands as of March 2020, there was almost no time-of-use pricing in residential contracts, apart from day/night metering. Smart meter deployment is still ongoing and over 40% of consumers did not have a smart meter in 2018. Consumers may be unaware of the benefits of time-of-use pricing or uninterested in changing their energy consumption behaviour or dealing with installing and operating energy management systems that bring the full value of time-of-use pricing.

The DSOs, energy suppliers and the ACM are already working together to establish a competitive market for energy consumption management services (EVM market) allowed by smart meters and time-of-use pricing. However, a 2018 study by the Netherlands Enterprise Agency indicates a lack of growth in the EVM market resulting from a failure to communicate options for energy consumption management services when a smart meter is deployed and low awareness of these services among consumers.

Current regulations for aggregators and a lack of clear frameworks for the use of smart meter data and the provision of distributed energy services limit opportunities for companies to develop attractive business models that could encourage more active consumers. The government should ensure that the challenges to broader participation of active consumers are addressed through the new Energy Law and other measures such as updated grid codes.

In 2019, the Netherlands passed a ban on coal-fired generation and all coal plants must completely switch to alternative fuels or shut down by 2030. This initiative will contribute substantially to meeting the electricity sector emissions reduction goals. The exact impact of the coal ban on the electricity system and emissions is not clear, as the owners of Dutch coal plants have not yet decided whether to shut down or convert completely to biomass.

The Netherlands has well-functioning electricity markets and supports European electricity market integration as a key enabler of a cost-effective energy transition. The

DSOs and TenneT have been unbundled from commercial activities like generating and selling electricity. However, energy supply companies in the Netherlands have expressed concerns over grey areas in unbundling, in particular due to the legal position of holding companies.

The Climate Agreement sets a minimum CO_2 price for electricity generation. The current CO_2 price has been set at a conservative level as a floor to the EU ETS and is not affecting electricity prices. The appropriate level of the CO_2 price should be evaluated on a regular basis to determine how it can help to achieve Climate Agreement targets. The Netherlands is pushing for regional or EU-wide adoption of a CO_2 price floor, which will likely be a more effective policy instrument than a unilateral national price.

Recommendations

The government of the Netherlands should:

- Revise the regulatory framework for electricity markets to provide room for innovation and to facilitate proactive development of an electricity system that can safely integrate increasing shares of variable renewable generation and support smart grid solutions.
- Establish an energy data system that harnesses the benefits of smart meters and promotes data-driven innovations, efficiencies and business opportunities.
- Develop instruments to enhance the flexibility of the electricity system, e.g. dynamic pricing, fair grid tariffs, effective spatial planning and innovative energy services.
- Support electricity markets that value all of the system services needed to maintain electricity security and ensure that providers of these services are remunerated in a competitive and non-discriminatory manner.

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8. Natural gas, green gas and hydrogen (energy transition focus area)

Key data

(2018)

Share of gas: 76.2% of domestic energy production, 42.1% of TPES, 51.0% of electricity generation, 33.6% of TFC

Gas demand: 42.6 bcm (billion cubic metres), heat and electricity 30.9%, industry 24.0%, residential 22.3%, services 16.7%, agriculture 6.8%, other energy 4.9%, others 0.2%

Gas production: 36.4 bcm, -46% since 2008

Net gas imports: 6.4 bcm (60.9 bcm imports, 54.5 bcm exports)

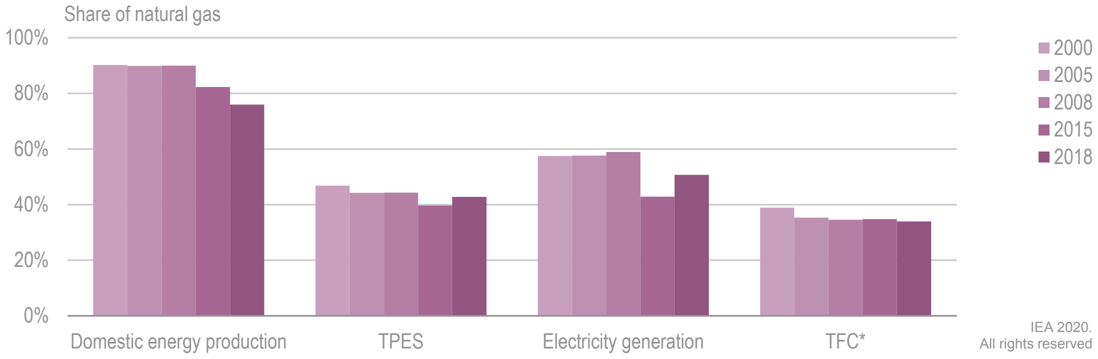
Overview

Natural gas is arguably the most important energy source in the Netherlands and the country is home to the largest gas-trading hub in Europe. In 2018, natural gas accounted for 90% of residential heating demand, 76% of domestic energy production, 51% of electricity generation, 42% of total primary energy supply (TPES) and 34% of total final consumption (TFC) (Figure 8.1). However, Dutch energy policy is pushing to rapidly and significantly reduce the role of gas in the energy system. The decision to end production from the Groningen gas field as soon as mid-2022 is quickly reducing domestic production. The Climate Agreement defines aggressive emissions reduction targets and specific measures relating to natural gas that will reduce gas demand.

The government foresees that natural gas will be an important part of the energy system through at least 2030 and that low-carbon gaseous energy carriers will play a critical role in supporting the transition to a carbon-neutral energy system by 2050, especially in industry and other hard-to-decarbonise areas. The Netherlands is executing a broad policy agenda to reduce gas demand and accelerate the production and use of low-carbon gaseous energy carriers, including options for leveraging existing gas infrastructure. The government is also looking to sustain offshore gas production to support security of supply, maintain Dutch gas expertise and provide options for carbon storage.

The Dutch Hydrogen Strategy and Green Gas Roadmap define strategies to accelerate large-scale production and use of low-carbon hydrogen and a variety of green gasses, including biomethane. These strategies support broad use of low-carbon gases across all sectors and aim to grow Dutch expertise in low-carbon gaseous energy carriers as the country transfers away from natural gas.

Figure 8.1 Share of natural gas in the Dutch energy system, 2000-18



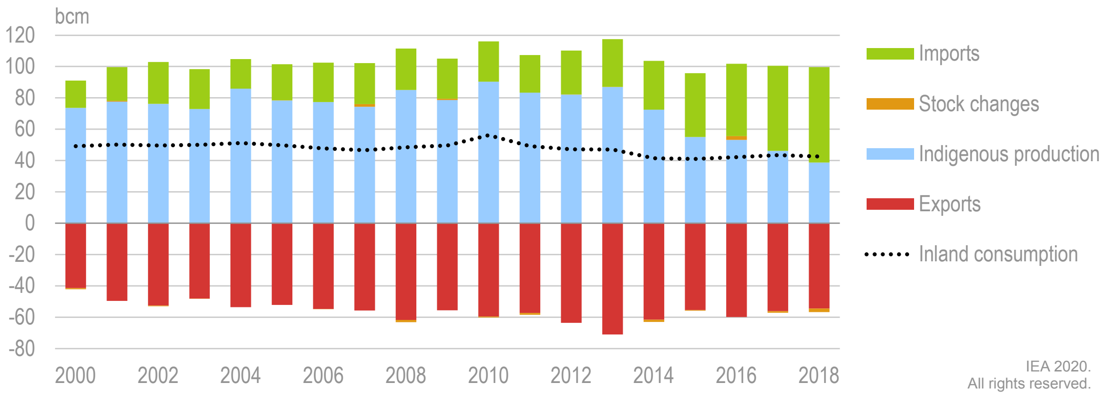
Natural gas dominates energy production, is the largest source in TPES and electricity generation, and the second-largest in TFC after oil. Domestic gas production is rapidly falling.

Notes: TPES = total primary energy supply; TFC = total final consumption.
Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Supply and trade

The Netherlands is a large natural gas producer, consumer and a major gas-trading hub (Figure 8.2). The Groningen gas field in the Netherlands is one of the ten largest fields in the world and contains gas reserves, estimated at over 2 800 bcm in 2019. Groningen's output is being rapidly reduced in response to earthquakes that occurred in 2018 and 2019, which were caused by natural gas production and resulted in damage to over 10 000 buildings in northeastern Netherlands. As a result, domestic gas production fell from 87 bcm in 2010 to 39 bcm in 2018. Despite falling gas production, the Netherlands was the third-largest European gas producer in 2018. Production will continue to decrease as the government plans to end extraction from Groningen as early as mid-2022.

Figure 8.2 Natural gas supply by source, 2000-18

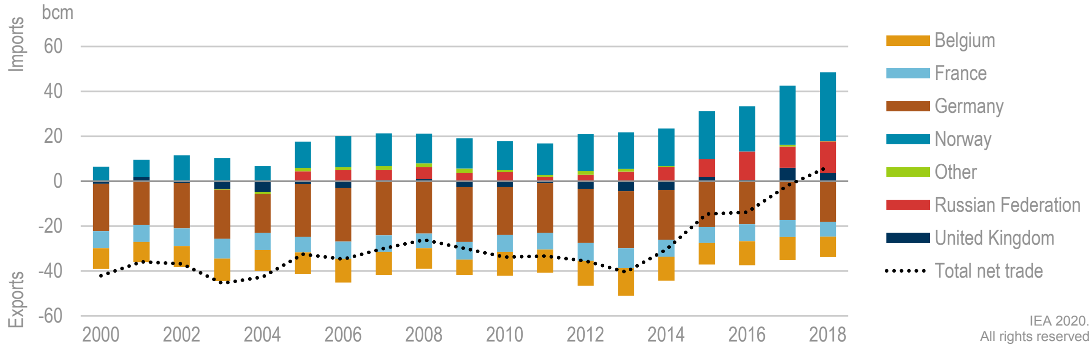


In the last five years, domestic natural gas production fell by 55% and gas imports and exports now both exceed production.

Source: IEA (2020b), *Natural Gas Information 2020* (database), www.iea.org/statistics.

The Netherlands is home to the largest gas-trading hub in Europe and has numerous gas interconnections with its neighbouring countries. As a result of declining production, the country is becoming more dependent on imports. In the last five years, imports have nearly doubled while exports have fallen by over 25%. As a result, in 2018, the Netherlands became a net importer of gas for the first time. Most imports come from Norway, followed by the Russian Federation and the United Kingdom (Figure 8.3). The Netherlands is still a large net exporter to Germany and Belgium, but exports are decreasing with falling domestic production.

Figure 8.3 Natural gas trade by country, 2000-18



The Netherlands is a major gas-trading hub. Due to falling domestic production and stable demand, the country became a net importer for the first time in 2018.

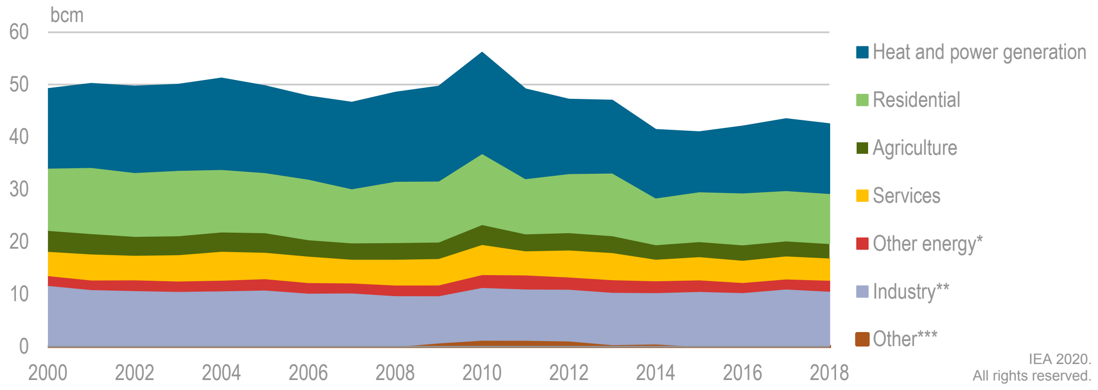
Source: IEA (2020b), *Natural Gas Information 2020* (database), www.iea.org/statistics.

Demand

Gas demand peaked in 2010 at 56.2 bcm due to unusually cold weather. From 2010 to 2015 gas demand fell to 41.0 bcm, but has since increased slightly to 42.6 bcm in 2018 (Figure 8.4). The electricity and heat sector was the largest gas consumer in 2018, accounting for 30% of total demand. Gas demand for electricity and heat generation declined significantly, from 19.2 bcm in 2010 to 13.2 bcm in 2018, but has been increasing since 2015. The industry sector was the second-largest gas consumer in 2018, accounting for 24% of total demand. The chemical and petrochemical industry accounted for the largest share of industrial gas demand (59% in 2018), followed by the food processing industry (18%). Natural gas demand in the agriculture sector (separate from food processing) accounted for 7% of total demand in 2018.

In 2018, the residential sector accounted for 22% of total gas demand and the service sector 10%. The Netherlands has an extensive gas network that reaches nearly the entire population. In 2019, roughly 95% of households and most commercial properties were connected to the gas network. Most of the energy demand in the residential and services sectors comes from heating buildings, with natural gas being the major energy source for heat in both sectors. In 2018, natural gas accounted for 72% of total residential energy consumption, the highest share in the IEA. Annual temperature variations drive fluctuations in energy demand for heating, which is seen as variations in natural gas consumption. The long-term trend shows slowly declining gas demand. From 2008 to 2018, gas demand decreased by 18% in the residential sector and by 14% in the service sector including agriculture, which has high gas demand for heating greenhouses. It is expected that Climate Agreement measures and the Groningen phase-out plan will begin to reduce gas demand in the next few years and that in the long term there will be substantial reductions in gas demand across all sectors.

Figure 8.4 Natural gas consumption by sector, 2000-18



Natural gas consumption has fluctuated between 41 bcm and 56 bcm in the last decade, mainly due to variations in demand from power generation and the residential sector.

* Includes oil and gas extraction and refineries.

** Includes non-energy use.

*** Includes small shares in transport and non-specified consumption.

Source: IEA (2020b), *Natural Gas Information 2020* (database), www.iea.org/statistics.

Institutions

The Ministry of Economic Affairs and Climate Policy has the primary responsibility over energy policy, including natural gas policy as set in the Mining Act and the Gas Act. Exploration and production activities regarding minerals including gas, require a licence from the ministry as defined in the Mining Act. A license from the ministry is also required for underground storage of natural gas, CO_2 and other gases.

The State Supervision of Mines (SSM) is the independent authority monitoring compliance with the Mining Act. It supervises the exploration, production, transport and storage of minerals including gas, and focuses on safety, health, the environment and technically efficient extraction. The SSM regularly advises the ministry and other authorities on mining-related topics. SSM carries out investigations and can impose administrative penalties or advise the ministry to remove licenses. The Authority for Consumers and Markets (ACM) is the independent regulator with authority over the energy sector including natural gas. The ACM regulates system operators, approves tariffs for gas transmission, and monitors the gas network and markets. Both the SSM and the ACM fall under the supervision of the Minister of Economic Affairs and Climate Policy (SSM, 2020).

Gasunie Transport Services B.V. (GTS) is the gas transmission system operator (TSO). GTS is a 100% subsidiary of Gasunie, a fully unbundled gas infrastructure company that is 100% owned by the Dutch state through shares held by the Ministry of Finance. There are eight gas distribution system operators (DSOs), all of which are owned by regional and local governments. The gas TSO and the DSOs are responsible for operating and maintaining the gas network.

Energie Beheer Nederland B.V. (EBN) is a state-owned energy company supporting upstream gas and oil investment. The Ministry of Economic Affairs and Climate Policy is the sole shareholder. The EBN is involved in almost every upstream gas and oil project in the Netherlands as a non-operating partner. The EBN also has interests in offshore gas pipelines and underground gas storage (EBN, 2020).

Legal framework

The Gas Act defines the terms and conditions for the functioning of the gas market and the responsibilities of the TSO, the DSOs, the SSM, the ACM and the government. The independence of the SSM and the ACM is set in the Mining Act and the Gas Act. The Security of Supply Gas Act and several ministerial decisions govern security of the gas supply and the delivery of gas to small consumers with a demand below 40 m^3 (cubic metres) per hour. Liquefied natural gas (LNG) installations are subject to several provisions in the Gas Act, including the obligation to designate an operator and submit the tariff structure to the ACM for approval.

The Mining Act defines the terms and conditions for gas and oil exploration and production activities, and for underground gas and oil storage. Under Dutch law, all minerals in the subsurface, including gas and oil, are owned by the Dutch state. All companies producing gas or oil in the Netherlands pay a State Profit Share (SPS) levy of 50%. The SPS is a resource rent tax charged in addition to the prevailing corporate income tax of 25%. Almost all gas and oil exploration and production in the Netherlands is undertaken by private companies in partnership with EBN, which covers 40-50% of the exploration and production licenses. Any profits EBN generates from production are paid into the state treasury. This arrangement reduces risk for upstream oil and gas companies and ensures revenue for the Dutch state from gas and oil production.

Policy

Dutch gas policy is focused on reducing gas demand and production in line with the Climate Agreement emissions reduction targets and safety concerns relating to earthquakes caused by natural gas production in the Groningen area. Given the expectation that natural gas will continue to play an important role in the Dutch energy system through at least 2030, the government supports continued offshore gas production to maintain energy security and Dutch expertise in the gas sector. The government is also encouraging production of alternative gaseous energy carriers, e.g. biomethane and low-carbon hydrogen.

The Climate Agreement and other policies aim to reduce natural gas demand, especially in the built environment. The Natural-gas Free Districts Programme seeks to reduce gas demand by transitioning 1.5 million homes to low-carbon heating by 2030. The lessons learnt from this programme will support the transition away from natural gas in an increasing number of buildings after 2030. There are numerous support schemes funding energy efficiency, renewable energy and district heating in existing and new buildings that will reduce gas demand. The Gas Act was amended in July

2018 to change the obligation for a gas connection into a ban on connecting new homes and buildings to the natural gas network.

Dutch policy also aims to reduce gas demand in industry through programmes and support schemes encouraging reduced emissions, energy efficiency, and a shift to electricity and direct use of renewables. In the electricity sector, a transition away from gas is encouraged through ambitious renewable energy targets and support schemes driving the deployment of wind, solar PV and other renewable generation (see Chapter 6).

Historically, Dutch policy on gas production has focused on maximising sustainable use of domestic gas resources. Policy has rapidly shifted to reducing gas production following earthquakes in the Groningen area that caused extensive damage to buildings and threatened public safety. In October 2018, the government announced a plan to phase-out Groningen by 2030. However, following additional earthquakes, a new more aggressive plan was developed. In September 2019, the government announced the details of an updated plan that includes a production cap of 11.8 bcm for the gas year[1] 2019/20 (nearly 40% lower compared to 2018/19) and plans to end production as soon as possible with a goal for close to zero production by mid-2022. In line with the Groningen phase-out, the government is implementing measures to maintain gas security of supply in the Netherlands and neighbouring countries that rely on gas from Groningen (see Box 8.1).

Groningen was historically the largest source of Dutch gas production. However, there are many small onshore and offshore gas fields. In 2019, these small fields made up a quarter of gas reserves and half of gas production. These fields are more complicated and expensive to explore and yield lower production. To encourage production from these fields, the government introduced a specific policy in 1974 which guarantees the purchase of natural gas extracted from small fields. Several recently introduced policies affect production from the small fields.

The 2017 Coalition Agreement states that no new licenses will be granted for onshore gas or oil exploration, and as a consequence, there will be no expansion of onshore gas production beyond what is expected under current licenses. New licences for offshore gas production are still allowed (Government of the Netherlands, 2017). In October 2019, the Minister of Economic Affairs and Climate Policy announced that the level of production from the small fields would not increase to compensate for declining production from Groningen (Meijer, 2019).

To promote energy security and maintain Dutch gas and oil expertise, the government introduced an investment allowance for offshore natural gas production in 2010. This tax incentive provides a 25% deduction on income subject to the SPS levy. For a field to qualify for the investment allowance, it must meet requirements on the expected level of production and distance of existing gas infrastructure. The allowance has not led to the desired increase in offshore production. In May 2020, a proposed law was presented in the Dutch parliament to expand the allowance to cover all new investments in onshore and offshore exploration and production for both natural gas

[1] Gas years are used with the natural industry as peak demand usually falls in the winter time. A gas year runs from 1 October until 30 September of the following calendar year.

and oil, regardless of field characteristics and to increase the tax deduction from 25% to 40% (Government of the Netherlands, 2020).

Gas transistion, green gas and low-carbon hydrogen

In March 2020, the Minister of Economic Affairs and Climate Policy sent three letters to parliament on the future of gas in the energy system. The first letter highlighted the critical role gas plays in the Dutch energy system and indicated that gas will continue to be a key energy source through at least 2030. However, the letter noted that natural gas demand will be reduced in line with the Climate Agreement through energy efficiency, electrification and expanded use of low-carbon gases. The letter notes that by 2050, almost all remaining demand for gaseous energy carriers must be covered with low-carbon alternatives like biomethane and low-carbon hydrogen (MEACP, 2020a).

The second letter covered the Green Gas Roadmap, which defines a broad range of policy measures driving increased production and use of green gas (primarily biomethane) to support the Climate Agreement target for 70 PJ of biomethane production by 2030. Supporting measures include production subsidies, targeted RD&D spending, investments in pilot projects and updating regulations (see Chapter 6) (MEACP, 2020b).

The third letter detailed the Hydrogen Strategy, which aims for rapid development of low-carbon hydrogen infrastructure, production and use. The strategy also serves as a guiding document to develop a national Hydrogen Programme, which will define specific policies and measures to support the achievement of the numerous hydrogen targets in the Climate Agreement (see the section on hydrogen in this chapter) (MEACP, 2020c).

Green gas

The Netherlands has notable production and use of green gas (biogas and biomethane) production. In 2018, there were 250 biogas digesters at 100 locations. The majority of these digesters use local agricultural and animal waste as feedstocks for biogas production. Many of the biogas facilities are equipped with processing equipment to upgrade biogas into biomethane, which can be used as a direct substitute for natural gas, including injection into the natural gas network. Biogas use has grown rapidly in the Netherlands from 2.3 PJ of final enegy demand in 2000 to 6 PJ in 2010 and 9.6 PJ in 2018.

In 2018, Dutch biogas was used mainly for electricity generation and heat production in combined heat and power (CHP) plants and gas boilers located near biogas production sites. In 2018, biogas supported 0.9 TWh (3.2 PJ) of electricity generation and 3.0 PJ of heat production. Biogas is also upgraded to biomethane and injected into the Dutch gas network. In 2018, 3.4 PJ of biomethane was injected into the network and covered about 0.2% of total natural gas demand (MEACP, 2020b). In 2019, two large new digesters with a combined production capacity of 1.5 PJ came on line. Under the Climate Agreement, the government is aiming to greatly expand the production of biomethane, with a target of 70 PJ of biomethane production by 2030.

Gas infrastructure

The Netherlands has extensive gas infrastructure comprising over 200 onshore and offshore production sites, 136 632 km of pipelines, and connections to 95% of households, most commercial properties, numerous industrial sites and gas-fired power plants. Table 8.1 gives an overview of gas pipelines and connection at the transmission and distribution levels. The Dutch gas network is linked to the European gas network through interconnections points with Belgium, Germany and the United Kingdom. The GATE LNG terminal allows imports from the global gas market.

Table 8.1 Gas pipelines and connections in the Netherlands, 2019

Distribution system operator (DSO)	Pipelines (km)	Connections
– *Coteq*	4 389	140 165
– *Enduris*	4 793	190 626
– *Enexis*	52 152	2 485 126
– *Liander*	35 303	2 256 085
– *Rendo*	3 492	104 062
– *Stedin*	23 464	1 958 462
– *Westland Infra*	1 039	53 646
Total DSO	124 632	7 188 172
Transmission system operator (TSO) (GTS)	12 000	1 100
Total DSO and TSO	**136 632**	**7 189 272**

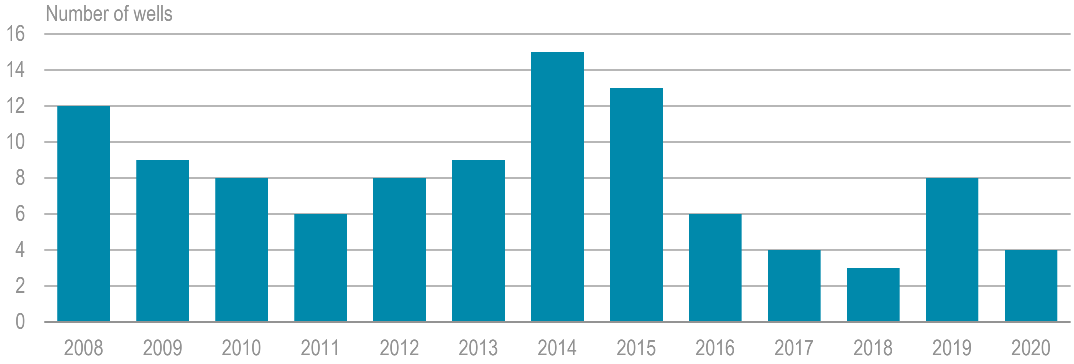
The Dutch gas system is relatively unique as it has separate networks for low calorific gas (L-gas) and high calorific gas (H-gas). The L-gas and H-gas networks each have their own supply sources, pipelines, storage facilities and associated infrastructure. The reason for this is that Groningen, historically the largest source of gas in the region, produces L-gas, while most of the small fields produce H-gas and almost all imports are H-gas. The Dutch gas system has four blending plants that use nitrogen to convert H-gas to L-gas and allow the H-gas network to supply L-gas (see Box 8.1).

Industrial consumers and gas-fired electricity plants in the Netherlands primarily use H-gas, although there is notable industrial demand for L-gas. Nearly all residential and commercial consumers in the Netherlands are connected to the L-gas network. L-gas is also exported through dedicated pipelines to Belgium, Germany and to France via Belgium. These countries have notable L-gas networks that primarily provide gas for heating.

Upstream production

The Netherlands has extensive infrastructure for onshore and offshore gas exploration and production. In 2019, gas was being produced from 216 fields (87 onshore and 129 offshore). The Dutch upstream gas and oil activity is undertaken by private companies in a liberalised market. The state-owned energy company EBN is a non-operating partner in almost all gas and oil exploration and production. NAM, jointly owned by Shell and ExxonMobil, operates the Groningen field and is by far the largest gas producer. The small fields are operated by a variety of private companies. Exploration activities have been in decline since 2014 (Figure 8.5). The 2017 Coalition Agreement states that the government will not issue any new licenses for onshore gas exploration. Existing licenses remain valid and new licenses for offshore exploration can be issued.

Figure 8.5 Number of exploration and appraisal gas wells, 2008-20



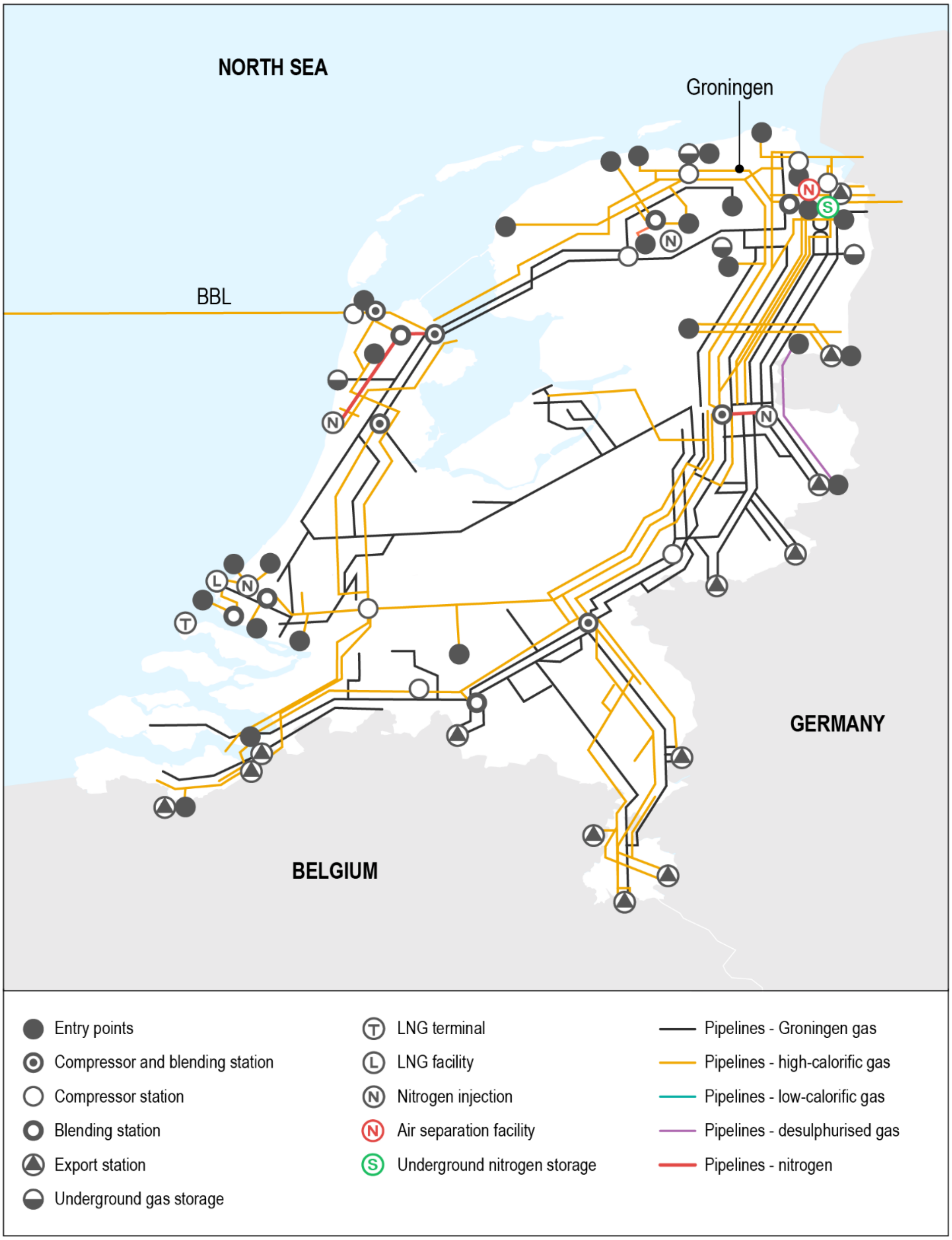
Natural gas exploration activities in the Netherlands have been in decline since 2014.

Note: 2020 number is estimated.
Source: EBN (2020), *The Netherlands Exploration Opportunities*.

Transmission network

The gas transmission system operated by GTS consists of a high-pressure network (87/60 to 40 bar) and a medium-pressure network (40 to 8 bar) (Figure 8.6). The high-pressure network has over 6 000 km of pipelines, 15 compressor stations, 4 nitrogen blending stations, numerous gas storage facilities, and sections for L-gas and H-gas. The H-gas high-pressure network supports imports and exports via pipelines and the GATE LNG terminal, and supplies large industrial customers and gas-fired power plants. There is also a high-pressure L-gas network that supports exports via pipelines and supplies some industrial customers. The high-pressure network has over 80 connections to the medium-pressure network, which has over 6 000 km of pipelines and supplies large consumers and the low-pressure distribution network. The medium-pressure network mostly transports L-gas, but there are two industrial H-gas sections in Maasvlakte and Limburg (GTS, 2019).

Figure 8.6 Natural gas infrastructure in the Netherlands, 2019



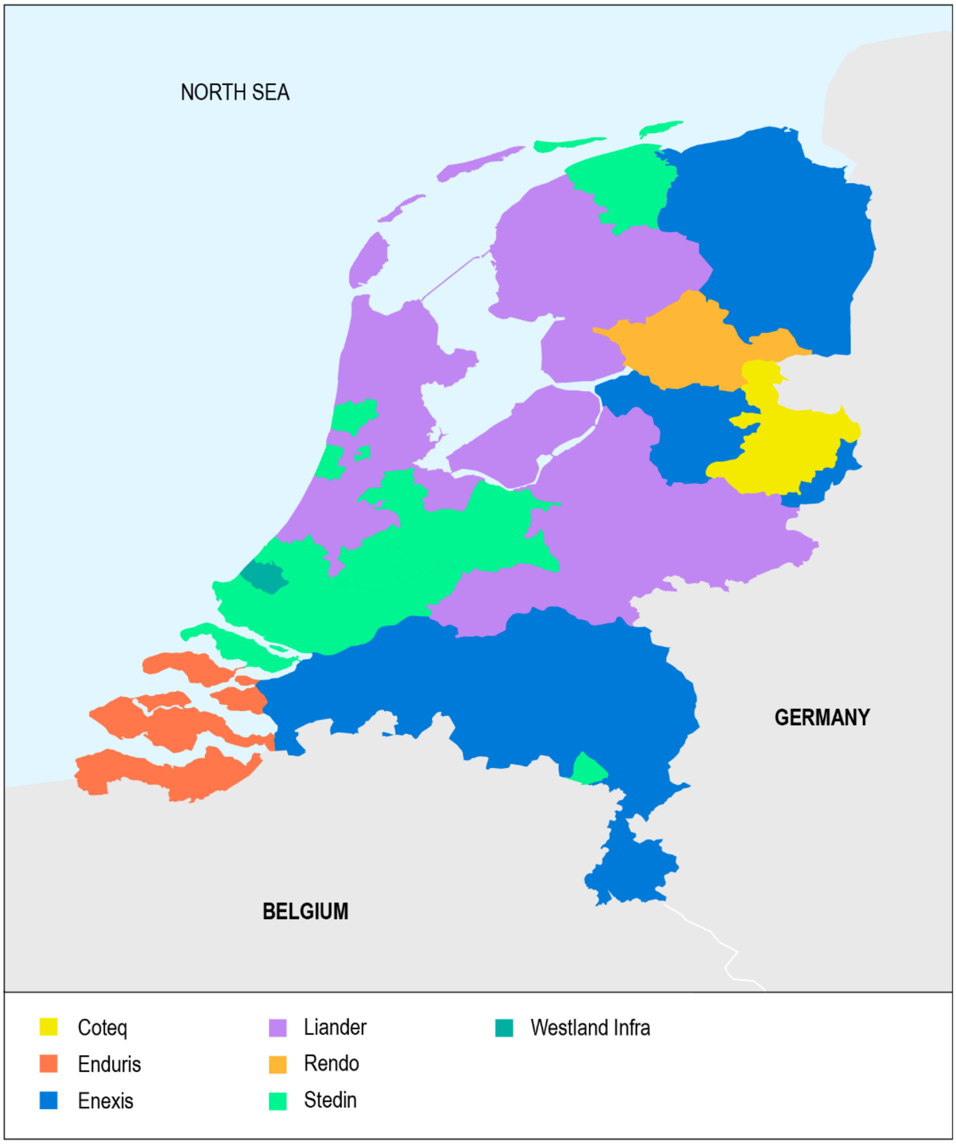
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: GTS (2019), *The Transmission Network*, www.gasunietransportservices.nl/en/network-operations/the-transmission-network.

Distribution network

The low-pressure gas distribution network has around 100 000 km of pipelines and is connected to millions of consumers. The low-pressure network primarily transports L-gas and mainly supports heating in the residential, services and agricultural (greenhouses) sectors. The distribution network is operated and maintained by eight DSOs, all of which are owned by regional and local governments. Seven of the DSOs (Coteq, Enduris, Enexis, Liander, Rendo, Stedin and Westland Infraall) operate L-gas networks and also act as electricity DSOs. The regional coverage of these seven DSOs is shown in Figure 8.7. ZEBRA Gasnetwerk B.V. operates a small H-gas network in Zeeland and Brabant (Energieleveranciers, 2019).

Figure 8.7 Natural gas distribution system operator network coverage, 2019



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: EL (2019), *Overview of Gas Network Operators*, www.energieleveranciers.nl/netbeheerders/gas.

Storage

There is extensive gas storage in the Netherlands, which is used to meet seasonal demand changes (especially in relation to increased winter demand for heating) and to support efficient market operation and regional security in the Netherlands and regionally. All gas storage facilities in the Netherlands are operated by commercial parties who are free to choose how they participate in the gas market.

There are five underground natural gas storage facilities in the Netherlands with a total capacity of 14.4 bcm (Table 8.2). Four facilities are depleted gas fields that address seasonal demand fluctuations and short-term demand peaks. One facility is a salt cavern used to address short-term peaks only. In addition to domestic gas storage, the Dutch gas transmission system is connected to an additional 6.1 bcm of gas storage capacity in salt caverns in Germany (Table 8.3). With the phase-out of Groningen production, gas storage will play an increasing role in maintaining security of supply (see Box 8.1).

Table 8.2 Gas storage facilities in the Netherlands, 2019

Facility	Gas type	Storage type	Capacity (TWh)	Withdrawal (GWh/d)		Injection (GWh/day)	Operator
				100%	30%		
Norg	L-gas	DGF	48.7	759	698	449	NAM
EnergyStock	L-gas	SC	2.8	252	252	215	EnergyStock
Alkmaar	L-gas	DGF	5	357	357	40	TAQA Energy
Bergermeer	H-gas	DGF	45.6	635	425	468	TAQA Energy
Grijpskerk	H-gas	DGF	27.7	719	630	173	NAM
Total			129.8	2 722	2 362	1 345	

Note: DGF = depleted gas fields; SC = salt cavern.

Table 8.3 Connections to gas storage facilities in Germany, 2019

Entry point	Gas type	Capacity (GWh/d)	
		Entry	Exit
Cluster Enschede/Epe storages	L-gas	314	168
Enschede (Eneco-UGS Epe)	L-gas	94	48
Enschede (Innogy-UGS Epe)	L-gas	103	53
Enschede (Nuon-UGS Epe)	L-gas	118	84
Cluster Oude Statenzijl storages	H-gas	816	590
Oude Statenzijl (Astora Jemgum)	H-gas	564	564
Oude Statenzijl (Etzel-Crystal-H)	H-gas	362	259
Oude Statenzijl (Etzel-EKB-H)	H-gas	396	278
Oude Statenzijl (Etzel-Freya-H)	H-gas	259	245
Oude Statenzijl (EWE Jemgum)	H-gas	564	564
Oude Statenzijl (EWE-H)	H-gas	216	209
Oude Statenzijl Renato (OGE)	H-gas	286	271
Total		4 092	3 333

Interconnectors

The Dutch transmission network has interconnections to the gas networks of Belgium and Germany via numerous underground pipelines, and the United Kingdom via a subsea pipeline (Table 8.4). Gas can be exported and imported to Belgium and Germany. The interconnection with Norway via Germany only supports imports into the Netherlands. The Balgzand Bacton Line (BBL) pipeline was originally designed to support exports from the Netherlands to the United Kingdom. In October 2019, BBL started bidirectional flows allowing imports from the United Kingdom to the Netherlands.

Table 8.4 Natural gas interconnector capacities, October 2019

Country	Gas cluster	Interconnection point	Capacity (bcm/y)	
			Export	Import
Belgium and Germany	L-gas	Hilvarenbeek (Fluxys)	22.3	-
		Zevenaar (Oge/Thyssengas)	18.5	-
		Winterswijk (Oge)	13.7	-
		Oude Statenzijl (Gtg Nord-G)	1.8	-
		Tegelen (Oge)	0.2	-
		Dinxperlo (Bew)	0.01	-
		Haanrade (Thyssengas)	0.1	-
		Oude Statenzijl (Gud-G)[Obebg]	4.7	-
Germany	North East H-gas	Vlieghuis (Rwe)	2.7	-
		Oude Statenzijl (Oge)	6	17
		Oude Statenzijl (Gud-H)[Obebh]	5.5	3
		Oude Statenzijl (Gascade-H)	5.5	13
Belgium	South West H-gas	Zelzate (Fluxys)	12	12.4
		Zandvliet (Fluxys-H)	1.8	-
		Zandvliet (Wingas-H)	1,1	-
Belgium and Germany	South East H-gas	Obbicht (Fluxys)	n.a.	-
		Bocholtz Tenp (Oge – Flx Tenp)	16.1	-
		S-Gravenvoeren (Fluxys)	16.1	-
		Bocholtz Vetschau (Thyssengas)	0.9	-
United Kingdom		Julianadorp (BBL) Subsea pipeline	18.5	6.9

LNG terminal

The GATE LNG terminal is the only LNG terminal in the Netherlands. GATE began operating in 2011 and is privately owned and operated by Gasunie and Vopak. The terminal only supports gas imports and has a throughput capacity of 12 bcm/y. GATE is located in the Port of Rotterdam and consists of two jetties for unloading ships, three storage tanks and a processing area for LNG regasification. The number of ship deliveries at GATE increased from 37 in 2016 to 104 in 2018 and 171 in 2019.

The majority of imports arriving at GATE are injected into the high-pressure H-gas transmission network. An increasing amount of imports are being moved by trucks, with a record 3 466 trucks loaded in 2019. The terminal operator is examining options for using rail to deliver imported gas to the market. In 2019, the terminal operator opened a bidding process to explore expanding annual regasification capacity from 12 bcm/y to 14 bcm/y. No contracts were signed, but the operator has indicated it is still interested in expanding import capacity (Cocklin, 2020).

Infrastructure planning

Under the Gas Act, GTS is required to develop an investment plan for the gas network every two years, with a ten-year outlook. Prior to 2018, the plan was presented to the ACM and the Ministry of Economic Affairs for information. Amendments to the Gas Act in 2018 now require that the plan be approved by both the ACM and the ministry. The ACM assesses whether the investments described in the plan are necessary and the ministry assesses whether GTS has taken sufficient account of developments in the energy market. Under the amended requirements, GTS must submit a new investment plan by 1 January of every even calendar year starting in 2020.

The 2020 GTS investment plan provides an overview of planned expansion and maintenance investments from 2020 to 2030. From 2020 to 2023, the annual cost of planned investments ranges from EUR 300 million to EUR 165 million per year and are focused on measures supporting the Groningen phase-out. The main project is a new nitrogen blending plant at Zuidbroek expected to cost just under EUR 500 million and to start operating in mid-2022. Another notable investment is the acquisition and integration of the Zebra H-gas network. The investment plan estimates that all major projects relating to the Groningen phase-out will be completed by 2023, which will lead to a notable reduction in annual investments to the level necessary to maintain the transport network. This amount is estimated at EUR 100 per year from 2024 to 2030. However, the plan notes that significant additional investment may be required in line with the Climate Agreement goals for green gases, hydrogen and other clean energy measures.

Wholesale market

The Netherlands is an integral part of the European gas market, which is composed of interconnected national wholesale markets. Within the European gas market, the Netherlands is one wholesale market area and one balancing zone. Because of its central location in Europe, extensive interconnection capacity and large LNG import terminal, the Netherlands plays an important role in the European gas market. The Dutch wholesale gas market has been liberalised in line with EU regulations and market functioning is based on an entry-exit system that allows gas traders to book capacity rights at entry and exit points between market areas and on a trading hub that provides a wide range of products, including within-day, day-ahead, month-ahead, quarter-ahead, season-ahead and calendar year. The various trading hubs in Europe allow gas producers to sell directly to large consumers and to gas suppliers, which in turn sell gas in the retail markets.

The Netherlands is home to the Title Transfer Facility (TTF), which is the largest gas-trading hub in Europe. The number of traders active on TTF increased from 114 in 2014 to 159 in 2019. The volume of gas traded on the TTF increased from 13 216 TWh in 2014 to 38 039 TWh in 2019. On the TTF, natural gas is traded based on energy content (EUR/MWh). The highly liquid EU gas market, in conjunction with an extensive transport network, ensures the delivery of gas specified in the contracts via clearing trading hubs. TSOs like GTS are responsible for transport of gas, but the balancing of supply and demand is handled directly through the market.

The major companies active in the Dutch wholesale gas market are Engie, Gazprom and GasTerra, a public-private venture owned by Shell (25%), ExxonMobil (25%) and the Dutch state through EBN (40%) and the Ministry of Economic Affairs and Climate Policy (10%). GasTerra sells gas produced from Groningen and gas from the small fields that is offered to GasTerra through the small field policy, and is the main holder of gas import contracts from Norway and the Russian Federation, which are by far the largest source of imports. In 2018, GasTerra was by far the dominant player in the wholesale market, with a share exceeding 70% (OECD, 2019). However, in line with the Groningen phase-out, GasTerra's activities have been rapidly falling and it is expected that the company will cease operation and be shut down when production for Groningen is ended.

Retail market

The Netherlands has an open and competitive retail gas market with numerous gas suppliers, all of which also sell electricity. The number of suppliers active on the retail gas market steadily increased from just 9 in 2004 to 59 in 2018; in 2019, the number dropped slightly to 57. However, the three largest energy suppliers – Essent (RWE), Vattenfall (Nuon) and Eneco – accounted for over 70% of retail gas sales in 2018. This is an improvement from 2012, when the three largest suppliers held 83% of the retail market.

The Netherlands is among the countries with the highest retail switching rates in Europe. The number of retail customers that switched suppliers increased from around 700 000 (12.6% of customers) in 2012 to 1.6 million (20% of customers) in 2019. A survey by the ACM shows good awareness among Dutch retail customers of the benefits of switching suppliers. Of the consumers consulted in the survey, 78% noted that a lower price was their main reason for switching suppliers, while 17% noted they switched because they wanted renewable energy. The survey also noted that 87% were satisfied with the process of switching suppliers and 28% expected to switch again within the next three years (ACM, 2019).

Retail market taxes and prices

The Netherlands has a broad energy tax that covers the consumption of gas, electricity and districting heating. Consumers also pay a Surcharge for Sustainable Energy Act levy (ODE) on top of the energy tax. The ODE provides funding to support schemes for renewables and emissions reductions. The rate of the energy tax and ODE depend on the level of consumption, with much lower rates for large consumers and an overall discount for gas used to heat greenhouses in the horticulture sector (Table 8.5).

Table 8.5 Energy tax and ODE rates for natural gas, 2019 and 2020

Tariff	Consumption bracket (mcm)	2019			2020		
		Energy tax	ODE	Total	Energy tax	ODE	Total
General tariff	0-0.017	29.31	5.24	34.55	33.24	7.75	40.99
	0.017-1	6.54	1.61	8.15	6.44	2.14	8.58
	1-10	2.38	0.59	2.97	2.35	2.12	4.46
	Above 10	1.28	0.31	1.59	1.26	2.12	3.38
Greenhouses	0-0.017	4.71	0.84	5.55	5.34	1.24	6.58
	0.017-1	2.47	0.61	3.08	2.43	0.81	3.24
	1-10	2.38	0.59	2.97	2.35	2.12	4.46
	Above 10	1.28	0.31	1.59	1.26	2.12	3.38

Note: mcm = million cubic metres.

Prior to 2020, households provided half of ODE funding with the other half coming from businesses. In 2020, the ODE will be adjusted so that two-thirds of funding comes from businesses and one-third from households. To support the transition from natural gas to low-carbon heating, the government will increase taxation of natural gas by up to 43% by 2026 (compared to 2019 levels) and will lower taxation on electricity.

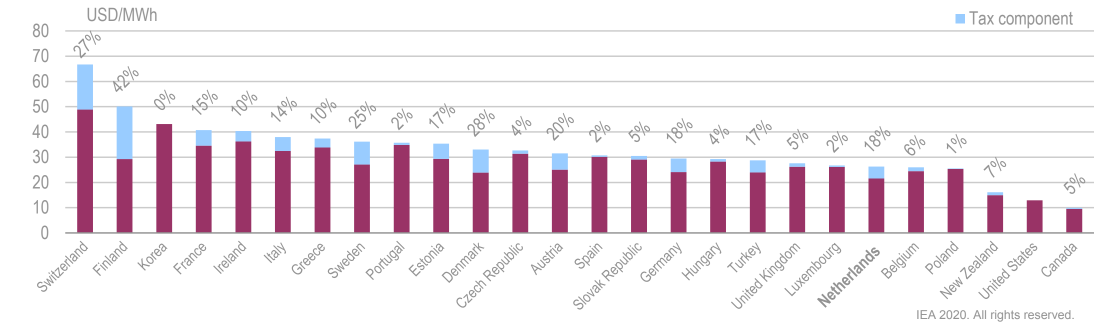
Retail gas prices are not regulated. However, suppliers must submit all prices to the ACM for review and the ACM has the power to oblige suppliers to change their prices. It is intended that this *ex ante* price monitoring will be ended under the new Energy Law in 2021. All suppliers active on the retail market need to have a license from the ACM.

Natural gas prices in the Netherlands differ significantly between industrial and household consumers. Industrial consumers paid on average around 26 USD/MWh for natural gas in 2019, of which 18% was for taxes and levies. The industry gas price was the sixth-lowest among IEA member countries (Figure 8.8). In contrast, Dutch households paid the second-highest price among IEA member countries at 104 USD/MWh. The high household price is a result of high taxation, which at 55% of the total price was the second-highest tax rate among IEA member countries in 2019.

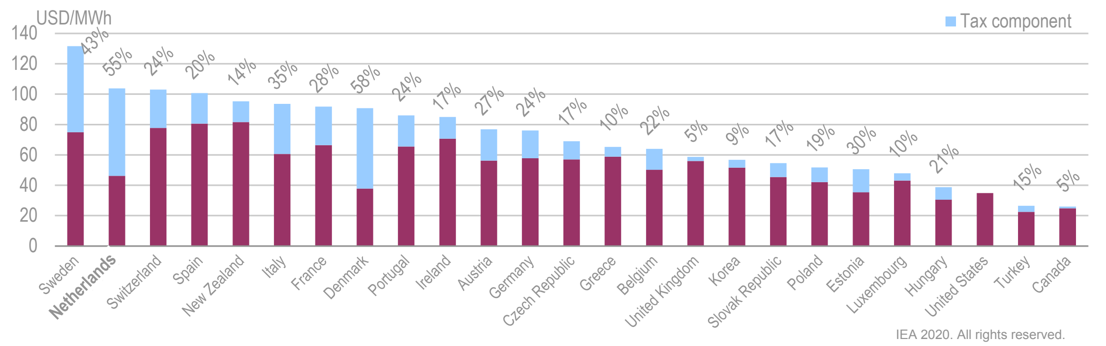
Gas prices increased rapidly in the early 2000s and peaked in 2008 at 46 USD/MWh for industry and 107 USD/MWh for households. Following 2008, prices stayed relatively high until 2015, when gas prices dropped to the lowest level seen in over a decade. Since 2017, prices have been increasing again, especially for industry (Figure 8.9). Dutch prices follow similar trends as in neighbouring countries, reflecting the interconnected markets in the region. Differences in price between the countries are mostly due to different taxation policies, especially for households.

Figure 8.8 Gas retail prices in IEA member countries, 2019

Industry



Households

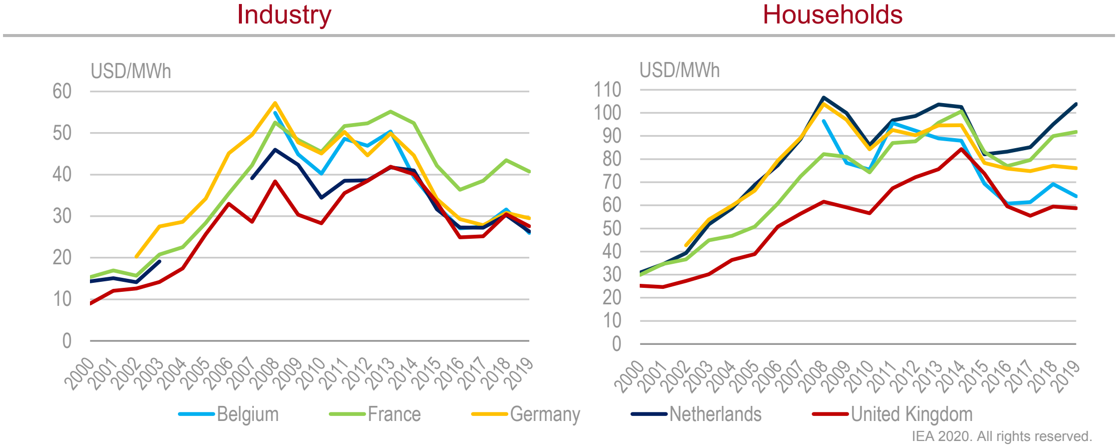


Among IEA member countries, the Netherlands has one of the lowest gas prices for industry but one the highest prices for households and the highest tax rate for households.

Notes: Industry prices are not available for Australia, Japan, Mexico and Norway. Household prices are not available for Australia, Finland, Japan, Mexico and Norway. Tax percentage is not available for the United States.

Source: IEA (2020c), *Prices and Taxes 2020* (database), www.iea.org/statistics.

Figure 8.9 Gas retail prices in northwestern Europe, 2000-19



Because of the highly integrated regional gas markets, gas prices in the Netherlands follow similar trends as in neighbouring countries. Tax policy is the main driver of price differences.

Notes: Data are not available for Dutch industry prices (2004-06) and for Belgium (2000-07), and Germany (2001); for household prices, data unavailable for Germany (2001), Belgium prices (2001-07).

Source: IEA (2020c), *Prices and Taxes 2020* (database), www.iea.org/statistics.

Security of supply

Security of gas supply is of critical importance in the Netherlands. In 2018, gas covered over a third of total energy demand, 51% of electricity generation and 28% of industrial demand. Gas is particularly important to meet heating demand. In 2018, around 90% of residential heating demand was supplied by gas. Gas heating is also of critical importance to greenhouses, which are a core part of the Dutch agricultural sector.

Because of the high level of gas heating, the Netherlands experiences significant seasonal changes in gas demand. In recent years, summer peak gas demand was around 35 GW, while winter peak demand reached almost 110 GW. The Dutch gas network is robust and has been designed to accommodate for seasonal variations in demand through large-scale gas storage and extensive interconnections. The network is also capable of dealing with supply disruptions. Supply can be maintained even under N-1 conditions (loss of the largest single element of gas infrastructure, i.e. the Norg gas storage facility).

Under the Gas Act, there are no requirements placed on system operators or industry participants to hold minimum reserves of natural gas, except that GTS is responsible for reservation of gas volumes and transport capacities necessary to meet increased demand of domestic consumers whenever the effective daily temperature falls below -9°C. GTS uses two facilities to guarantee the supply of protected customers for peak demand: 1) gas stored at the peak shaver installation in Pernis; and 2) gas volumes purchased on the global market by annual tender. The volume contracted by GTS for peak supply is about 95 mcm. This volume follows from the existing Dutch security of supply standard, laid down in the Dutch Gas Act and in the Decision Security of Supply Gas Act. This decision stipulates that GTS should take all necessary measures to allow suppliers of protected customers to satisfy the peak gas demand (volume and capacity) of their customers in the event of exceptionally high gas demand occurring with a statistical probability of once in 50 years.

The ability of the Netherlands to ensure gas security of supply and to meet seasonal demand fluctuations has traditionally relied on Groningen to act as a swing producer. The Groningen phase-out has major implications for gas security of supply in the Netherlands and regionally, especially in those neighbouring countries that have a high use of L-gas. The Netherlands is taking numerous steps to ensure security of supply in line with the Groningen phase-out (Box 8.1).

Box 8.1 Phasing out Groningen while ensuring security of supply

L-gas is critical for security of gas supply in North Western Europe (NWE), and in particular to the Netherlands, Belgium, and parts of France and Germany. In 2018, NWE gas demand was 271 bcm, just over half of total European demand. L-gas covered over 20% of NWE demand (55 bcm) and was concentrated in the Netherlands (25 bcm) and northwest Germany (20 bcm), along with smaller demand in Belgium (5 bcm) and France (5 bcm). In 2018, the NWE L-gas served around 15 million consumers.

Groningen has been the primary source of L-gas supply for the NWE. Small fields in Germany and L-gas produced from H-gas in nitrogen blending plants also contribute to meeting L-gas demand. The majority of L-gas conversion capacity is located in the Netherlands and is owned and operated by GTS. Belgium, France and Germany together have four smaller conversion plants, which are used to cover peak demand.

The Netherlands plans to end production from Groningen as early as mid-2022. To achieve this target, while maintaining national and regional security of gas supply, the Netherlands is undertaking a wide range of measures, including reducing L-gas demand, increasing L-gas conversion and storage, and supporting regional co-operation on security of gas supply. The phase-out plan considers security concerns related to L-gas demand for heating and allows exceptional production from Groningen through 2026 to meet heating demand in the case of a particularly cold winter (MEACP, 2018a).

To support reductions in L-gas demand, the Gas Act was amended in 2018 to oblige the nine largest industrial gas consumers (each with over 100 mcm/y of L-gas demand) to switch to other fuels such as electricity, biomethane or H-gas by 1 October 2022. Gasunie is working on a plan to convert 53 large-scale industrial L-gas users to H-gas between 2020 and 2022. Converting the eight largest L-gas consumers would reduce annual L-gas demand by 2.3 bcm/year. Conversion of the remaining 45 largest L-gas consumers would reduce L-gas demand by an additional 1.1 bcm/year. Gasunie estimates that this plan would increase network tariffs by 1-2% to pay for the needed upgrades and new infrastructure. Reduction in L-gas demand is also supported by the overall gas reduction measures in Dutch policy.

To ensure security of L-gas supply, the Netherlands is increasing L-gas conversion and storage. The capacity of the Norg L-gas storage facility will be expanded from 5 bcm to 6 bcm. L-gas conversion will be increased by operating existing conversion plants at 100%

capacity and investing in new conversion capacity (Table 8.6). The government is aiming for 40 bcm/y of L-gas conversion capacity by 2022.

Table 8.6 L-gas conversion plants, operational and planned, 2020

Plant	Status	Nitrogen capacity (cubic metres/hour)
Wieringermeer*	In operation	295 000
Heiligerlee	In operation	190 000
Ommen	In operation	146 000
Zuidbroek I	In operation	16 000
Pernis	In operation (back up)	45 000
Total in operation		676 000
Zuidbroek II	Planned Q1 2022	180 000

* Includes 80 000 cubic metres/hour of capacity added in Q1 2020.

Source: MEACP (2019), *Preventive Action Plan 2019*, https://ec.europa.eu/energy/sites/ener/files/documents/2019.10.08-nl_-_preventive_action_plan_2019.pdf.

The government is working to reduce regional L-gas demand through the Pentalateral Gas Platform, which is supported by the Benelux Secretariat and is home to the risk group for L-gas created under EU Regulation 2017/1938 for gas security of supply. Through this platform, the Netherlands has developed an indicative plan to gradually reduce L-gas exports to Belgium, France and Germany with an agreement that L-gas exports will end by the gas year 2029/30 (Table 8.7).

Table 8.7 Indicative L-gas export targets (bcm/year), 2020-30

Year	Germany	Belgium and France	Total	Annual reduction
2020	19.0	10.7	29.7	
2021	17.6	9.6	27.2	2.5
2022	13.8	8.6	22.4	4.8
2023	12.0	7.5	19.5	2.9
2024	9.8	6.4	16.2	3.3
2025	7.9	5.4	13.3	2.9
2026	5.7	4.3	10.0	3.3
2027	4.4	3.2	7.6	2.4
2028	3.0	2.1	5.1	2.5
2029	1.1	1.1	2.2	2.9
2030	0.0	0.0	0.0	2.2

Source: Response from the Netherlands to a questionnaire sent out for this report.

The Dutch strategy to ensure gas security of supply is defined in the 2019 Preventative Action Plan and the 2019 Emergency Plan. Together these plans detail the measures to prevent disruptions to the gas supply and to mitigate the impact of any disruption that may occur, especially for protected customers.[2] The Ministry of Economic Affairs and Climate Policy is the national Competent Authority for security of supply. Under the Gas Act, the ministry has delegated certain tasks to the gas TSO, including the responsibility for updating the plans and executing the required risk assessments.

The Preventative Action Plan and Emergency Plan are required under the EU regulation on Security of the Gas Supply (EU 2017/1938), which entered into force in November 2017. The regulation requires EU member states to update these plans every four years starting in March 2019 or more frequently if warranted by circumstances or requested by the EC. To ensure that the emergency plans are always up-to-date and effective, the regulation requires EU member states to carry out at least one test between updates of the plans by simulating high- and medium-impact scenarios and responses in real time. The regulation defines various risk groups to support EU-wide and regional co-operation on gas security of supply. The Netherlands is participating in the risk groups on North Sea gas supply (L-gas, with Denmark, Norway and the United Kingdom), and two risk groups on eastern gas supply (Belarus and the Baltic Sea).

The 2019 Preventive Action Plan indicated that there is a negligible risk for a disruption of the gas supply in the Netherlands. This finding is in line with previous assessments of gas security of supply undertaken by the Netherlands in 2011, 2014, 2016 and 2018. As such, the 2019 Preventive Action Plan does not define any new security of supply measures beyond those already in place under Dutch regulation.

The 2019 Emergency Plan describes the institutional roles and procedures to address a gas emergency. Within the Ministry of Economic Affairs and Climate Policy, the Energy Market and Innovation Directorate holds the operational and co-ordination role in a gas emergency and serves as the National Emergency Security Organisation (NESO). Roles and responsibilities are shared between this directorate (expert input) and the Department Co-ordination Centre of the ministry (policy/co-ordination input). In an emergency, an Energy Crisis Team is set up to monitor the situation, propose measures and ensure communication.

Because of the robust gas system, high interconnection capacity and liquid gas market, the Dutch emergency response strategy relies primarily on market-based measures to address a gas emergency. If these measures prove insufficient to address the emergency, the Emergency Plan defines an escalating series of non-market measures that can be taken (Table 8.8). These measures are designed such that the protected customers will be the last group affected in an emergency. Most of these measures require legislation before they can become effective. As of June 2020, the legislation was still under preparation. The Netherlands currently does not have any demand-side measures to limit gas demand, but this may change with the phase-out of gas production in Groningen.

The government and GTS have recently invested in an emergency communication system which can be used during a disruption. Key stakeholders to address an energy disruption (Director General of Climate Policy and Energy, GTS, and TenneT, the electricity TSO) now have satellite telephones to be used in case of an electricity disruption.

[2] Protected customers in the Netherlands are currently customers who have a connection to the gas network with a total maximum capacity not exceeding 40 cm per hour. The protected customer definition is being revised in line with the requirements of the EU Security of the Gas Supply Regulation 2017/1938.

Table 8.8 2019 Emergency Plan gas crisis response measures

Order implemented	Measure	Type	Customers targeted
1	General call to reduce natural gas consumption	Social	All
2a	Voluntary request to neighbouring countries to reduce gas off-take	International	Unprotected
2b	Request to the European Commission to declare a regional emergency	International	Unprotected
3	Institute an annual savings tender “reduced consumption”	Economic	Unprotected
4	Impose an additional tax on natural gas	Economic	Unprotected
5	Enforced fuel switching for industry	Legal	Unprotected
6	Enforced fuel switching for electricity	Legal	Unprotected
7	Administrative and/or technical disconnection of unprotected customers	Legal/technical	Unprotected
8	Administrative and/or technical disconnection of customers other than protected customers	Legal/technical	Other than protected
9	Invoke mutual solidarity among EU member states	International	Protected
10	Administratively disconnect protected customers	Legal	Protected
11	Technically disconnect regions, including export	Technical	Protected

Source: MEACP (2019), *Preventive Action Plan 2019: The Netherlands*, https://ec.europa.eu/energy/sites/ener/files/documents/2019.10.08-nl_-_preventive_action_plan_2019.pdf.

Natural gas assessment

Natural gas is a critical energy source in the Netherlands. In 2018, gas covered over a third of total energy demand, most heating demand, over half of electricity generation and over a quarter of industrial energy demand. The Netherlands also plays a key role in the regional and European gas markets. It is home to the Groningen gas field, one of the largest fields in the world, has high-capacity gas interconnections, an LNG import terminal and the Title Transfer Facility, the largest gas-trading hub in Europe.

However, in line with the Climate Agreement emissions reduction goals and safety concerns relating to earthquakes caused by gas production, Dutch energy policy is pushing to rapidly and significantly reduce the role of gas in the energy system. A reduction in gas consumption of around 25% (from 40 bcm/year to 30 bcm/year) is expected by 2030, in particular due to reduced demand from heating in buildings and the industry sector. The Natural Gas Free Neighbourhood Programme aims to transition 1.5 million homes from natural gas to low-carbon heating by 2030. In 2018, the Gas Act was amended, banning the connection of new homes and buildings to the gas grid.

Responding to social unrest in the province of Groningen resulting from earthquakes induced by gas production, the government decided to end regular production from the Groningen field as soon as possible, taking into account security of supply. The government estimates that the cost of the damage caused by the induced earthquakes and reinforcement operations are between EUR 3.5 billion and EUR 5.5 billion.

In September 2019, the government issued a decision on the allowed production level in Groningen, setting the extraction volume for a year with average temperatures at 11.8 bcm for the gas year 2019-20, a reduction of nearly 40% compared to the gas year 2018-19. The decision also aims to phase-out production from Groningen as soon as possible, with expected production near zero by mid-2022. The decreased production from Groningen has led to increased gas imports to meet relatively stable domestic gas consumption, and in 2018 the Netherlands became a net gas importer for the first time.

The Groningen phase-out poses challenges for maintaining security of supply, especially in relation to L-gas demand in the Netherlands and other markets relying on Dutch L-gas supply. In 2018, L-gas covered over half of Dutch gas demand and almost all heating demand. The L-gas from Groningen also plays a key role in supplying consumers in Belgium, and parts of France and Germany. The Netherlands has a well-elaborated plan to co-ordinate the Groningen phase-out, both at the national level and with neighbouring countries. Strong measures have been taken to reduce production as quickly as possible (for the safety of people in the Groningen region) and a task force has been set up to monitor the evolution of the low-calorific gas market with Belgium, France and Germany.

The Netherlands is taking numerous steps to compensate for reduced production from Groningen. These include requirements for reductions in industrial L-gas demand; increasing the capacity for L-gas conversion and storage; and co-ordination with Belgium, France and Germany to reduce regional L-gas demand. The gas TSO is also examining the need for increased interconnection capacity. The overall policy push for reduced natural gas demand in the Netherlands will also help to support security of supply.

The PBL's 2019 Climate and Energy Outlook (KEV) estimated that demand from end-uses currently covered by natural gas will stay relatively constant through 2030. However, the 2019 KEV indicates that planned policy measures are expected to push an increasing share of this demand to other energy carriers, including electricity, biogas and low-carbon hydrogen. As a result, natural gas demand is expected to decline from 41% of primary energy demand in 2018 to 20.7% in 2030 (PBL, 2019). The 2019 KEV does not account for all of the measures defined in the Climate Agreement. Consideration of these measures would likely result in a lower estimate for 2030 natural gas demand. The next KEV, which will cover all Climate Agreement policy measures, is expected to be published in October 2020.

The government foresees that natural gas will be an important part of the energy system through at least 2030 and that gaseous energy carriers will play a critical role in supporting the transition to a carbon-neutral energy system by 2050, especially in industry and other areas with limited decarbonisation options. The government seeks to maintain offshore gas production and is executing a broad policy agenda to reduce gas demand and accelerate the production and use of low-carbon gaseous energy carriers.

The government has indicated that small field production will not be increased to compensate for reduced production from Groningen; however, the government is seeking to slow declining domestic production to support security of supply, maintain gas expertise and allow existing offshore gas infrastructure to support CO_2 storage. Production from small Dutch fields has decreased by about 10% per year since 2014. This drop is partly due to decreased investments in exploration and increased operational costs. The 25% investment allowance deduction for offshore gas development costs has proven insufficient to induce the desired exploration and production levels. The government has proposed increasing the deduction to 40% to slow down the expected decrease in production and avoid a premature decommissioning of offshore infrastructure. Th EBN estimates that this policy change would support a total of 22-37 bcm of additional gas production.

The energy transition envisioned in Dutch policy requires quickly reducing natural gas demand while also decarbonising gas supply for end-uses that need gaseous energy carriers. This requires a co-ordinated approach across many sectors and support from a variety of measures, including energy efficiency, electrification, scaling up low-carbon gases and leveraging existing gas infrastructure. The government has numerous programmes to support the energy transition in relation to natural gas, but there is a need for a coherent cross-sectoral vision that helps to manage the transition by identifying in one place how each energy sector and the various transition options can contribute in a mutually beneficial manner.

Natural gas recommendations

The government of the Netherlands should:

- ☐ In collaboration with neighbouring countries, monitor the impact of the phase-out of the Groningen field on domestic supply and on the export of low calorific gas, to ensure security of supply.
- ☐ Analyse the impacts of the Climate Agreement on gas consumption and develop policy options supporting the use of gas infrastructure for other needs, such as transport and storage of CO_2 and low-carbon gases.
- ☐ Clearly define the roles each energy sector and the various options for reducing gas demand and decarbonising gas supply should play to support a co-ordinated and cost-efficient transition away from natural gas.

Hydrogen

The Netherlands aims for low-carbon hydrogen to play a major role in supporting the achievement of emissions reduction targets and has already started a strong policy push for low-carbon hydrogen through the Hydrogen Strategy. The government is developing a broad policy framework under the Hydrogen Programme to scale up low-carbon hydrogen production, infrastructure and demand. The 2019 Climate Agreement and 2020 Hydrogen Strategy define numerous targets and support schemes for low-carbon hydrogen covering a wide range of sectors and applications. The Netherlands is seeking to become a global centre for low-carbon hydrogen and sees low-carbon hydrogen as a key opportunity for economic growth that supports energy transitions.

The Netherlands has numerous assets that could be leveraged to support rapid progress on low-carbon hydrogen. The country already has significant hydrogen production (from natural gas) linked to strong hydrogen demand in the Dutch chemical, petrochemical and refining sectors. The Netherlands plans to rapidly scale up low-carbon hydrogen production in industrial clusters via carbon capture and storage (CCS) and electrolysis powered by renewable energy, with a focus on leveraging the low cost and high availability of Dutch offshore wind generation. The Netherlands is also taking an integrated approach to electricity and gas infrastructure development, with a clear intention to support the production, transport and storage of hydrogen, including by leveraging existing natural gas infrastructure. The Netherlands' central location in Europe, extensive cross-border energy infrastructure and large port facilities also support the potential for the country to play a role in developing a robust regional and global market for low-carbon hydrogen.

Infrastructure

Because of its large chemical and petrochemical industry, the Netherlands is a leading producer and consumer of hydrogen and has extensive infrastructure for hydrogen transport. A 2019 study by the Ministry of Economic Affairs and Climate Policy and the Dutch Technology Industry Employers Organisation (FME) identified over 250 Dutch companies with operations in the hydrogen sector (FME, 2019).

Supply

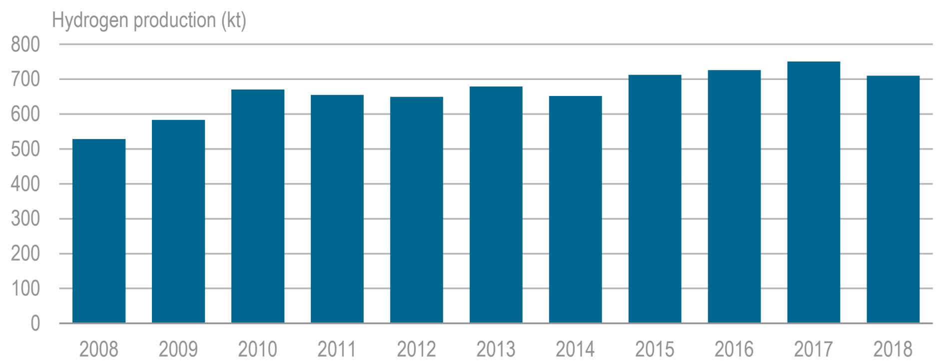
Most of the hydrogen supply in the Netherlands is produced in the five largest industrial clusters of Maasdelta (Rotterdam), Zeeuws-Vlaanderen (Zeeland), Limburg, Eemshaven and IJmond. In 2019, these clusters produced an estimated 175 PJ of hydrogen (Table 8.9) (DNV-GL, 2020a). Production is concentrated in the Maasdelta and Zeeuws-Vlaanderen clusters, which are home to the majority of Dutch chemical and petrochemical facilities (DNV-GL, 2019). Hydrogen production in the Netherlands has has been growing. From 2008 to 2018, hydrogen production associated with the oil refining and key chemical production processes increased by 34% (Figure 8.10).

Almost all hydrogen production in the Netherlands is based on steam methane reforming (SMR) of natural gas. SMR is an energy- and emission-intensive process that uses very high temperatures and steam to drive a catalytic reaction that converts methane (the main component of natural gas) into carbon dioxide and hydrogen. SMR requires substantial natural gas input as both a feedstock and an energy source for the needed heat and steam. In 2019, hydrogen production in the Netherlands accounted for around 10% of total Dutch natural gas demand and resulted in around 7 million tonnes of CO_2 emissions, 5% of total energy-related emissions and over a quarter of industry emissions (MEACP, 2020c). In 2019, SMR hydrogen production costs in the Netherlands were EUR 1.04 per kg (around EUR 3.1 per kWh or EUR 9.1 per mmbtu).

Table 8.9 Estimated Dutch hydrogen production, 2019

Industrial cluster	Hydrogen production (PJ/y)
Maasdelta	67.5
Zeeuws-Vlaanderen	53.5
Limburg	25.8
Eemshaven	18.4
IJmond	9.7
Total	175

Figure 8.10 Estimated hydrogen production in select industries, 2008-18



Sources: IFA (International Fertilizer Association) (2018), *International Fertilizer Association Database*, http://ifadata.fertilizer.org/ucSearch.aspx; Wood Mackenzie (2018), *Methanol Production and Supply Database*, www.woodmac.com/research/products/chemicals-polymers-fibres.

In 2020, there were several small-scale pilot and demonstration projects in the Netherlands producing low-carbon hydrogen via electrolysis, which uses high-voltage electricity to break the atomic bonds of water to produce hydrogen and oxygen. The Netherlands plans to rapidly increase the production of low-carbon hydrogen via electrolysis and using natural gas-based production techniques in combination with CCS.

Demand

Hydrogen demand in the Netherlands is driven primarily by industrial processes that require hydrogen, including oil refining in Rotterdam and Vlissingen, ammonia production in Geleen and Sluiskil, and methanol production in Delfzijl. In 2019, 175 PJ of hydrogen was produced in the Netherlands, primarily to meet demand from domestic industry processes. Dutch hydrogen production also supports regional hydrogen demand via export through a dedicated hydrogen pipeline network. A minor share of Dutch hydrogen demand comes from the small but growing fleet of hydrogen fuel cell vehicles.

In the near term, hydrogen demand in the Netherlands could notably increase to meet a growing demand for low-sulphur transport fuels. In 2020, the International Maritime Organization (IMO) implemented a regulation placing strict limits on sulphur emissions from marine shipping, which has resulted in a notable increase in demand for low-sulphur fuels from the large number of ships that refuel at Dutch ports (see Box 9.1 in Chapter 9). Dutch refineries are a major source of marine fuels and hydrogen is required for the process to produce low-sulphur fuels.

In the long term, demand for hydrogen is expected to greatly increase in the Netherlands, regionally and globally. Dutch industrial demand for hydrogen is estimated to reach up to 250 PJ in 2030. A study by the Netherlands Enterprise Agency (RVO) estimated that in 2050, a fully sustainable energy system could require gaseous energy carriers to cover 30-50% of energy demand (337-775 PJ) (RVO, 2018). The study estimated that this level of demand could be significantly higher than the maximum economic level of Dutch biomethane production and indicated that low-carbon hydrogen would be one of the main options to meet future demand for gaseous energy carriers. Several of the Netherlands' key trading partners are also looking to greatly expand the use of hydrogen.

Pipelines

The Netherlands has an extensive system of hydrogen pipelines that connect hydrogen producers and consumer in the industrial clusters at the Port of Rotterdam and in Zeeland. The hydrogen network at the Port of Rotterdam is owned and operated by Air Products and consists of around 140 km of pipelines (van der Lans, 2019). The Dutch hydrogen network is part of the regional pipeline network owned by Air Liquide, which includes dedicated pipelines for a variety of gases used in industrial processes. The Air Liquide hydrogen network is the largest in Europe and one of the largest in the world, with over 1 000 km of pipelines that extend through the southern Netherlands, Belgium and northern France (Air Liquide, 2020). The Netherlands is examining the option of using existing natural gas pipeline infrastructure.

Transportation sector

Globally, hydrogen use in transport is still in the early stages of development. A few major vehicle manufacturers sell hydrogen fuel cell vehicles in small numbers in limited markets. Hydrogen vehicle fuelling infrastructure has seen limited deployment in a few countries. In May 2020, the hydrogen fuel cell vehicle fleet in the Netherlands consisted of 251 passenger cars, 13 light duty trucks, 7 heavy duty trucks and 11 buses, and 5 hydrogen vehicle fueling stations (Helmond, Rhoon, Delfzijl, Arnhem and The Hague). The Netherlands has plans to significantly increase hydrogen use in transport and is supporting the deployment of additional hydrogen fueling stations (see the section on policy).

Hydrogen projects

The Netherlands is a global centre for hydrogen pilot projects, with numerous completed, ongoing and planned projects across several sectors and applications. In early 2020, the

New Gas Top Consortia for Knowledge and Innovation (TKI) conducted a review of hydrogen projects in the Netherlands,[3] which identified close to 100 low-carbon hydrogen projects covering production, transportation and storage, and use of hydrogen in industry, mobility, electricity generation and heat production (de Laat, 2020). These projects include privately funded commercial endeavours and demonstration projects developed through public-private partnerships or dedicated public funding. Starting in 2020 public funding for low-carbon hydrogen projects, which is currently primarily RD&D support, will be greatly increased and expanded to cover support for low-carbon hydrogen production (see support measure section).

Dutch companies also support hydrogen projects. Several of the largest Dutch companies are part of the Hydrogen Council, a global initiative of leading energy, transport and industry companies with a united vision and long-term ambition for hydrogen to support energy transitions. Three of the Hydrogen Council flagship low-carbon hydrogen projects are located in the Netherlands (Hydrogen Council, 2019).

The largest projects currently planned in the Netherlands are centred on increasing low-carbon hydrogen production to reduce industry emissions. The Port of Rotterdam is an epicentre for several interlinked projects. The H-Vision project aims to convert existing hydrogen production to low-carbon hydrogen via CCS and expand low-carbon production.[4] H-Vision is linked to the Porthos project, which aims for major investments in CCS to allow CO_2 emissions from hydrogen production and other industrial processes in the port to be stored in depleted offshore gas fields (see Chapter 3).

Port of Rotterdam stakeholders are also looking to rapidly scale-up hydrogen from electrolysis, including notable plans to link offshore wind generation with large-scale electrolysers. Two 700+ MW projects that submitted bids in the spring 2020 offshore wind auction came from companies that have indicated the projects could eventually support over 200 MW of electrolyser capacity. Global electrolyser capacity was around 300 MW at the end of 2019 (Parnell, 2020). An estimated 125 MW of electrolyser capacity is expected to be deployed in 2020 (IEA, 2020d).

The Port of Amsterdam H_2ermes project is examining using offshore wind to support 100 MW of electrolyser capacity to be used in chemical processes and steel manufacturing (Port of Amsterdam, 2020). The NorthH2 project (Gasunie and Shell) aims to support low-carbon hydrogen production via electrolysers linked to 3-4 GW of offshore wind generation by 2030 and up to 10 GW by 2040, which would allow up to 800 000 tonnes per year of low-carbon hydrogen production by 2040 (Parnel, 2020). There are several other 100 MW+ electrolyser projects under consideration in the Netherlands and numerous smaller scale electrolyser projects are expected to come on line in the near future. The HyStock pilot project, for instance, includes 1 MW of solar PV, an electrolyser and storage in salt caverns at the Energystock natural gas storage facility. In May 2019, the project started testing production and storage of hydrogen in above-ground gas cylinders. Full operation is planned for 2020 (Energystock, 2020).

[3] www.topsectorenergie.nl/sites/default/files/uploads/TKI%20Gas/publicaties/Overview%20Hydrogen%20projects%20in%20the%20Netherlands%20versie%201mei2020.pdf.

[4] The H-vision project indicates that high-pressure auto thermal reforming is the preferred technology for large-scale hydrogen plants. Auto thermal reforming offers some technical advantages versus SMR, including the ability to control the level of CO (syngas), which is a useful feedstock for industrial processes. As with SMR, auto thermal reforming hydrogen production requires CCS to produce low-carbon hydrogen.

There are notable existing projects capturing CO_2 produced from SMR hydrogen production. The OCAP (Organic CO_2 for Assimilation by Plants) project takes CO_2 coming from SMR hydrogen production at a refinery (and from an ethanol facility in the Port of Amsterdam) and uses it to support agricultural production in greenhouses. The CO_2 is compressed and transported via a network of pipelines to greenhouses in the Western Netherlands. OCAP has been in operation since 2005 and currently supplies around 500 000 tonnes of CO_2 per year to approximately 600 greenhouses, covering 2 500 hectares (OPAC, 2020).

There are also projects looking at hydrogen for electricity generation. The Hydrogen to Magnum project is examining conversion of the existing 1.3 GW Magnum natural gas power plant to partly run on hydrogen. The project plans to use SMR hydrogen production and CCS with CO_2 storage in depleted fields in Norway. The project is looking to test the use of hydrogen in one of the plant's three turbines by 2023 and to be fully operational on hydrogen by 2030 (Vattenfall, 2020).

The Netherlands is examining the potential to use existing natural gas infrastructure for hydrogen. A 2008 project on the Dutch island of Ameland successfully demonstrated hydrogen injection into a small section of the gas grid for use in residential heating and cooking. The project reached shares of up to 20% hydrogen (Quarton and Samsatli, 2018). In 2018, Gasunie completed the first full conversion of an existing gas pipeline to transport 100% hydrogen. The 12 km pipeline transports hydrogen generated as a by-product to a chemical plant that uses the hydrogen as a feedstock. The pipeline started operation in November 2018, with a capacity of four kilotonnes of hydrogen per year (Gasunie and TenneT, 2018).

Gasunie is supporting numerous low-carbon hydrogen projects that aim to leverage existing natural gas infrastructure, including a project aiming to deploy hydrogen storage in salt caverns currently used for natural gas storage by 2024. Gasunie is also aiming to develop a national hydrogen transport network connecting the main industrial clusters and other users and interconnections via existing infrastructure by 2027. Initial steps on the national hydrogen network are being taken in the northern Netherlands, with plans to use gas infrastructure to connect low-carbon hydrogen production, demand and storage in Eemshaven, Delfzijl and Emmen by 2024 (Gasunie, 2020).

In the mobility sector, numerous projects aim to increase the deployment of hydrogen fuelling infrastructure and hydrogen vehicles, especially for public transit and heavy vehicles. Dutch truck manufactures are developing and testing hydrogen powered trucks for freight and municipal waste collection and other applications. There is a project to convert ten inland transport ships serving the Port of Rotterdam to hydrogen and deploy three supporting fuelling stations (de Laat, 2020). From February to March of 2020, a pilot project testing a fuel cell passenger train powered with low-carbon hydrogen was conducted in the Netherlands. The project was undertaken by a local railway operator in the Groningen region and a group of international rail and energy companies that are aiming to introduce hydrogen powered trains in the Netherlands by 2024 (ENGIE, 2020).

Policy

The Climate Agreement defines hydrogen targets for 2025 and 2030 and provides insights into the role hydrogen is expected to play in meeting emissions reduction targets. The Climate Agreement also calls for a Hydrogen Programme to define a policy framework for hydrogen development. A cross-sectoral working group of stakeholders from government, the private sector and research institutes has been set up to develop the Hydrogen Programme. The Top Consortia for Knowledge and Innovation New Gas report Hydrogen for the Energy Transition[5] defines a 2020-30 programmatic approach and will serve as a basis for developing the Hydrogen Programme (Gigler et al., 2020). The government's Hydrogen Strategy, released in March 2020, provides details on supporting measures and identifies key challenges that need to be addressed as the Hydrogen Programme is developed and executed.

Climate Agreement

The Climate Agreement details targets for hydrogen across several sectors and provides the overall direction on how hydrogen could support 2030 emissions reduction targets and 2050 carbon neutrality goals. The Climate Agreement outlines three stages for hydrogen development through 2030, and the Hydrogen Programme will be based in part on these stages. The first stage (2019-21) consists of evaluating existing initiatives, developing plans for the following stages and deploying 20-30 MW of electrolysers linked to renewable generation in industrial clusters, to build experience. The first stage will also examine establishing a hydrogen certification system and changes to regulations to enable network operators to experiment with hydrogen.

The second phase is currently planned to run from 2022 to 2025 and will focus on increasing investment in electrolysis, development of hydrogen demand (especially outside of existing industrial demand), investment in supporting infrastructure and the development of hydrogen clusters. The third phase is planned for 2026-30, with goals to further increase investment in electrolysis (provided there is sufficient renewable generation) and infrastructure for transport and storage.

In relation to hydrogen production, the Climate Agreement gives 2025 targets for 500 MW of electrolyser capacity and 15 000 tonnes/year of hydrogen from biomass. 2030 targets include 3-4 GW of electrolyser capacity and a 65% reduction in electrolysers investment costs (from 1 000 EUR/kW to 350 EUR/kW) to support the goal that hydrogen produced with renewable electricity be cost competitive with other energy carriers. Climate Agreement targets for hydrogen production relate to hydrogen from electrolysis with renewable electricity. The Climate Agreement also indicates that CCUS linked to hydrogen production from natural gas will be a key option for reducing industrial CO_2 emissions (see Chapter 3).

The Climate Agreement's targets for 2025 for the transport sector include 15 000 passenger fuel cell electric vehicles (FCEVs), 3 000 heavy goods FCEVs, 50 hydrogen refuelling stations and a 10% reduction per year in the cost of hydrogen refuelling infrastructure. 2030 targets are for 300 000 FCEVs using 0.14 million tonnes of hydrogen per year. The Climate Agreement also has 2030 targets for 100% of new vehicle sales to be zero-emission vehicles – battery electric vehicles (BEVs) or FCEVs – and for 1.9 million zero-emission vehicles in the total vehicle fleet. It is expected that BEVs will cover the majority of these goals; however, the Netherlands envisions a major

[5] www.topsectorenergie.nl/sites/default/files/uploads/TKI%20Gas/publicaties/7017-TSE%20Programmatische%20Aanpak%20Waterstof_EN.pdf

role for hydrogen in mobility, especially in heavy transport, buses and as a potential replacement for diesel trains. There is a 2025 target that all new buses should to be zero-emission.

The Climate Agreement discusses the important role hydrogen could play in industry, especially for high-temperature processes and as an alternative to coking coal in steel production. The agreement estimates that achieving the indicative 2030 target for industrial emissions reductions could require at least 150-250 PJ/year of low-carbon hydrogen production. The Climate Agreement sees low-carbon hydrogen as essential to maintaining and growing Dutch industrial capacity while meeting 2050 carbon neutrality goals.

The Climate Agreement also indicates the role hydrogen could play in reducing natural gas demand for heating, including options for injecting hydrogen into the existing gas network and direct use for district heating networks. The agreement discusses the opportunities and challenges for these applications, but does not define targets. The Climate Agreement also discusses the important role hydrogen could play in energy storage to meet seasonal heat demand and support integration of variable renewable generation. No targets for hydrogen storage are defined.

The Climate Agreement mandates that statutory and regulatory flexibility should be created to allow gas network operators to gain experience in the transport and distribution of hydrogen. A process has been initiated to enable this through the General Administrative Order on Temporary Tasks under the current Gas Act. The aim is to have this order finalised in 2020 to quickly support increased operational knowledge on hydrogen.

Hydrogen Strategy

In March 2020, the Minister of Economic Affairs and Climate Policy sent a letter to parliament presenting the government's Hydrogen Strategy. The strategy defines policies and measures supporting the achievement of the Climate Agreement hydrogen targets and serves as a guiding document for the development and implementation of the Hydrogen Programme. The strategy gives details on numerous studies, regulatory and legal changes, support measures and projects that the government is planning or currently undertaking.

The strategy notes the critical need for co-ordinated development of the electricity, natural gas and hydrogen networks. The government is supporting this co-ordination through the Main Energy Infrastructure Programme, which is informed by the Infrastructure Outlook 2050, a joint study by the gas and electricity TSOs (Gasunie and TenneT) on integrated energy infrastructure in the Netherlands and Germany. The study provides insights on how electricity, gas, hydrogen and biomethane infrastructure could be developed in a complementary manner (Gasunie and TenneT, 2020).

The strategy sees the use of existing gas infrastructure as key to scaling up the production and use of hydrogen, but notes legal, regulatory and technical challenges to be addressed. The government, Gasunie, TenneT and the DSOs are undertaking a review to determine how gas infrastructure can support hydrogen. The review will identify potential demand, supply and storage capacity, and the potential for the Netherlands to act as a hub supporting the development of a North Western Europe hydrogen market. The Port of Rotterdam supports the review by identifying potential import supply sources.

The government will examine regulatory options for a future hydrogen market, including the operation of a transport network and the role of Gasunie in the hydrogen supply chain. This regulatory review will focus on potential temporary options to quickly develop a viable hydrogen market and on structural roles once this market matures. The main goals are to determine regulatory options that ensure security of supply, keep the social costs of the hydrogen supply chain as low as possible, and support the development of an efficient and liquid market.

The strategy notes that one option to increase demand for low-carbon hydrogen is a blending obligation for the gas grid (either physically or through certificates). The government indicates that physical blending of up to 2% hydrogen is already achievable with minor adjustments to the gas network. Further adjustments could support gradually increasing the hydrogen share to approximately 10-20%. A government study of options for physical and administrative hydrogen blending will be undertaken in consultation with Gasunie, the DSOs and natural gas users to investigate technical, regulatory, safety and price impacts.

The strategy emphasises quickly developing low-carbon hydrogen production in industrial clusters with existing hydrogen demand and discusses the potential for expanded hydrogen infrastructure linking industrial clusters to support scaling up of hydrogen production and industrial use. The strategy indicates that the initial focus will be on conversion of the existing hydrogen supply to low-carbon production via CCS, but notes that hydrogen from electrolysis with renewable energy should be considered in all planning processes for hydrogen production and use.

In May 2020, the Infrastructure Climate Agreement Taskforce (TIKI) delivered a study to the Ministry of Economic Affairs and Climate Policy giving recommendations on developing a Multi-year Infrastructure Energy and Climate Programme. The study details the energy sector infrastructure necessary for achieving the emissions reductions targets (especially for industry), with several recommendations in relation to low-carbon hydrogen and CCS, with a focus on the need for rapid development of supporting infrastructure. The study will inform development of the Industry Memorandum 2050, which will be published in 2020 (DNV-GL, 2020b).

The strategy indicates that a co-operation agreement with key transportation sector stakeholders will be signed in 2020 to support the achievement of the numerous hydrogen targets for mobility. The Hydrogen Strategy also notes that the regional energy strategies being developed to support the Climate Agreement should account for mobility from hydrogen. A Green Deal is being implemented that includes support for hydrogen use in the shipping industry (maritime transport and inland waterways) and in ports.

The strategy also points to the role hydrogen could play in reducing emissions from aviation and notes that the Netherlands is committed to a European sustainable fuel blending obligation for aviation. The government will also unilaterally pursue a national obligation to be implemented as early as 2023. The government and the aviation sector have negotiated a Sustainable Aviation Agreement that includes a target to reach 14% blending of sustainable fuels by 2030 and 100% by 2050. It is expected that a significant share of any sustainable blending obligation for aviation would need to be met with synthetic fuels from hydrogen.

Furthermore, the strategy notes potential roles for hydrogen in the electricity sector as a fuel for electricity generation and as an alternative energy carrier/storage medium to support integration of variable renewables and reduce the need for grid investment. The government will carry out a study in 2020 on linking hydrogen production to offshore wind via integrated tenders and sees this as a key option for supporting significant electrolyser deployment before 2030. The study will examine options for tendering of electrolysis capacity at coastal landing sites for offshore wind generation and the long-term potential for offshore hydrogen production and transport via pipelines as an alternative to subsea electrical cables. The study will consider the results of an offshore hydrogen generation pilot project by the Netherlands Organisation for Applied Scientific Research (TNO) at an existing offshore platform near Scheveningen, which is planned to start in 2020.

The strategy notes that onshore low-carbon hydrogen production and blending into the gas grid would increase the opportunities for decentralised energy production in places where the electricity grid has insufficient capacity. The strategy also points to the agricultural sector as an option for decentralised hydrogen production and demand in heavy farm equipment.

The Hydrogen Strategy cites a March 2020 TNO study concluding that low-carbon hydrogen could make significant contributions to low-carbon heating. The study notes that important questions remain unanswered regarding availability, sustainability, safety and affordability. To help reduce uncertainty and gain knowledge on the use of hydrogen for heating, a number of targeted pilots will be realised from 2020 to 2025 with the potential for larger pilots from 2025 to 2030. Although the government does not expect significant volumes of hydrogen from electrolysis to be available until 2030, heating with low-carbon hydrogen will be added as one of the possible heating options in the study performed by the PBL, which will provide municipalities with information to take well-founded decisions for their Regional Energy Strategies.

In 2020, the Netherlands launched the four-year Hydrogen Safety Innovation Programme. The programme is a public-private partnership between the government, network operators, emergency services, knowledge institutes and companies. It will identify hydrogen safety issues and propose policy solutions. The Netherlands is also pushing for the adoption of European and/or global safety standards for hydrogen.

The Hydrogen Strategy calls for work on guarantees of origin (GOs) to facilitate a market for low-carbon hydrogen. The EU Renewable Energy Directive requires and provides a framework for the development of an EU-wide hydrogen GO system. The Netherlands is seeking co-operation with EU member states to quickly develop an EU-wide GO system and will implement European rules and methodologies for its national GO system as much as possible. The government has indicated that Vertogas, the Dutch company responsible for green gas GOs, will develop the Dutch hydrogen GO system.

Support measures

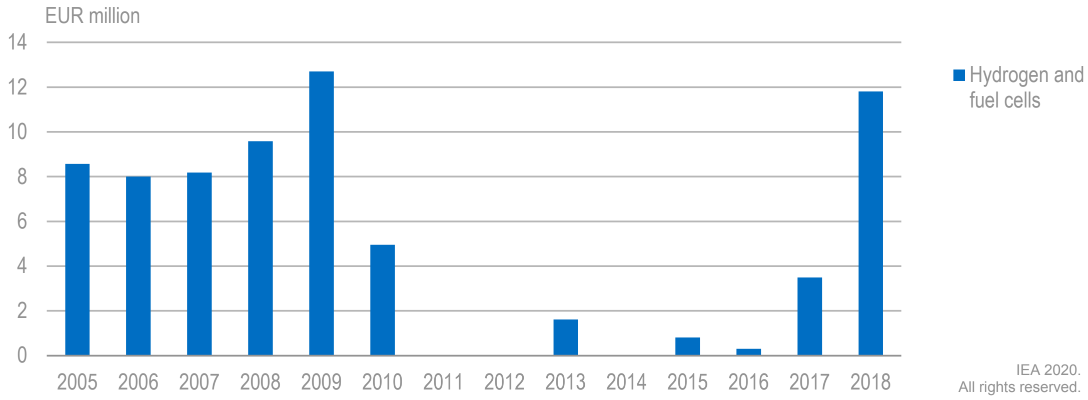
The Netherlands has a variety of support measures to encourage low-carbon hydrogen production and use. These include subsidies for production, tax credits supporting investments in a range of relevant technologies, and a notable RD&D budget and programmes. The main support for low-carbon hydrogen production comes from the SDE++ emissions reduction support scheme, under which hydrogen projects compete on a least-cost basis in an auction process with other CO_2 reduction technologies. It is planned that SDE++ auctions will be held once a year, with the first auction taking place in the second half of 2020. The 2020 SDE++ auction allows bids from low-carbon hydrogen projects based on electrolysis and CCS (see Chapter 6 for details on SDE++).

Zero-emission vehicles (including hydrogen FCEVs) are supported through tax policy, including lower taxes related to company cars. Employees receiving a diesel or gasoline company car must add 22% of the vehicle price to their taxable income. For zero-emission vehicles, the percentage of the company car price added to taxable income is notably less; 4% until the end of 2019 and 8% as of 2020. Zero-emission vehicles do not pay the annual road tax (MRB) or the vehicle registration tax (Bpm). The government is planning to extend the MRB tax exemption through 2025, from which time it will be gradually reduced. Through the Sustainable Procurement Programme and other measures, the government and local and regional authorities act as launching customers for zero-emission vehicles.

RD&D

In 2018, the total energy RD&D budget in the Netherlands was EUR 225 million, a 46% increase from the year before and the highest level of spending since 2010. Hydrogen RD&D funding (including a small share for fuel cells) was stable or increasing from 2005 to 2009, when it dropped drastically in line with the overall reduction in RD&D spending following the 2008 financial crisis (Figure 8.11). Funding levels have increased and in 2018, hydrogen RD&D spending was EUR 11.25 million (5% of the total energy RD&D budget). Recent funding is focused on cost reductions of hydrogen production from electrolysis.

Figure 8.11 Hydrogen RD&D spending, 2005-18



Hydrogen RD&D was drastically reduced in line with an overall drop in RD&D after the 2008 crisis. Funding has been increasing since 2016, reaching 5% of energy RD&D in 2018.

IEA (2020d), *Energy Technology RD&D Budgets 2020* (database), www.iea.org/statistics.

Several RD&D support schemes provide funding for hydrogen along the innovation value chain, from fundamental to applied research to demonstration. The government sees the Demonstration Energy and Climate Innovation grant scheme (DEI+) as a key mechanism to support deployment of hydrogen pilot projects. DEI+ supports projects with potential for strengthening the Dutch economy in terms of GDP; employment; and export by Dutch manufacturers, technical service providers or suppliers. Projects selected for DEI+ funding receive grants covering up to 45% of project costs, with a maximum of EUR 15 million per project (RVO, 2020).

The Netherlands is in the process of implementing the Mission Oriented Knowledge and Innovation Agenda (IKIA), a new framework that aligns RD&D with the goals of the Climate Agreement. The IKIA defines RD&D priorities through 13 Multiannual Mission-driven Innovation Programmes (MMIPs). Three of the MMIPs specifically mention support for low-carbon hydrogen.

- MMIP 6: Creating circular industrial chains, calls for CCUS RD&D, including for hydrogen production.
- MMIP 8: Maximum electrification and radically redesigned processes, calls for RD&D to reduce electrolyser investment costs to 350 EUR/kW to support hydrogen costs of 2.00 EUR/kg by 2030 and 1.00 EUR/kg by 2050.
- MMIP 9: Innovative propulsion and use of sustainable energy carriers for mobility, calls for RD&D supporting zero-emission vehicle propulsion systems (including hydrogen) and hydrogen distribution systems for vehicle refuelling.

In January 2020, the Top Consortia for Knowledge and Innovation New Gas published a dedicated multi-year programmatic approach for low-carbon hydrogen RD&D, based on a survey of hydrogen research defined under the IKIA. The Hydrogen Strategy points to this study as a solid basis for organising and stimulating the necessary innovation in low-carbon hydrogen, indicating that it will serve as a basis for developing the Hydrogen Programme (Gigler et al., 2020).

International co-operation

The Hydrogen Strategy notes that GW-scale deployment of hydrogen in the Netherlands will rely on, and be accelerated by, the development of hydrogen infrastructure and demand in North Western Europe. Increased international co-operation on hydrogen development is needed to drive economies of scale; reduce costs; and support the creation of the infrastructure, regulations, standards and markets needed to bring hydrogen into the energy system in a serious manner. The Netherlands seeks to leverage co-operation on hydrogen through regional, European, and international groups and initiatives. Since 2018, international co-operation is fostered via a dedicated Hydrogen Envoy for the Minister for Economy and Climate Policy.

The Netherlands is pushing for an EU-wide approach on key issues, such as common standards for hydrogen sustainability, safety, quality, blending in gas grids and market regulations. These efforts include investigating the potential for creating an EU Important Projects of Common European Interest Programme to support hydrogen projects. Within the Pentalateral Forum (Austria, Belgium, France, Germany, Luxembourg, the Netherlands and Switzerland), the Netherlands and Austria have taken the initiative to develop common approaches to critical issues such as standards, regulations and incentives (MEACP, 2020c). A joint Political Declaration by Ministers of the Pentalateral Energy Forum on Hydrogen was published in June 2020.

The Netherlands is heavily involved in the European Hydrogen Valleys Partnership, a programme under the EU Smart Specialisation Platform, which identifies regions (valleys) with the potential to drive deployment of technologies supporting carbon neutrality in 2050. The Northern Netherlands is one of four co-ordinating regions under the Hydrogen Valleys Partnership and the first to receive EU subsidies to develop the valley (EHVP, 2019).

Within the North Sea Region (Belgium, Denmark, France, Germany, Ireland, Luxembourg, Norway and Sweden), the Netherlands is pushing for co-operation in offshore wind linked to hydrogen production. The North Sea Wind Power Hub consortium, including the TSOs from the Netherlands, Denmark and Germany, is working to develop a modular hub-and-spoke approach to facilitate large-scale offshore wind deployment linked to hydrogen production as an alternative means of transporting the electricity from wind generation. The optimal hub-and-spoke project size is foreseen to be around 10-15 GW of offshore wind capacity, and a first project could be operational in the early 2030s (NSWPH, 2020).

The Netherlands is also engaged in bilateral co-operation on hydrogen. A feasibility study was recently launched with the German government to review how Dutch and German offshore wind energy could support the scaling up of low-carbon hydrogen production and delivery of this hydrogen to Dutch and German industry through the regional gas network (MEACP, 2020c). There is ongoing work between the Netherlands and Portugal on developing a solar power hydrogen production facility in Sines, Portugal (ECO, 2020).

The Netherlands also participates in international initiatives on hydrogen through the IEA technology collaboration programmes, Mission Innovation, the Hydrogen Initiative of the Clean Energy Ministerial (as a co-lead), and the International Partnership for Hydrogen and Fuel Cells in the Economy. At the level of provinces, there is also increasingly concrete international co-operation on hydrogen projects (e.g. between Groningen and Lower Saxony, between Gelderland and North Rhine-Westphalia, and between Zeeland and West Flanders).

Many of the Netherlands' key energy trading partners for natural gas and electricity are also developing hydrogen policy programmes. France introduced a hydrogen strategy in 2018. Germany's forthcoming hydrogen strategy places an emphasis on availability of clean hydrogen for industry and heavy-duty transport, which could directly correlate with Dutch hydrogen projects. The United Kingdom has numerous advanced pilot projects aimed at the use of hydrogen in the built environment. Norway is working on the production of hydrogen linked with CCUS and maritime applications. The EC has similarly recognised the key role clean hydrogen could play in achieving climate neutrality by 2050 and hydrogen is one of the key priorities in the recently published EU Industrial Strategy and upcoming hydrogen strategy and recovery plan.

Hydrogen assessment

The Netherlands aims to take a leading role in developing regional and global markets for low-carbon hydrogen that support energy transitions and economic growth. The Climate Agreement and Hydrogen Strategy set ambitious targets for low-carbon hydrogen production and use. The Hydrogen Programme is being developed and implemented to help hydrogen play a key role in achieving 2030 emissions reduction targets, 2050 climate neutrality goals and to support the Netherlands' ambitions for leadership in a low-carbon hydrogen market.

The Hydrogen Programme will use a phased and adaptive approach to reduce the cost of low-carbon hydrogen production and develop supporting infrastructure, regulations and markets. The first stage of the programme aims to quickly deploy commercial scale low-carbon hydrogen production to demonstrate emissions reduction potential and provide insights on how broader adoption of hydrogen can be achieved. The following two stages of the programme are still under development, but aim to drive low-carbon hydrogen development in line with Climate Agreement goals through greatly expanded electrolysis capacity, CCS deployment on existing natural gas hydrogen production and use of low-carbon hydrogen in all sectors.

A clear alignment of renewable energy and hydrogen policy would help ensure that renewable generation is available in the quantity and locations to best support low-carbon hydrogen. Replacing the current hydrogen production in the Netherlands with electrolysis would require around 40 TWh of electricity. CCUS also has substantial electricity demand. In 2018, generation from renewables was 18.5 TWh. Even with significant improvement in the efficiency of low-carbon hydrogen production, the deployment levels targeted in Dutch policy require a rapid increase in renewables generation, which needs to be accounted for in renewable energy policy. Aligning hydrogen and renewable energy policy would also help clarify the role low-carbon hydrogen can play in supporting the integration of variable renewables.

Achieving the hydrogen targets requires a co-ordinated scaling up of production, infrastructure and demand. It also entails regional and EU-wide co-ordination. This calls for a transparent flow of information and co-operation between numerous stakeholders. This is especially true for increasing hydrogen demand outside of existing industrial clusters, where experience with hydrogen is limited and supporting policy is dispersed across various programmes. The government should ensure that the Hydrogen Programme is developed through stakeholder engagement from all sectors and create a clear and coherent framework supporting cross-sector co-operation. It would also be helpful for hydrogen to have a dedicated place in the planning process for updating and implementing overall energy and climate policy and to make sure the potential of low-carbon hydrogen is considered in the numerous sector-specific policy measures and programmes.

The Netherlands has numerous RD&D support measures for low-carbon hydrogen with a focus on cost reductions and rapid deployment of demonstration projects. The largest potential funding source for commercial scale low-carbon hydrogen production is the SDE++ subsidy. The government sees a gap between existing RD&D programmes and SDE++ support for commercial scale electrolysis. To address this gap and facilitate scaling-up of electrolysis, around EUR 35 million of the 2021 DEI+ grant budget will be redirected to commercial scale electrolysis projects. The government is also looking to expand support for electrolysis under the EU programme for Important Projects of European Common Interest that allows flexibility in state aid rules.

The 2020 SDE++ auction will limit support for electrolysers to 2 000 full load hours per year,[6] which results in a maximum subsidy of EUR 300 per tonne of avoided CO_2. The SDE++ subsidy can be combined with the DEI+ grant for a total subsidy of up to EUR 1 000 per tonne of avoided CO_2, which is a higher level of subsidy than is offered to other emissions reduction options. The government sees this higher level of support as necessary to drive the deployment of electrolysers. However, it is unclear if this level of subsidy will allow for profitable operation of electrolysers and attract the private investment needed for commercial scale deployment. The high costs of electrolysers require that they be operated as much as possible to generate a return, and electrolysers are more efficient when operated continuously for long periods of time. As such, the restriction of limiting SDE++ support to 2 000 full load hours could limit the ability of SDE++ to encourage commercial scale electrolysis deployment.

The 2 000 full load hour limit is linked to the estimated availability of renewable electricity from the grid in 2030 and is intended to ensure that electrolysers are powered by renewable electricity only, and thus contribute to emissions reductions. It is intended that future rounds of SDE++ will allow support for more than 2 000 full load hours, as the share of electricity generation from renewable energy increases. However, many of the large-scale hydrogen projects currently planned in the Netherlands aim to link electrolysis to a dedicated supply of offshore wind generation, which could easily support more than 2 000 full load hours of annual operation from renewable electricity. If the first round of SDE++ does not result in the desired level of electrolysis projects winning support, the government should consider increasing or removing the 2 000 full load hour limit and study what other changes are needed for electrolysis to achieve commercial scale deployment in the near term.

Additional options to accelerate low-carbon deployment include financial derisking measures (e.g. guaranteed offtake, capital subsidies, loan guarantees), which would support cost reductions and access to private sector funding. The supportive environment provided for offshore wind deployment serves as an excellent example of a coherent policy framework that can reduce risk and spur cost reductions and rapid deployment (see Chapter 6). Other options include a hydrogen-focused implementation of the updated EU Renewable Energy Directive, establishing an obligatory 2030 low-carbon hydrogen target and developing fiscal incentives to position hydrogen as a cost-effective alternative to natural gas.

Another option to help reduce risk and costs for large-scale electrolysis would be to include requirements for electrolysis capacity in the offshore wind tender process or the SDE++ subsidies for onshore renewables. This would allow the extensive experience with private capital financing and project development of renewable energy projects to leverage scaling-up electrolysis capacity. The 2 000 full load hour per year restriction would make no sense in such tenders, as all electricity for the electrolysis process would come from renewables. The government will carry out a study in 2020 on the advantages and disadvantages of linking hydrogen and offshore wind via integrated tenders.

[6] Full load hours are hours of operation at 100% of the rated capacity of the electrolyser. Hours of operation below full capacity are counted based on the level of production. Two hours of operation at 50% capacity translate to one full load hour. The 2 000 full load hour results in a subsidy limit for a certain amount of hydrogen production per year based on electrolyser capacity. An electrolyser with a 1 MW hydrogen production capacity would be eligible for subsidies on production of 2 000 MWh of hydrogen per year. Production beyond this amount is possible, but would not be subsidised.

Blending hydrogen into natural gas and repurposing natural gas infrastructure could also increase demand for low-carbon hydrogen. Given the expected rapid decline in production from Groningen and the policies pushing to reduce natural gas demand, it is imperative that the government quickly determines options for the use of the existing gas infrastructure, especially by identifying key elements of the gas network that are at risk of permanent decommissioning but could play a role in supporting hydrogen.

Based on the results of the upcoming study on hydrogen blending, the government should investigate options for rapid implementation of cost-effective measures supporting the injection of hydrogen into the natural gas grid. A hydrogen blending obligation for the gas grid would help to establish a stable demand for low-carbon hydrogen and send a clear signal supporting investment decisions in hydrogen production.

The government should closely examine the current barriers to scaling-up the use of hydrogen in the built environment, especially as an alternative to natural gas heating. The regional energy strategies offer an opportunity to clearly identify and address the legal, regulatory and technical barriers to broad use of hydrogen in the built environment. Dedicated pilot projects focused on hydrogen use in the built environment will also be critical to build the capacity and knowledge needed for secure and reliable transport and use of hydrogen.

The Climate Agreement requires hydrogen to be included in the comprehensive infrastructure survey for 2030-50, which Gasunie and TenneT will carry out in 2020. This presents an excellent opportunity to develop a more detailed understanding of how infrastructure for hydrogen, natural gas and electricity can be developed in a mutually beneficial manner. It could also serve to identify priority projects and key areas for sectoral and international co-operation. Developing transparent forecasts on hydrogen supply, demand and infrastructure would also be helpful to reduce risk and facilitate investments.

Hydrogen recommendations

The government of the Netherlands should:

- ☐ Drive commercial scale low-carbon hydrogen development in the near term by facilitating investment decisions and creating an adequate support scheme for scaling-up electrolysis, CCUS and supporting infrastructure.
- ☐ Continue its proactive international hydrogen strategy and increase co-operation with neighbouring countries to stimulate the creation of a well-functioning low-carbon hydrogen market, drive down costs, and accelerate scaling-up the production and use of low-carbon hydrogen.
- ☐ Take steps to facilitate transport, storage and trade of hydrogen, including through repurposing of existing natural gas infrastructure.
- ☐ Identify opportunities and barriers for using low-carbon hydrogen as a cross-sector energy carrier and support co-operation among energy sector stakeholders to enable low-carbon hydrogen to increase overall system efficiency, integration of variable renewable energy and cost-effective emissions reductions.

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9. Oil

Key data

(2018)

Domestic oil production*: 24.5 kb/d, -59% since 2008

Net imports of crude oil: 1 277.1 kb/d, +6% since 2008

Domestic oil products production: 1 301.6 kb/d

Net exports of oil products:** 431.8 kb/d, +159% since 2008

Share of oil: 37.0% of TPES**, 42.8% of TFC

Oil consumption by sector: 41.9 Mtoe*** (international bunkering 36%, industry including non-energy consumption 32.9%****, transport 24.1%, energy sector 4.3%, residential, services and agriculture 1.8%, heat and power generation 1.2%)

* Includes crude oil, natural gas liquids, and additives/oxygenates.

** Not including international bunkering fuel.

*** Presented in Mtoe for comparisons over different fuels and sectors, includes oil in TPES and international bunkering.

**** Industry energy consumption was 8.5% and petrochemical industry non-energy consumption was 24.7%.

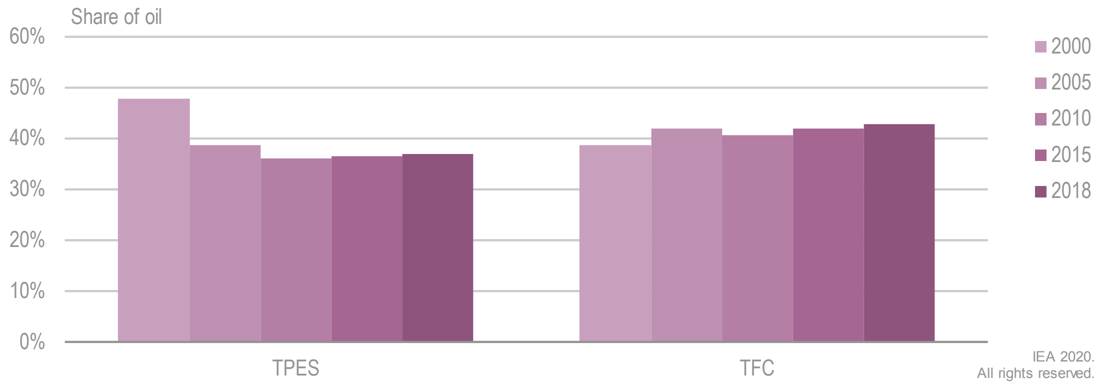
Overview

Oil plays an important role in the Dutch energy system and Dutch economy. In 2018, oil was the second-largest energy source in total primary energy supply (TPES) after natural gas and the largest energy source in total final consumption (TFC). In contrast to natural gas, very little oil is produced domestically. In 2018, domestic oil production covered only around 2% of oil demand. The share of oil in the energy system has been relatively stable for several decades at around 35% of TPES and 40% of TFC (Figure 9.1). Oil product consumption decreased by 14% from 2008 to 2018, in line with a reduction in overall energy demand.

Oil consumption in the Netherlands has several unique characteristics. In most IEA member countries, domestic transport is the main source of oil demand. In the Netherlands, demand from international bunkering and industry are both notably larger than demand from domestic transport. In 2018, domestic transportation accounted for 26% of oil demand while bunkering fuels for international shipping and aviation accounted for over a third of oil demand. Industry accounted for another third of oil demand, mostly for non-energy use in chemical and petrochemical processes. Notably, in 2017 and 2018, the non-energy consumption of oil in the chemical and petrochemical industries surpassed the demand from domestic transport. The Netherlands is also a major refinery hub, with substantial net exports of refined products (equal to about a third of domestic demand), and a major transit country for oil products and crude oil (equal to about the amount of crude oil refined in the country itself).

The Climate Agreement aims to accelerate the transition to a low-carbon economy and includes ambitious emissions reduction goals for industry and transport that will reduce domestic oil demand and require significant emissions reduction measures from the Dutch oil industry.

Figure 9.1 Share of oil in total primary energy supply and total final consumption, 2000-18



The share of oil in TPES and TFC has been stable in recent decades.

Note: TPES = total primary energy supply; TFC = total final consumption.
Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

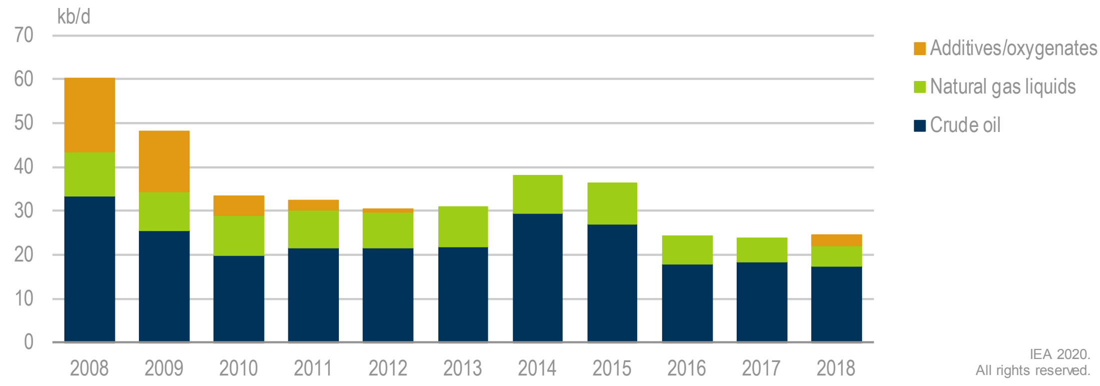
Supply and demand

Oil production and imports

There is limited oil production in the Netherlands. Production fell by more than half, from 60 kb/d (thousand barrels per day) in 2008 to 25 kb/d in 2018 (Figure 9.2). Crude oil accounts for most of domestic production. Natural gas liquids are declining as natural gas production is being phased out. The government expects domestic oil production to slightly increase in the near future; however, in the long-term, Dutch oil production is expected to continue to decline.

Domestic oil production covered around 2% of oil demand from Dutch refineries in 2018. The remaining 98% of the oil supply for refining was imported from a diversified range of countries. In 2018, the Russian Federation was the largest supplier of oil imports for refining, followed by the United Kingdom and Norway (Figure 9.3). Imported oil is used as feedstock by Dutch refineries or shipped to refineries in Belgium and Germany.

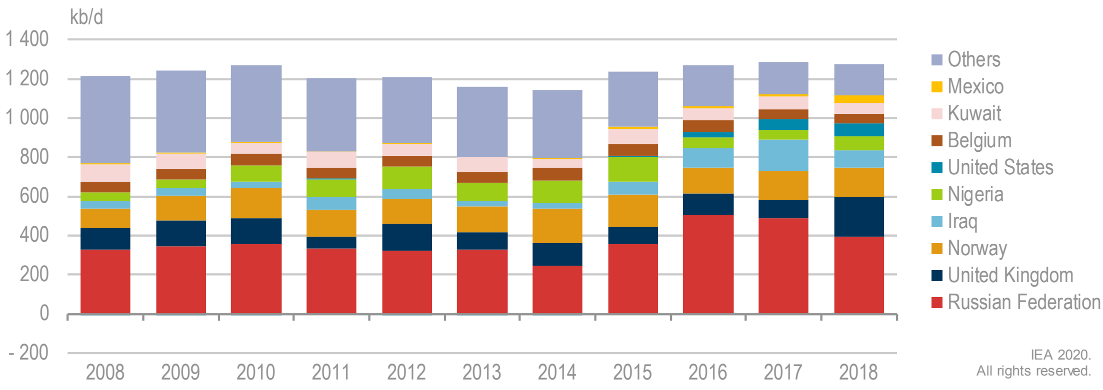
Figure 9.2 Domestic oil production in the Netherlands, 2008-18



Oil production in the Netherlands has fallen by more than half in a decade and covered around 2% of domestic refinery oil demand in 2018.

Source: IEA (2020b), *Oil Information 2020* (database), www.iea.org/statistics.

Figure 9.3 Crude oil net trade by country, 2008-18



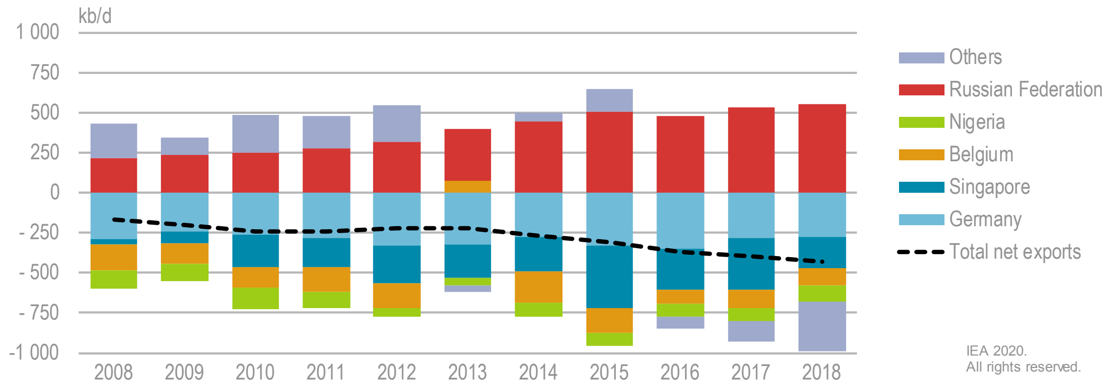
Nearly all crude oil is imported to the Netherlands, with three large suppliers (Russia, the United Kingdom and Norway) accounting for over half of imports in 2018.

Source: IEA (2020b), *Oil Information 2020* (database), www.iea.org/statistics.

Oil products

The Netherlands is a large producer and exporter of oil products and a major trading hub (Figure 9.4). In 2018, the Netherlands produced 1 301 kb/d of oil products, imported 1 930 kb/d and exported 2 361 kb/d; domestic demand was only 890 kb/d (international bunkering represents the main part of the difference between production, net exports and domestic demand). Net exports have increased by over 150%, from 167 kb/d in 2008 to 432 kb/d in 2018. Russia is the largest net supplier of oil products to the Netherlands, while the largest net oil products exports from the Netherlands go to Germany, Singapore, Belgium and Nigeria.

Figure 9.4 Oil products net trade by country, 2008-18

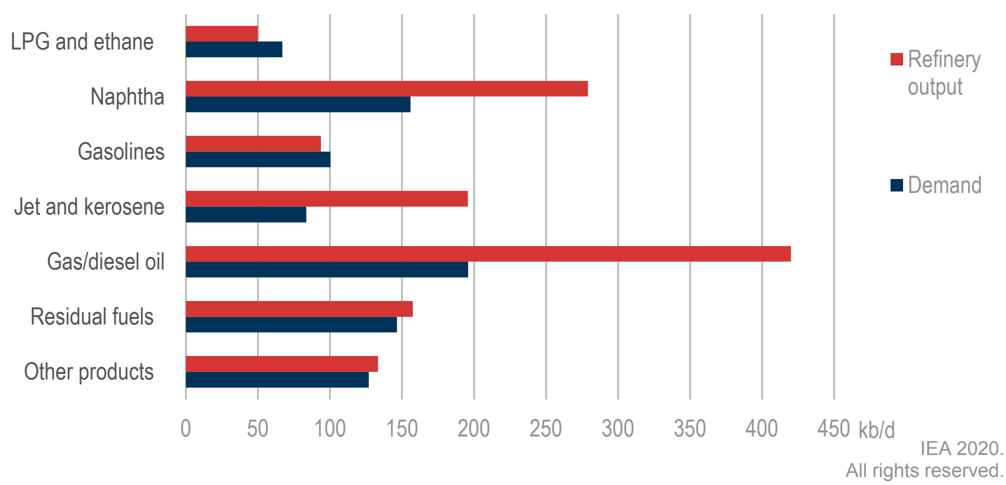


Net exports of refined oil products have increased by over 150% in the last decade.

Source: IEA (2020b), *Oil Information 2020* (database), www.iea.org/statistics.

Thanks to a large refinery capacity, the Netherlands is self-sufficient in most oil products (Figure 9.5). In 2020, domestic refinery output was significantly higher than domestic demand for naphtha, jet fuel and kerosene, and gas/diesel oil. Gasoline and residual fuel oil output also exceeded domestic demand. For liquefied petroleum gases (LPG, including ethane), domestic demand was higher than production.

Figure 9.5 Refinery outputs and domestic demand, March 2020



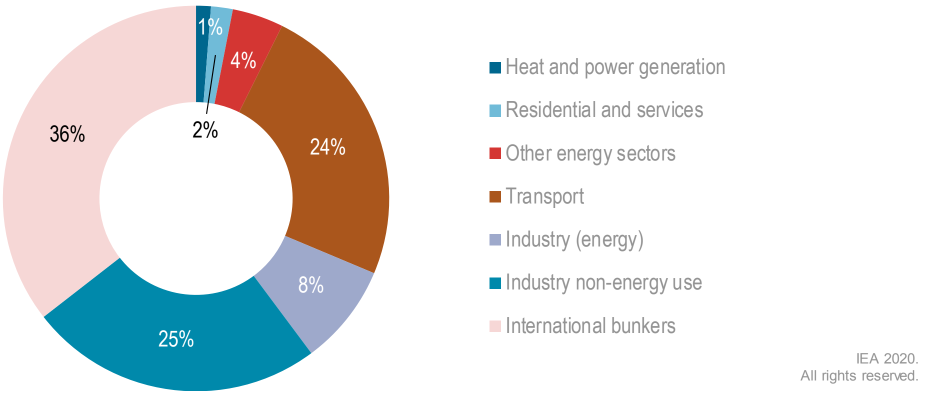
The Netherlands is a net exporter of most oil products, with the exception of LPG and ethane.

Source: IEA (2020b), *Oil Information 2020* (database), www.iea.org/statistics.

Oil consumption

Transport and industry are the main sources of oil demand (Figure 9.6). International bunkering of shipping and aviation fuels accounted for 36% of demand in 2018. Domestic transport, which is the largest oil-consuming sector in most IEA member countries, accounted for less than a quarter of Dutch oil demand. Industry accounted for a third of oil demand, primarily for non-energy uses in chemical and petrochemical processes.

Figure 9.6 Oil consumption by sector, 2018

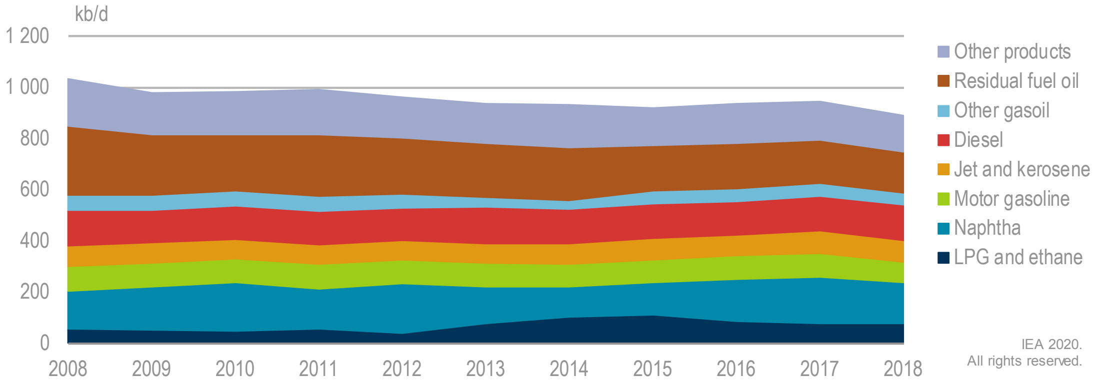


International bunkering fuels and non-energy use dominate oil consumption in the Netherlands. Transport and industry together account for over 90% of oil consumption.

Note: Oil in total primary energy supply plus international bunkering by consuming sector.
Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Oil product consumption in the Netherlands, including international marine and aviation bunkers, declined by 14%, from just over 1 000 kb/d in 2008 to 890 kb/d in 2018, following a reduction in overall energy demand over this period (Figure 9.7). The oil product demand had the following mix in 2018: residual fuel oil (18%) and naphtha (18%), diesel (16%), jet fuel (10%), LPG (9%) and motor gasoline (9%). The notable shares of naphtha and LPG reflect the high demand from the chemical and petrochemical industries. Thanks to the extensive natural gas network, very little oil is used for heating.

Figure 9.7 Oil consumption by fuel, 2008-18



Total oil consumption declined by 14% from 2008 to 2018.

Source: IEA (2020b), *Oil Information 2020* (database), www.iea.org/statistics.

Oil industry

Upstream

Dutch domestic oil production started in the 1940s with the discovery of oilfields near Schoonebeek, in the northeast of the country. Oil production from onshore fields near Rotterdam and Dutch North Sea offshore oilfields started in the 1980s and 1990s. Production at Schoonebeek, the largest Dutch oil field, stopped in 1996 as it was no longer economical. Thanks to new technologies, such as low-pressure steam injection in combination with horizontal wells, production at Schoonebeek restarted in 2011 and is expected to continue at around 14 kb/d up to 2040. However, overall domestic oil production is expected to decline. As of 1 January 2019, Dutch oil reserves were estimated to be 28.6 million m^3 (cubic metres), with 16.8 million m^3 onshore and 11.8 million m^3 offshore. The level of reserves is unchanged from 1 January 2018 and reflects reserves that can be produced commercially and those that are assumed to be commercially viable, which are categorised as production pending.

In 2019, there were 11 oil production clusters in the Netherlands, operated by 5 companies: Dana, NAM (jointly owned by Shell and ExxonMobil), Neptune, Petrogas and TAQA. Dana and NAM are the country's main domestic crude oil producers. The Netherlands Oil and Gas Exploration and Production Association (NOGEPA) is the industry association representing Dutch oil- and gas-producing companies. The Dutch Petroleum Industry Association (VNPI) represents the main companies operating on the Dutch upstream, retail and wholesale oil markets. Companies that are part of VNPI account for 99% of oil production and 80% of oil products sales in the Netherlands (VNPI, 2019a).

Downstream

There are six oil refineries in the Netherlands. Four are operated by the major oil companies Shell, ExxonMobil, BP and Lukoil/Total and two by the trading houses Gunvor and Vitol (VNPI, 2019b). Oil trading is supported by well-developed infrastructure in the Port of Rotterdam, an extensive pipeline system that includes connections to Germany and the Port of Antwerp in Belgium, and significant infrastructure for both inland water and road transportation. The Netherlands has been able to maintain leadership in oil product exports thanks to its strong petrochemical industry. However, the Dutch refining sector is impacted by declining regional demand and increased competition from other global players (the United States, Russia, the Middle East and Asian countries).

Retail

The Netherlands has an open, non-regulated, competitive retail market and does not impose any price control on oil products. Prices at retail service stations are based on supply and demand dynamics. There are many retailers in the Netherlands, including AVIA, BP, Esso, Gulf, Tango, Shell, Tamoil, Texaco and Total. The Dutch Association for Independent Fuel Suppliers on Land and Water (NOVE) is the industry association for independent, private retail and distribution companies that are active in trading, transporting, stockholding and selling of liquids, gaseous fuels and lubricants. NOVE represents 80% of all independent fuel retailers, about 1 400 retail service stations (NOVE, 2019). BETA is an association of independent retail service stations (rented or own license operated) with 450 members representing more than 1 000 retail service stations.

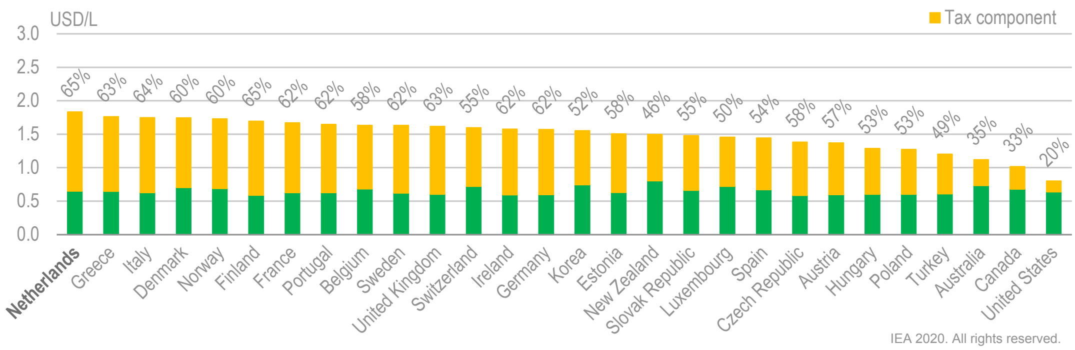
The total number of retail service stations in the Netherlands is more or less stable at around 4 000, with a decline of 3% in the last 15 years. The share of unmanned retail service stations reached 51% in 2018 (2 098 stations) and is increasing (BETA, 2019). Retail service stations in the Netherlands with two or more fuel pumps are obliged to offer E10 at a minimum of half of their pumps since 1 October 2019 onwards. Retail service stations with infrastructure for only one type of gasoline are free to choose which fuel to sell. The majority of cars are already suitable for E10, which contains a maximum of 10% bioethanol by volume (see Chapter 6).

Prices and taxation

In the fourth quarter of 2019, the Netherlands had the highest unleaded gasoline price (USD 1.83/litre) and the highest tax rate (65%) among IEA member countries (Figure 9.8). The price of automotive diesel ranked 11th highest among IEA member countries at USD 1.52/litre (53% tax), close to the median price of IEA member countries (USD 1.41/litre) (Figure 9.9). Fuel oil prices (USD 1.23/litre) were the fifth highest among IEA member countries and had the highest tax rate (63%) (Figure 9.10).

The current vehicle tax system consists of a mix of taxes on the purchase and ownership of each vehicle and the use of fossil fuels via the excise duty scheme. Revenues from taxation of motor vehicles and excise duties on gasoline and diesel rose in 2018. The reason for this increase is growing car sales with a preference for more expensive vehicles and increased diesel and gasoline consumption driven by a shift to heavier vehicles, including SUVs.

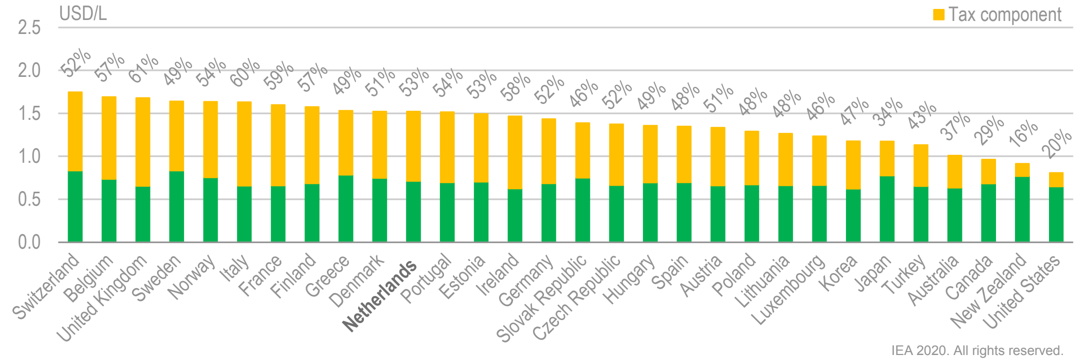
Figure 9.8 Gasoline (95 RON) retail prices in IEA member countries, 4Q 2019



Note: Gasoline data are not available for Japan, Lithuania and Mexico.

Source: IEA (2020c), *Energy Prices and Taxes First Quarter 2019* (database), www.iea.org/statistics.

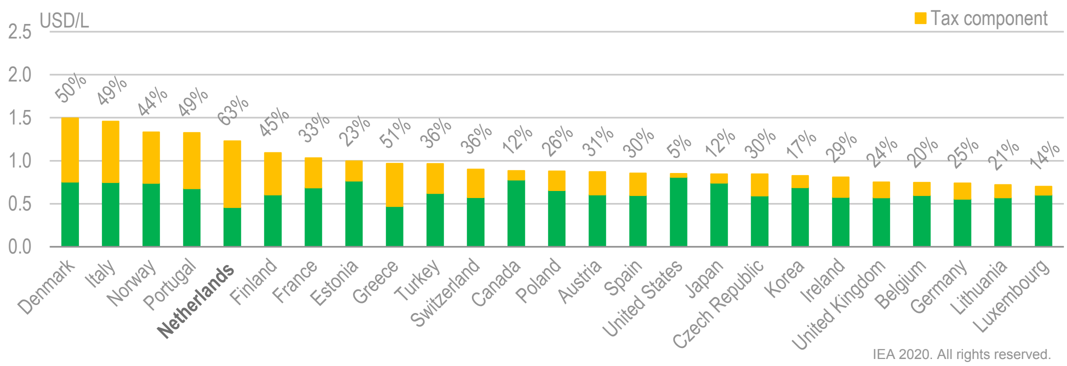
Figure 9.9 Automotive diesel retail prices in IEA member countries, 4Q 2019



Note: Automotive diesel fuel is not available for Mexico.

Source: IEA (2020), *Energy Prices and Taxes Fourth Quarter 2019* (database), www.iea.org/statistics.

Figure 9.10 Fuel oil retail prices in IEA member countries, 4Q 2019



Note: Fuel oil retail are is not available for Australia, Hungary, Mexico, New Zealand, the Slovak Republic and Sweden.

Source: IEA (2020c), *Energy Prices and Taxes Fourth Quarter 2019* (database), www.iea.org/statistics.

Oil policy

In relation to oil, Dutch energy policy focuses primarily on reducing oil demand to achieve emissions reductions in the transport sector in line with the Climate Agreement. The Climate Agreement contains several measures aiming to substantially reduce domestic transportation fuel demand, including a 2030 target for 100% of new passenger cars sales to be emission-free vehicles, a 2025 target for emission-free transportation logistics in cities, a goal for increased emission-free public transportation, and a reduction of road transportation passenger kilometres. Achievement of the 100% emission-free passenger car target currently relies on a mix of supporting measures primarily driven by tax policy (see Chapters 3 and 4). EU targets for biofuels in the transport sectors of all member states (10% by 2020 and 14% by 2030) will also result in a reduction in oil demand through fuel switching to biofuels (see Chapter 6).

The Climate Agreement emissions reduction goals for industry and transport will require strong decarbonisation efforts and will reduce oil demand and product output of the Dutch chemical and petrochemical industry. To support the achievement of the Climate Agreement's emissions reductions goals, the government is establishing the SDE++

support scheme to subsidise investments in emissions reduction measures. A portion of SDE++ funding (up to EUR 550 million per year by 2030) can be used for emissions reduction technologies in the industry sector. The government sees carbon capture and storage (CCS) and low-carbon hydrogen as key technologies to enable the needed industry emissions reductions. Industrial CCS will be supported when SDE++ begins operating in 2020. Low-carbon hydrogen production will also be included in SDE++, but until costs have fallen substantially, it is unlikely that low-carbon hydrogen projects will be awarded any support under the cost-competitive SDE++ auction process. Therefore, low-carbon hydrogen will be supported through programmes funding RD&D and pilot projects that aim to bring costs down (see Chapters 3 and 5).

To encourage emissions reductions in the oil industry (and all other Dutch industries), the government is establishing a carbon levy that will come into effect in 2021. The levy must be paid on industrial emissions above a certain threshold, which will be set by government to drive emissions reductions from industry in line with the Climate Agreement. The emission threshold triggering payment of the levy will be reduced annually through at least 2030. The levy is aligned with the EU Emissions Trading System (ETS), but aims for emissions reductions beyond those required under the ETS and requires a payment on top of any ETS payments. The government is aiming to design and manage the levy in combination with the SDE++ support scheme in a manner that allows domestic companies to stay competitive while investing in cost-effective emissions reductions measures (see Chapter 3).

Energie Beheer Nederland B.V. (EBN) is a state-owned energy company supporting upstream oil and gas investment. As a non-operating partner, EBN is involved in almost every oil and gas project in the Netherlands. EBN takes a share of 40-50% of exploration and production licenses, thereby reducing the risk of upstream oil and gas companies. Any profits generated from EBN's share are paid into the state treasury (EBN, 2020).

In relation to oil supply, there is no specific policy to stimulate crude oil exploration and production on land. The 2017 Coalition Agreement states that no new licenses will be granted for oil or gas exploration on land and, as a consequence, there will be no expansion of oil and gas production on land beyond what is expected under current licenses. New licences for offshore oil and gas production are allowed and there is a deduction of 25% for investments in offshore natural gas exploration and production. However, to date, investments are not taking place at the level the government would like. In response, the government is planning to increase the deduction to 40% and expand it to cover investments in oil and gas exploration and production both onshore and offshore (see Chapter 8). This incentive is aimed at maintaining existing offshore gas and oil infrastructure and the related tax revenue. If effective, the increased deduction could lead to increased oil production, or at least a slower decline in oil production (see Chapter 2 for a discussion on fossil-fuel subsidies).

The International Maritime Organization (IMO) sets limits on sulphur content in marine fuels, which have been progressively tightened to reduce pollution from ships. Starting on 1 January 2020, the sulphur limit for marine bunkering fuels has been reduced from 3.5% to 0.5%. This limit has important implications for the Dutch oil sector, which is oriented towards the export of refined products, and for the Port of Rotterdam, which is a major hub for international shipping and marine bunkering fuels (Box 9.1).

Box 9.1 Impact of IMO 2020 sulphur regulation on the Dutch petrochemical industry

The International Maritime Organization (IMO) is the United Nations' specialised agency responsible for safety and security of shipping and prevention of pollution by ships. Combustion of heavy fuel oil (traditionally the main fuel for ships) results in sulphur oxide (SO_x) emissions, which are harmful to human health and degrade air quality. The IMO regulations for SO_x emissions from ships first came into force in 2005, under Annex VI of the International Convention for the Prevention of Pollution from Ships, and have been consistently tightened since their introduction.

Under the IMO 2020 regulation, which entered into force on 1 January 2020, ships operating outside designated emission control areas must use fuels with sulphur content below 0.5%, a significant reduction from the previous 3.5% limit. While the global average sulphur content in bunkering fuel in 2019 was close to 2.5%, IMO 2020 still requires an overall fivefold decrease in the sulphur content of marine bunkering fuels. Ships sailing in the emission control areas of North West Europe and North America are still subject to the stricter limit of using fuel with a sulphur content below 0.1%.

Ship owners can choose how to comply with IMO 2020. They can use high-sulphur fuels in conjunction with exhaust gas cleaning systems, known as scrubbers. They can use fuels with a sulphur level below 0.5%, e.g. very low sulphur fuel oil (VLSFO), marine gasoil (MGO) or marine diesel oil (MDO). They also can use liquefied natural gas (LNG) as a fuel, but this solution is suitable only for newly built ships with LNG propulsion systems. Driven in part by IMO 2020, global sales of LNG-powered ships increased by 50% in 2019 (HSN, 2020).

The Netherlands is a global centre for the bunkering of marine fuels. IMO 2020 is significantly affecting marine fuel bunkering in the Port of Rotterdam. Bunkering of high-sulphur heavy fuel oil has notably fallen as VLFSO and LNG take an increasing share of marine fuel sales. The share of VLFSO in total fuel oil sales at the Port of Rotterdam increased from 1.8% in September 2019 to 52.0% in March 2020 (POR, 2020). Sales of LNG as a marine fuel at the Port of Rotterdam increased from just 100 tonnes in 2016 to 31 944 tonnes in 2019, sales for Q1 2020 were 15 710 tonnes (The Maritime Executive, 2020; World Marimtime News, 2020).

There are currently three permanent LNG bunkering vessels in the Port of Rotterdam and four additional companies specialising in LNG bunkering currently have licenses to bunker LNG at the Port of Rotterdam. The port expressed interest to become a global leader in LNG bunkering and has an Environmental Shipping Index that awards discounts on port dues to shipping companies with the cleanest ships; including a 10% discount for LNG-fuelled ships (World Marimtime News, 2020).

Dutch refineries are a major producer of marine fuels. In order to meet the IMO 2020 sulphur standard for marine fuels, Dutch refineries will need to produce cleaner fuels, such as VLSFO, MGO or MDO. In 2008, the Energy Research Centre of the Netherlands pointed out that producing low sulphur fuels is technically feasible by converting heavy oil residues into lighter fuel products, but this process is expected to increase refinery energy demand

and potentially increase CO_2 emissions. The ECN study estimated that the investment required for the Dutch petrochemical sector to adjust its refining capacity to produce lower sulphur fuels in compliance with IMO 2020 was EUR 1.5-2 billion (de Wilde, 2008). Two projects were carried out to upgrade refining units at the Pernis and Botlek refineries to allow for low-sulphur fuel production. There is also a low-sulphur fuel project under development at the BP refinery with a final investment decision expected in 2020.

Sources: IMO (2019), *Sulphur 2020: Cutting Sulphur Oxide Emissions*, www.imo.org/en/mediacentre/hottopics/pages/sulphur-2020.aspx; Port of Rotterdam (2020), *Port of Rotterdam Bunker Sales 2017-2020*, www.portofrotterdam.com/en/shipping/sea-shipping/other/rotterdam-bunker-port; HSN (2020), *LNG-Fuelled Ships on Order Rise By 50% in 12 Months Says SEA\LNG*, www.hellenicshippingnews.com/lng-fuelled-ships-on-order-rise-by-50-in-12-months-says-sealng; World Maritime News (2020), *Port of Rotterdam Points to Rise in LNG Bunkering*, https://worldmaritimenews.com/archives/289716/port-of-rotterdam-points-to-rise-in-lng-bunkering; The Maritime Executive (2019), *LNG Bunkering in Rotterdam Takes Off*, www.maritime-executive.com/article/lng-bunkering-in-rotterdam-takes-off.

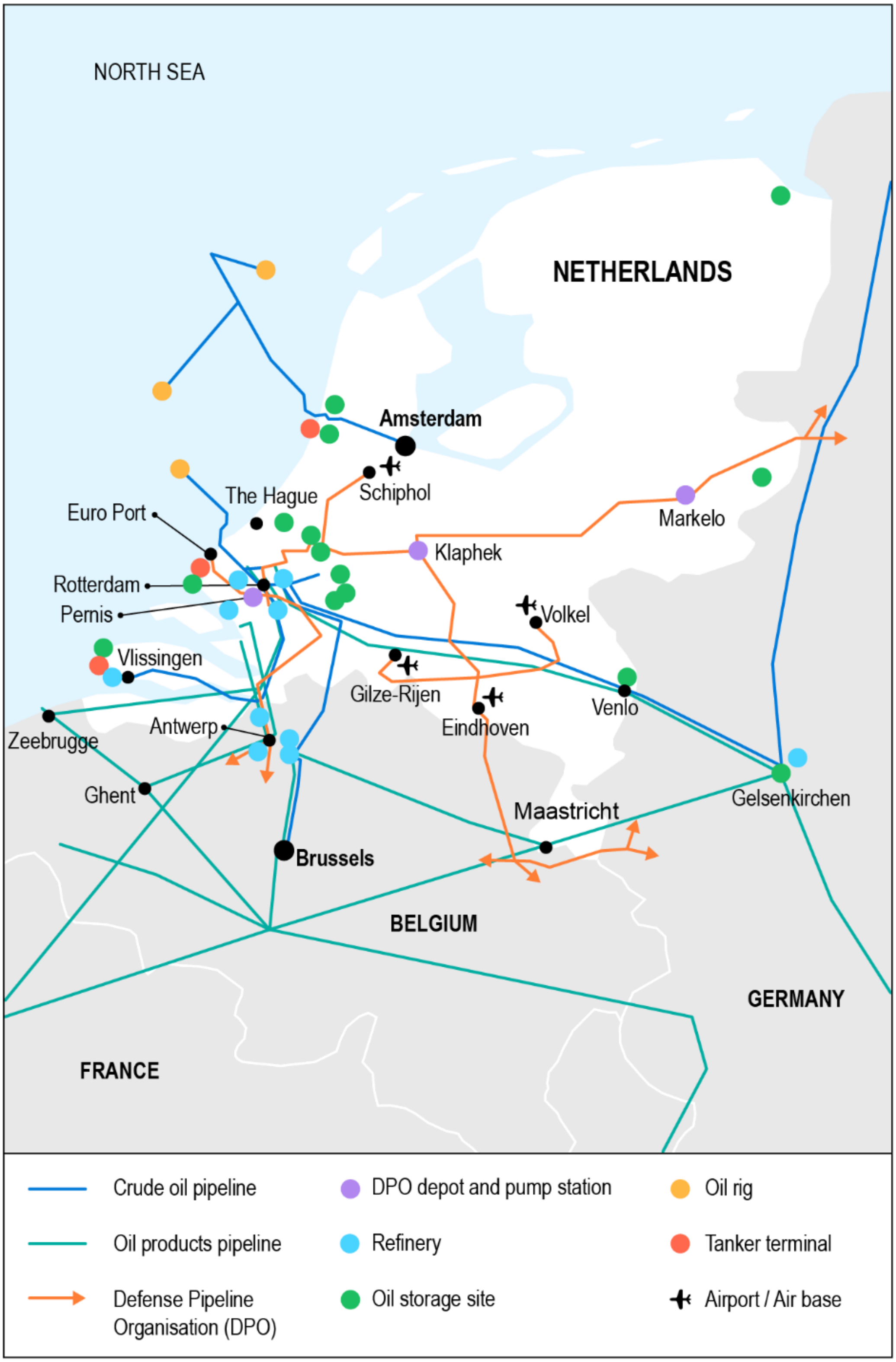
Oil infrastructure

The Netherlands is not a significant oil producer, but its geographic position has helped to make it one of the crucial global oil trading hubs and gives it a major role in the pricing of oil products. Due to its important role in global oil trade, the Netherlands has well-developed infrastructure dedicated to oil, including ports, refineries, pipelines and storage facilities (Figure 9.11).

Ports

Dutch ports are of international importance to global oil trade and the country is the largest hub in Europe for inland waterway trade (Thompson, 2019). The Port of Rotterdam is well connected with the rest of the country and region by river and pipeline and in 2019 was the world's third-largest marine bunker port, after Singapore and Fujairah (United Arab Emirates). The Rotterdam port authority is working to maintain the port's global role in a low-carbon economy with projects including the development of bio-based industries, biofuel production and stockholding, and the Porthos CCS project (see Chapters 3 and 6). The Port of Amsterdam is oriented towards oil products and is one of the most important gasoline stockholding sites in the world and has large fuel blending facilities. Europe's first dedicated plant for the production of sustainable aviation fuel is being planned in the Port of Delfzijl. The plant is planned to open in 2022 and will specialise in sustainable aviation fuel, LPG and naphtha production primarily using regional waste and residue as feedstock (SkyNRG, 2019).

Figure 9.11 Oil infrastructure in the Netherlands, 2019



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Refineries

There are six refineries in the Netherlands, with a total production capacity of 1.3 mb/d (million barrels per day). Five refineries are located in the Port of Rotterdam. The two largest ones have a capacity of 416 kb/d (operated by Shell) and 400 kb/d (operated by BP). The other three facilities are smaller, Botlek: 195 kb/d (operated by ExxonMobil), Europoort: 80 kb/d (operated by Gunvor) and VPR: 80 kb/d (operated by Vitol). The sixth refinery (jointly owned by Total and Lukoil) has a capacity of 147 kb/d, and is located in the Vlissingen Port between the Ports of Antwerp and Rotterdam and is of strategic importance in balancing supply between these major export centres. The country's refined product output has consistently averaged 1.2 mb/d, close to the maximum technical utilisation rate. Most refinery production is exported to Germany, Singapore, Belgium and Nigeria (VNPI, 2019a).

Transport

There are two major crude oil pipelines in the Netherlands: the Rotterdam-Rhine Pipeline (RRP) to the Ruhr region in Germany with a capacity of 400 kb/d, and the Rotterdam-Antwerp Pipeline (RAPL) to Antwerp, Belgium with a capacity of 600 kb/d. The Rhine-Main Pipeline (MMP, also referred to as the RMR) is a major oil product pipeline to Germany, with a capacity of 250 kb/d. In the Rotterdam area and the southwest of the country, a huge grid of pipelines connects port terminals, depots and refineries. Schiphol airport is fed by two product pipelines: the Amsterdam-Schiphol Pipeline (APS) and a pipeline from Rotterdam which is part of the NATO Central European Pipeline System (CEPS) pipeline system. CEPS is an oil products pipeline (mostly for jet kerosene) that is used commercially in times of peace. The Dutch section of the CEPS is called the Defence Pipeline Organisation (DPO) and consists of several dedicate storage facilities and 550 km of products pipelines to various civilian and military airports (Ministry of Defence, 2020).

VELIN is the Dutch Association of Pipeline Owners. The 26 member companies have about 22 000 km of pipelines within the Netherlands: 16 000 km of high-pressure gas transportation pipelines and 6 000 km for long-distance transport of petroleum, petroleum products and chemicals. Within the Netherlands, about 370 million tonnes of oil, oil products and chemicals are transported every year. About 35% of this volume is transported by pipelines (VELIN, 2020). The Netherlands also supplies significant volumes of oil products to Germany and Switzerland via barge transportation on the Rhine River (Thompson, 2019). In recent years, Rhine transportation has been disrupted by low water levels (Knowler, 2019).

Storage

Total storage capacity for oil and oil products in the Netherlands is 38.7 million m^3. Most of this storage is in the Rotterdam area, but Amsterdam and Vlissingen also have abundant storage capacity. In addition to the large storage facilities of the oil companies, several independent tank storage companies have significant stockholding capacities in the Netherlands. The largest storage site is the Maasvlakte Olie Terminal near Rotterdam. A joint venture of BP, ExxonMobil, Kuwait Petroleum, Shell, Total and Vopak, MOT is one of the world's largest oil terminals, comprising 39 crude oil tanks with a total capacity of 28 million barrels (4.4 million m^3). Ultra large tankers can be unloaded at the Maasvlakte Olie Terminal and it is linked by pipeline to the refineries of the associated oil companies. In the east of the Netherlands, near Hengelo, two salt cavern projects for holding of diesel were completed in 2015. Each cavern has a capacity of 150 000 m³ at a depth of 450 metres (300 000 m³ total capacity).

Because of the large storage capacity in the Netherlands, as well as the high number of bilateral agreements the government has concluded, Dutch companies are very active in international stockholding arrangements.

VOTOB is an association representing 17 independent storage operators in the Netherlands, defined as companies providing logistic services to customers without having ownership of the products in custody. These companies store products for customers in tanks ranging from 100 m³ to 100 000 m³.

Security of oil supply

Stockholding regime

The Netherlands meets its IEA stockholding obligations through a mixture of compulsory stockholding requirements imposed on companies and public emergency oil stocks owned by the stockholding agency COVA. In 2012, the Netherlands started implementing the EU Oil Stocks Directive (2009/119/EU) and changed its stockpiling regime. The 2012 Oil Stockpiling Act was approved by the Dutch parliament and entered into force on 1 April 2013. The act sets a legal stockholding obligation of 90 days of net oil products imports of which approximately 75-80% should be held by COVA and 20-25% by refineries and traders. The exact percentage is set each year depending on the volumes sold to the inland market. COVA's operational costs and financial expenses are covered by a stockholding levy on diesel, gasoline and LPG set at EUR 8.00/m³ in the 2012 Stockpiling Act.

Thanks to abundant industry stocks on top of the obligatory stocks, the Netherlands has consistently held stocks well above IEA and EU requirements. However, the Dutch IEA stockholding obligation dropped in 2019, due to declining net imports, which are the basis for calculating the IEA stockpiling obligation. As naphtha is not included in the calculation, its increasing role as a gasoline blending stock has driven the significant decrease in the IEA obligation. In 2018, the net import of naphtha increased with almost 5 million tonnes, whereas domestic consumption of naphtha by the petrochemical industry fell by more than 0.7 million tonnes. The extra naphtha import volume was not used as raw material for the petrochemical sector, but was blended into gasoline, which was exported or consumed domestically. The practice of naphtha blending for export gasoline might increase further with changing fuel specifications. The Netherlands has large blending facilities and the Port of Amsterdam is the world's largest gasoline port (POA, 2020).

The increasing share of biofuels used in the Dutch transport sector could also result in a reduction in net imports of oil products and a lower IEA stocking holding obligation. The impact of biofuels on oil imports will likely grow due to EU directives requiring all EU member states to reach 10% biofuels in transportation consumption by 2020 and 14% by 2030 (see Chapter 6). The Netherlands has not set an obligation on the strategic stockholding of biofuels.

The government considers its current oil stockholding obligation level too low for its domestic security of oil supplies, and its ability to fully participate in IEA collective actions, and is therefore considering to voluntarily increase its emergency oil stockholding from 90 days of net imports (excluding naphtha) to 90 days of inland consumption calculated according the definition of the EU stockholding directive.[1]

Emergency response policy

The Minister of Economic Affairs and Climate Policy is responsible for emergency policy covering oil, natural gas and electricity. The government believes that the market will adequately allocate oil in most crisis situations. Any emergency measures are determined according to the nature and duration of the crisis. However, Dutch oil emergency policy has a strong preference for stock draw to address supply disruptions. Given the limited use of oil in the electricity and heating, fuel switching is not considered a valid emergency response measure. Dutch refinery production is operating close to full capacity, which means that there is little potential for increasing the production of oil products in an emergency.

In the event of an emergency, the Minister of Economic Affairs and Climate Policy has the power to instruct both COVA and private companies to draw down compulsory stocks. The Dutch National Emergency Stockholding Organisation (NESO) advises the Minister of Economic Affairs and Climate Policy and/or the Cabinet on the implementation of emergency measures. During very severe oil supply disruptions, NESO would advocate reducing private and recreational use of oil products to leave industrial economic activities as untouched as possible.

The Netherlands is in the process of updating its oil emergency policies. In 2013, the government started modernising the general emergency laws. The NESO handbook will be updated in 2021 and the government is working on several emergency documents. For instance, to maintain fuel distribution in the event of an electricity supply disruption, the Dutch national plan for diesel distribution will be completed in 2021.[2] Under the plan, critical oil distribution infrastructures will have to be self-sufficient for 72 hours in case of disruption. Seventy-two hours is the expected lead-time before the emergency stock releases can reach the market. An implementation plan will be added to the diesel distribution plan and will contain a list of priority users and the relevant operational procedures. The implementation plan is expected to be completed in 2021.

Emergency oil reserves

As of the end of 2019, 145.6 million barrels of oil stocks were held in the Netherlands. Roughly 43 million barrels of these stocks are held under bilateral storage agreements to benefit other countries in meeting their strategic storage requirements. Total oil stocks held in relation to the Dutch strategic storage requirements equated to 436 days of net imports (263 held by industry and 173 held by COVA). These stocks were held as 42% crude and 58% refined products.

[1] This consumption methodology is defined in the EU stockholding directive Annex II: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02009L0119-20200101

[2] The Diesel Distribution Plan is designed to address disruptions to the electricity supply as the distribution of diesel is essential to support back-up electricity generators for vital sectors (telecom, emergency services, water management, gas infrastructure, etc.) and transportation by emergency service vehicles. In case of a crisis triggered by a fuel supply disruption, emergency stocks of diesel, gasoline and kerosene can be deployed through existing retail networks.

The Netherlands has a mixed system for stock holding, in which both industry and the government agency COVA are required to hold emergency stocks; oil refiners and traders have an obligation to cover 20% of the national 90-day stockholding requirement while COVA is required to hold stocks which cover the remaining 80%. Dutch emergency stocks can be held abroad as long as bilateral agreements are in place. Because of the high cost of domestic storage, COVA holds a notable share of crude stocks in salt caverns abroad. At the end of 2019, COVA held 13.0 million barrels of stocks abroad, primarily in the form of crude oil held in Germany (11.7 million barrels). COVA stored an additional 12.3 million barrels of oil stocks domestically, with 42% of this amount held as crude oil. Company stocks under obligation are emergency stocks which are stored as part (commingled) of normal operating inventories. Many traders on the Dutch market have little or no inventory levels, instead operating just-in-time deliveries from refineries or depots directly to customers by truck. In such instances, companies fulfil their obligation with stockholding ticket contracts.

Oil demand restraint

As an IEA member country, the Netherlands has measures to reduce oil demand during oil supply emergencies. The Dutch demand restraint programme relies on voluntary measures first, before applying mandatory measures. Oil is mainly used in transportation and the petrochemical industry. No assessment has been made on the possible oil demand restraint from petrochemical production, but an assessment on demand restraint contributions from the transport sector was carried out in 2010 by the Energy Centre Netherlands. The 2021 update of the NESO handbook will include new demand restraint measures.

The 2010 assessment of demand restraint in the transport sector examined the potential impacts of Sunday driving bans, work-trip reductions and carpooling to meet the IEA national oil demand reduction target of 7-10% in case of a supply emergency that requires collective action. The assessment estimated that a Sunday driving ban would reduce national oil demand by 1-1.5%. Policies reducing daily commuting were estimated to reduce total oil demand by 0.5-1%. Carpooling was estimated to reduce demand by 0-2.5% with the broad range due to the limited options to encourage motorists to share their vehicles.

Assessment

The Climate Agreement contains numerous measures to reduce fuel demand that will also reduce tax revenues from the excise duties on transportation fuels. The current vehicle tax system consists of a mix of taxes on car ownership and the use of fossil fuels. The government wants to maintain a vehicle taxation system where everyone using road infrastructure contributes to infrastructure costs. This will require a new taxation policy that captures revenue from zero-emission vehicles to replace the reduced revenue from gasoline and diesel taxes without disrupting the goal to increase the share of zero-emission vehicles.

In its assessment of the Climate Agreement, the PBL stated that current incentives for zero-emission vehicles do not support the achievement of the target for 100% of new car sales to be zero-emission by 2030. Even if this target is achieved, a substantial portion of the vehicle fleet will still rely on gasoline and diesel in 2030 and for a significant period after that before older cars are replaced. Therefore, the outlook for domestic transport fuel consumption does not show the drastic decline needed to achieve the transport emissions reductions envisioned in the Climate Agreement. Achieving the desired reductions could require adjusting the zero-emission vehicles incentive scheme and ensuring that substantial volumes of biofuels are available for the vehicles that continue to use liquid fuels. The government will need to closely monitor the actual trend and future outlook for domestic transportation fuel demand to identify the impact of policy on emissions reductions in the transport sector and be ready to implement additional measures to achieve the desired reductions.

The outlook for the economically critical Dutch oil and petrochemical sector is uncertain. The Climate Agreement requires significant emissions reductions from industry and will place a carbon levy on industry emissions. The decarbonisation options for the oil and petrochemical sector are limited and emissions reductions from this sector will have to be achieved largely through CCS and/or low-carbon hydrogen. Both of these options have yet to be developed at a large scale, and their cost effectiveness is uncertain. The oil and petrochemical sector will also be impacted by the reduction in domestic oil demand needed to achieve the Climate Agreement's emissions reduction goals for the transport sector. The PBL and the government conducted studies examining the impact of Climate Agreement's measures on the domestic oil and petrochemical industry. These studies indicated a low risk of carbon leakage. However, given the critical role of this sector in the economy, the IEA recommends that the government monitor closely the impact of Climate Agreement measures on the oil and petrochemical industry.

The Dutch oil and petrochemical industry operates in a very competitive global environment, and relies to a significant extent on exports to international markets where governments are working to reduce CO_2 emissions and the use of fossil fuels. In 2018, 48% of oil product exports went to EU-28 countries (Eurostat, 2019). The Dutch government should therefore closely monitor the impact of policies on the competitiveness of the sector, and support the industry in maintaining its international leadership in a carbon-constrained world.

A clear policy platform supporting the deployment of commercial scale and cost-effective CCS and low-carbon hydrogen would help provide the Dutch oil and petrochemical sector with certainty that it can support the Climate Agreement's goals while maintaining a competitive position. The government should examine how energy RD&D policy, SDE++ and other support schemes can be aligned to bring to market the technologies Dutch industry will need to contribute to emissions reductions in a cost-effective manner.

Climate Agreement goals for transport and EU mandates requiring all member states to increase the share of biofuels in transport will increase biofuels demand in the Netherlands and across the EU. Increasing biofuels demand could create an opportunity for the oil and petrochemical industry to expand its operations in the production, transport and storage of biofuels. The government should examine how it could support industry in moving towards the large-scale production of biofuels and other products that are likely to have a higher demand in a low-carbon economy.

The Netherlands plays a leading role in oil supply security through its strong position in the market for international oil stock tickets. The government has 24 bilateral agreements for strategic oil stockholding, 19 with EU countries and 3 with non-EU countries. The IEA commends this bilateral co-operation and encourages the government to expand efforts to non-OECD countries in Asia-Pacific and Africa, as this would contribute to strengthening global oil security while at the same time providing for effective use of excess oil storage capacity in the Netherlands.

No assessment has been made on oil demand restraint measures from industry and the most recent assessment on demand restraint measures from the transport sector was conducted in 2010. The government should conduct an updated assessment of the impact of oil demand restraint measures covering all sectors, with a special focus on the high demand sectors of transport and industry. The results of this study should be used to inform emergency response policy, including the 2021 update of the NESO handbook.

The Dutch IEA stockholding obligation is falling rapidly, due to declining net imports, which are used to calculate the IEA obligation. The lower net imports are driven primarily by the blending of increasing shares of naphtha in exported or domestically consumed gasoline and could also be impacted by the increasing use of biofuels. In 2019, the IEA obligation had declined to a level that the government considers too low for its domestic security of oil supplies, and its ability to fully participate in IEA collective actions. Therefore, the government is considering voluntarily increasing its emergency oil stockholding to 90 days of consumption. This exceeds the minimum EU stockholding obligation of 61 days of consumption, a level intended for countries with substantial domestic production and which is too low for the Netherlands, which has large net imports.[3] While implementing this commendable policy change, the Netherlands will need to consider the right amount and best mix of oil products, striking a balance between national and international energy security and cost effectiveness.

Recommendations

The government of the Netherlands should:

- ☐ Monitor closely the impact of Climate Agreement measures on the competitiveness of the Dutch oil and petrochemical sector, and assist the sector in transitioning to net climate neutrality.
- ☐ Continue the wide-ranging engagement in bilateral oil stock agreements with IEA member countries, and expand co-operation with non-OECD member countries, thereby contributing to strengthening global oil security.
- ☐ Assess the adequate amount and best mix of Dutch emergency oil stocks, in line with the expected decrease in the Dutch IEA stockholding obligation.

[3] Due to declining net oil imports, the relevant EU stockholding obligation for the Netherlands is 61 days of consumption. This is a minimum threshold intended for countries with substantial indigenous oil production that contributes to security of supply; this is not the case for the Netherlands, which is over 97% reliant on oil imports.

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10. Coal

Key data

(2018)

Imports: 13.0 Mt (8.2 Mtoe), +3% since 2008

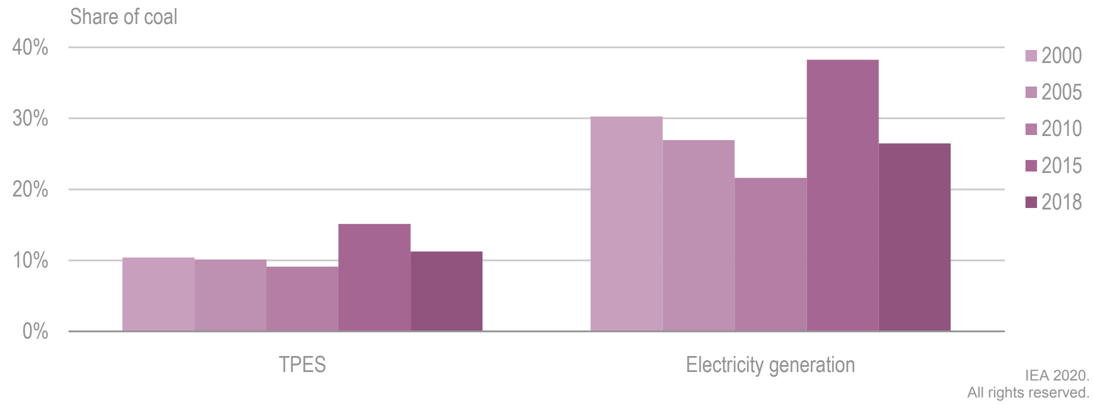
Share of coal: 11.3% of TPES and 26.5% of electricity generation

Consumption by sector: 8.2 Mtoe (heat and power generation 71.5%, other energy [mainly coke ovens and blast furnaces in steel industry] 18.4%, industry [energy use] 10.1%)

Overview

Coal is an important fuel in the Dutch energy supply. In 2018, coal was the third-largest energy source in total primary energy supply (TPES) after oil and natural gas. Coal-fired power plants accounted for almost three-quarters of coal demand and 26% of electricity generation in 2018. Coal is also a critical input for the Dutch steel industry. The share of coal in TPES has been just above 10% for several decades. Use of coal in electricity generation has declined consistently since the 1980s, but increased from 2011 to 2015 as new coal plants were built in response to high natural gas prices (Figure 10.1). Since 2016, Dutch coal consumption has fallen in response to strong policy measures aiming to reduce Dutch CO_2 emissions. A law passed in December 2019 requires an end to the use of coal in electricity generation by 1 January 2029. One coal-fired power plant closed at the end of 2019 in relation to the Urgenda legal case (see Chapter 3).

Figure 10.1 Share of coal in total primary energy supply and electricity generation, 2000-18



The share of coal in TPES has been just above 10% for several decades. Coal-fired electricity generation has been in an overall decline and will end by 2030.

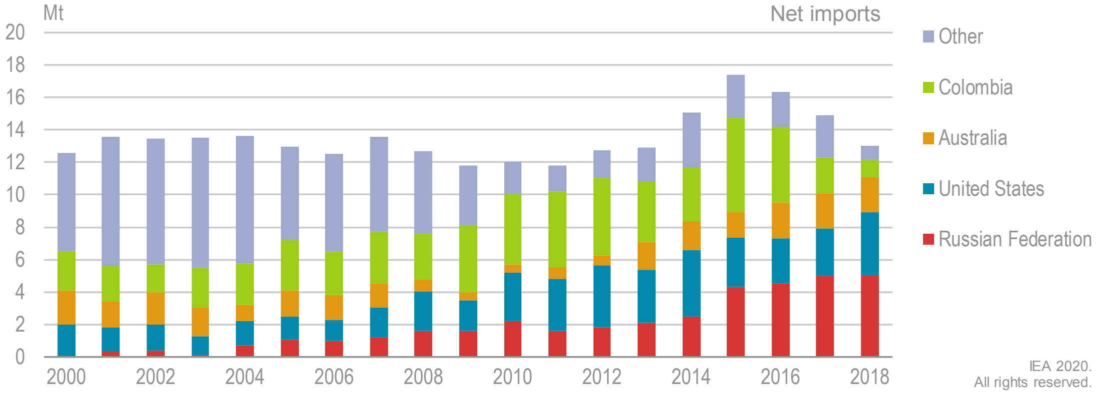
Note: TPES = total primary energy supply.
Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Supply and demand

Coal imports

The Netherlands has no domestic coal production, depending entirely on coal imports (Figure 10.2). In 2018, the country imported 13.0 Mt of coal (8.2 Mtoe). Of this, 39% came from the Russian Federation, 30% from the United States, 17% from Australia and 8% from Colombia. The rest came from a number of smaller suppliers. The variation in coal imports is driven primarily by shifting demand from coal-fired electricity plants.

Figure 10.2 Hard coal trade by country, 2000-18



The Netherlands imports its entire coal supply, mostly from Russia, the United States, Australia and Colombia. Domestic coal production ended in the 1970s.

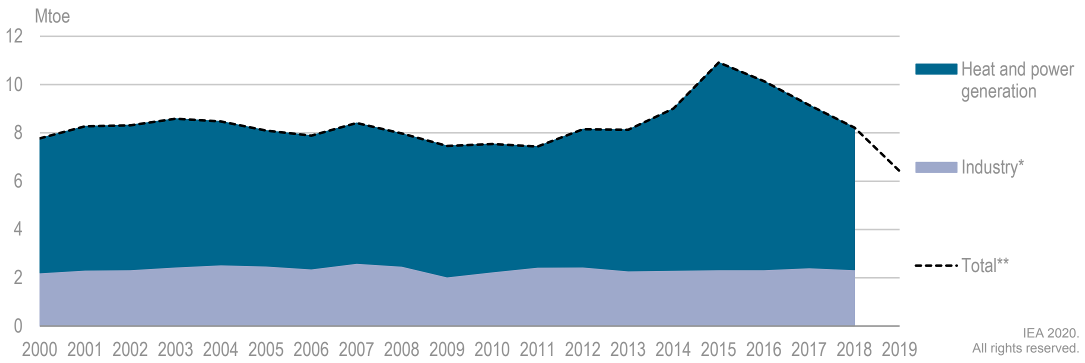
Source: IEA (2020b), *Coal Information 2020* (database), www.iea.org/statistics.

Coal consumption

Dutch coal consumption in 2018 was 8.2 Mtoe. Steam coal used for heat and electricity generation accounted for 72% of consumption (5.9 Mtoe). Coal-fied power plants generating only electricity consumed 89% of steam coal while 11% of was consumed in combined heat and power (CHP) plants. Twenty-nine per cent of total coal consumption (2.32.4 Mtoe) was coking coal and pulverised coal injection (PCI) used in the steel industry. While industrial demand for coal has remained stable, demand for coal in heat and electricity generation has varied significantly since 2011 (Figure 10.3).

From 2011 to 2015, demand from coal-fired power plants increased from 5.0 Mtoe to 8.6 Mtoe. This growth resulted from higher natural gas prices that drove a shift to coal-fired generation and the construction of three new coal-fired plants in 2015 with a combined capacity of 3.47 GW. Coal-fired generation increased from 25 TWh in 2011 to 42 TWh in 2015. However, starting in 2016, changing market conditions and increasingly strict policy measures began to reduce coal-fired generation, which decreased to 30 TWh in 2018. Demand from coal-fired generation dropped to 5.9 Mtoe in 2018. Statistics Netherlands indicated that in 2019, coal demand for electricity generation continued to rapidly decline. Dutch coal-fired power plants generated only 17 TWh in 2019, the lowest level of coal-fired generation in the Netherlands since 1985 (CBS, 2020).

Figure 10.3 Coal consumption by sector, 2000-18



Steam coal used for heat and power generation accounted for 72% of total coal consumption in 2018; the remainder was coking coal and pulverised coal injection for steel manufacturing.

* *Industry* includes coke ovens and blast furnaces.

** *Total* includes 2019 estimate.

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Policy

The 2017 Coalition Agreement called for a ban on the use of coal in electricity generation by 2030. On 11 December 2019, the Netherlands passed a law requiring an end to the use of coal in electricity generation by 1 January 2029. The coal ban law gives coal-fired power plants a transition period intended as in-kind compensation to allow plants to continue generating revenue and facilitate their transition to alternative fuels. The length of the transition period is based on plant efficiency. Older plants with an efficiency of less than 46% must stop using coal by 1 January 2025. Newer plants with efficiencies greater than 46% must stop using coal by 1 January 2030. At these dates, the plant must have fully converted to alternative fuels or it must be shut down. Table 10.1 gives the impact of the law on the four operating coal plants (MEACP, 2019).

Table 10.1 Coal ban impact on Dutch coal fleet

Plant name (*operator*)	Capacity (GW)	Commissioned	Ban on coal use
MMP 3 (*UNIPER*)	1.07	2015	1 January 2030
Centrale Rotterdam (*Riverstone*)	0.73	2015	
Eemshaven (*RWE*)	1.6	2015	
Amercentrale (*RWE*)	0.6	1993	1 January 2025

As a result of the Urgenda legal ruling, the Dutch state is required to take action to reduce greenhouse gas (GHG) emissions by 25% by 2020 compared to 1990 levels (see Chapter 3). To support the achievement of the Urgenda target, the 0.63 GW Hemweg 8 coal-fired power plant was permanently closed at the end of 2019. The Dutch Cabinet and Vattenfall, the operator of the Hemweg 8 plant, have undertaken a joint investigation to determine financial compensation for the plant closure. The level of compensation cannot be higher than actual damages and will consider loss of income, costs for early termination of contracts, costs for employees who lost their jobs due to the plant closure and other factors.

Along with the closure of the Hemweg 8 coal plant, the government has implemented numerous additional measures to support the achievement of the Urgenda target. However, 2019 analysis by the Netherlands Environmental Assessment Agency (PBL) indicated that the Netherlands is not track to achieve the target. The PBL expects an emissions reduction of 23% in 2020. In response, the Dutch Cabinet introduced a plan in April 2020 for additional GHG reduction measures that can be implemented quickly, be as cost-effective as possible, and be supported by citizens and companies. The largest emissions reductions are expected to come from a measure to reduce coal-fired generation as much as possible while maintaining a secure supply of electricity. Additional measures primarily focus on energy efficiency in industry, construction, the built environment and agriculture. The largest measure in terms of funding is an expansion of the 2020 budget for the SDE+ renewable support scheme from EUR 2 billion to EUR 4 billion.

A July 2018 report developed for the Ministry of Economic Affairs and Climate Policy examined the effect of the coal ban and the carbon floor price (see Chapter 2) on the Dutch electricity system. The report concluded that the coal ban achieves notable CO_2 reductions while slightly increasing electricity costs and moderately affecting energy security with slightly lower but still positive capacity margins and increased electricity imports at hours of peak demand (Frontier Economics, 2018).

In 2016, the Netherlands awarded subsidies for biomass co-firing to the MMP 3, Rotterdam, Eemshaven and Amercentrale coal plants, which the plants received through the SDE+ scheme. The goal of the subsidies was to support achievement of the 2020 renewable energy target (see Chapter 6). Subsidies of USD 99/MWh to USD 111/MWh were awarded for a period of 8 years with a supporting budget of EUR 3.6 billion.

The 2017 Coalition Agreement called for an end to new subsidies for co-firing biomass in coal-fired power plants. On 6 December 2017, the Ministry of Economic Affairs and Climate Policy sent a letter to parliament indicating that as of the first round of SDE+ in 2018, the co-firing of biomass in coal plants will not be eligible for SDE+ support (MEACP, 2017). This decision does not affect the SDE+ subsidies awarded in 2016.

The Climate Agreement's emissions reduction goals for industry require strong efforts by the Dutch steel industry to reduce its emissions related to coal consumption. To support the achievement of the Climate Agreement's emissions reductions goals, the government is establishing the SDE++ support scheme to subsidise investments in emissions reduction measures. A portion of SDE++ funding (up to EUR 550 million per year by 2030) has been earmarked for emissions reductions in the industry sector.

The government sees carbon capture and storage (CCS) and carbon-free hydrogen as key technologies to enable the needed industry emissions reductions. CCS in the industry sector will be supported when SDE++ begins operating in 2020. Carbon-free hydrogen production will not be included in SDE++ until its costs have fallen substantially, but it will be supported through programmes funding RD&D and pilot projects that aim to bring costs down (see Chapters 3 and 5).

To encourage emissions reduction in the steel industry (and all other Dutch industries), the government is establishing a carbon levy that will come into effect in 2021. The levy must be paid on industrial emissions above a certain threshold, which will be set by the government to drive emissions reductions from industry in line with the Climate Agreement. The emission threshold triggering payment of the levy will be reduced annually through at least 2030.

The levy is aligned with the EU Emissions Trading System (ETS), but aims for emissions reductions beyond those required under the ETS and requires a payment on top of any ETS payments. The government is aiming to design and manage the levy in combination with the SDE++ support scheme in a manner that allows domestic companies to stay competitive while investing in cost-effective emissions reductions measures (see Chapter 3).

The Netherlands has a broad energy tax that covers consumption of gas, electricity and districting heating. Most energy products and fuels used to generate electricity are exempted from the energy tax, but the energy tax must be paid for coal consumption by coal-fired power plants.

Assessment

Coal plays a major role in the Dutch energy system. In 2018, it was the third-largest energy source in TPES and the second largest in electricity generation. Coal is mainly used for electricity generation, including a small share supporting CHP plants. Coal is also used in the Dutch steel industry. There is no domestic coal production; the entire coal supply is imported.

In 2018, Dutch coal consumption was 8.2 Mtoe. Dutch coal consumption peaked in 2015 in response to increased natural gas prices that drove a shift to coal-fired generation and the construction of three new coal-fired power plants. Coal consumption has been falling steeply since 2016, reaching the lowest level seen in decades in 2019. The sudden decline is due to changing market conditions and strict new policy measures aimed at sustained emissions reductions. Coal consumption will likely continue to fall in the coming years in response to strict new emissions reduction measures.

The Netherlands passed a law in December 2019 requiring an end to the use of coal in electricity generation by 1 January 2030. The Amercentrale coal plant, which began operating in 1993, has an earlier deadline to stop using coal by 1 January 2025. The coal ban law mandates that the four coal-fired plants operating in the Netherlands fully convert to alternative fuels or shut down. All four coal plants are moving towards increased co-firing of biomass to maintain operations. As a result of the Urgenda legal case, the Hemweg 8 plant was permanently closed at the end of 2019.

In 2016, the Netherlands awarded subsidies for biomass co-firing through the SDE+ scheme. The Amercentrale coal plant already had the infrastructure necessary to co-fire biomass at high levels and began co-firing in 2016. In 2018, Amercentrale was running on 80% biomass. The Maasvlakte 3, Rotterdam and Eemshaven plants have only been in operation since 2015 and required more time to begin substantial biomass co-firing. All three plants invested in co-firing capabilities and in 2018 were running on 15-25% biomass.

To remain operating beyond 2030 (2025 for the Amercentrale plant), Dutch coal plants have to convert to 100% biomass. The plant operators have indicated an interest in investing in full biomass conversions to keep the plants open. This raises the importance of robust sustainability criteria given the large volumes of imported biomass that would be required (see Chapter 6).

Uniper, the German company operating the MMP 3 coal plant, announced in January 2020 that it will take the government to court seeking financial compensation in relation to the coal ban. RWE, the German company which operates two of the other coal-fired plants, has also indicated that it plans to go to court for financial compensation.

A report developed in July 2018 for the Ministry of Economic Affairs and Climate Policy analysed the effect of the coal ban on the Dutch electricity system. The analysis was conducted in relation to a reference case based on current policy that strongly pushes for increased generation from renewable energy. In relation to the reference case, the report estimated that the coal ban would reduce CO_2 emissions by an additional 18 Mt by 2030. The ban would also increase electricity prices by up to EUR 1.4/MWh in 2030 (Frontier Economics, 2018).

The report also examined the effects of the coal ban on security of supply in terms of: the adequacy reserve margin; the utilisation of import capacity in peak demand hours; and the contribution of imports to residual load in peak demand hours. The report concluded that with the coal ban, the adequacy reserve margin remains positive, the utilisation of interconnectors increases by one-third in peak demand hours and the import contribution in peak demand hours grows from 29% (reference case) to 44% (with coal ban) in 2030. The report reference case foresees that due to the deployment of significant energy generation from renewable sources, the Netherlands will become a net exporter of electricity around 2023, with increasing net exports through 2030. The report estimated that this is still case with the coal ban, however with lower exports; reference case net exports would be 39 TWh in 2030 while with coal ban they would be 22 TWh.

The report analysing the coal ban does not specifically examine the effects the ban could have on security of supply in relation to the planned rapid expansion of generation from variable renewable energy (VRE). To meet the Climate Agreement emissions reduction target, it is envisioned that VRE generation (onshore and offshore wind and PV) would reach 84 TWh in 2030 (up to 70% of total electricity generation). In 2018, VRE generation was around only 14 TWh and 12% of total electricity generation (see Chapter 6). The government should expand the analysis of the coal ban, including the potential for plant closures and 100% biomass conversions, to examine how the ban could impact security of supply in relation to integrating the envisioned high shares of VRE generation.

Support for CCS in the 2020 round of SDE++ funding should provide the Dutch steel industry with an opportunity to lower CO_2 emissions. Current steel production processes require coal as an input and CCS is one of the few opportunities to reduce the steel industry's coal-related emissions. In the longer term, government support for carbon-free hydrogen could also present an option for reduced steel industry emissions from coal, but this will require innovations to replace coal with hydrogen in steel production processes.

Recommendations

The government of the Netherlands should:

- ☐ Facilitate the use of CCUS and carbon-free hydrogen to help the steel industry address CO_2 emissions from coal.
- ☐ Examine how the coal ban could impact security of supply of electricity, particularly in relation to integrating the envisioned high shares of variable generation from wind and solar PV.

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11. Nuclear

Key data

(2018)

Number of nuclear reactors active in the electricity market: 1

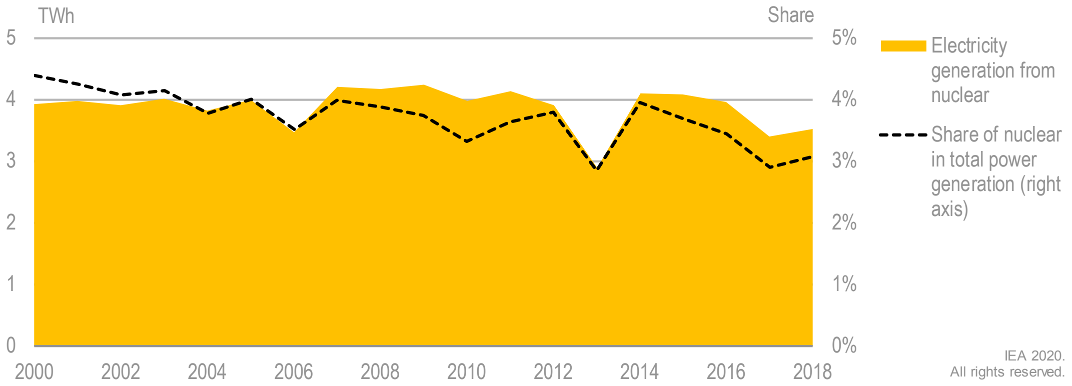
Installed nuclear generation capacity: 485 MW

Nuclear electricity generation: 3.5 TWh (3.1% of generation) -16% since 2008

Overview

The Netherlands has a small but diverse nuclear sector. The only nuclear facility delivering electricity to the grid is the 485 MW Borssele nuclear power plant. From 2008 to 2018, generation from the Borssele plant was relatively steady, at around 3.5-4 TWh per year. Over the same period, the share of nuclear power in total electricity generation slowly declined, from around 4.5% to 3.1% (Figure 11.1). Besides the Borssele power plant, the Netherlands has two research reactors, a nuclear enrichment plant and a central national storage facility for radioactive waste.

Figure 11.1 Nuclear power generation and share in electricity generation, 2000-18



Nuclear power makes a small but relatively stable contribution to the electricity generation mix.

Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Borssele plant

The Borssele plant is the only commercial nuclear plant in the Netherlands. It is a two-loop Siemens pressurised water reactor with an electrical generation capacity of 485 MW. In 2018, the plant generated 3.5 TWh (3.1% of total electricity generation), a slight reduction from the generation of around 4 TWh seen from 2008 to 2018. Over this period, the plant's capacity factor averaged around 95%. The global nuclear fleet's capacity factor fell below 80% in 2018 (World Nuclear Association, 2019).

The plant has been in commercial operation since 1973. It was initially given an indefinite licence and a planned lifetime of 40 years (corresponding to a 2013 shutdown date). Political discussions from 1995 to 2006 led to an agreement, approved by parliament in 2006, setting a 31 December 2033 shutdown date. This shutdown date was later incorporated in the Nuclear Energy Act (NEA), the main piece of legislation covering the Dutch nuclear sector. To extend the design lifetime of 40 years to 60 years, the license holder demonstrated that the Borssele plant could operate safely until the end of 2033 (UNECE, 2015).

In 2017, Delta N.V., the main owner of Borssele plant, was split into three separate companies. This was mandated by national legislation requiring unbundling of generation and network activities. Since this time, the operator and licence holder of the Borssele plant is the Dutch company EPZ, whose shares are held by the energy production and trading companies PZEM (70%) and Essent/RWE (30%) (ANVS, 2019). Currently it is planned that the Borssele plant will be decommissioned immediately upon shutdown in 2033 and that EPZ will hire an external company to dismantle the facility (IAEA, 2019).

Institutions

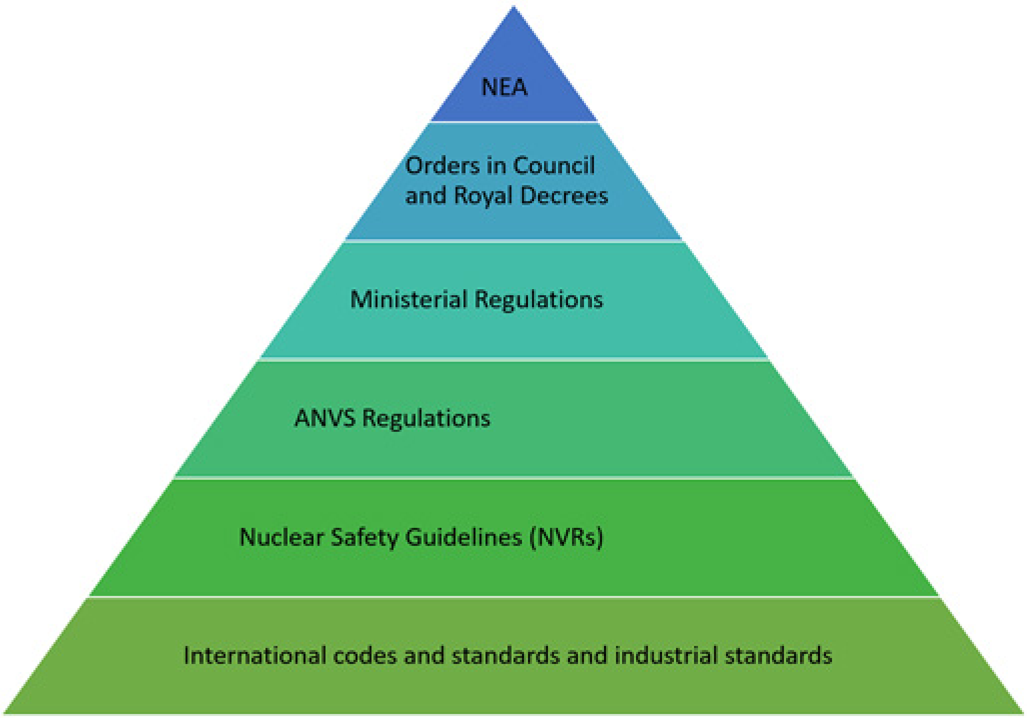
Since the last IEA in-depth review, the Netherlands has established a new regulatory body, the Nuclear Safety and Radiation Protection Agency (ANVS), which has the main responsibility for maintaining and controlling most national legislative, regulatory and organisational frameworks for nuclear safety, security and radiation protection. Since August 2017, the ANVS has been an independent administrative body within the Dutch government. The ANVS advises the Minister of Infrastructure and Water Resources on policies, laws and regulations on nuclear safety, security and radiation protection.

The Ministry of Infrastructure and Water Management has responsibility over the performance of the ANVS. The Ministry of Economic Affairs and Climate Policy is responsible for the role of nuclear power in the energy mix and for support to applied nuclear research. Annex 11.1 details how responsibility over the Dutch nuclear sector is divided across the government.

Nuclear policy

The legal framework for the Dutch nuclear sector is given in Figure 11.2. The most prominent law is the NEA, which governs all nuclear activities. The NEA is a framework law setting out the basic rules on the use of nuclear technologies and materials. It makes provisions for radiation protection, designates the competent authorities and outlines their responsibilities. The orders in council and royal decrees, the ministerial and ANVS regulations, and the Nuclear Safety Guidelines include additional regulations. The Nuclear Safety Guidelines apply to installations or nuclear facilities and are based on IAEA Safety Standards and other relevant standards. The international codes and standards are also part of the licensing for reactors.

Figure 11.2 Legal framework for the Dutch nuclear sector



Source: IAEA (2019), *Country Nuclear Power Profile*, https://cnpp.iaea.org/countryprofiles/Netherlands/Netherlands.htm.

In 2017, the EU Commission Directive 2014/87/Euratom was enacted as a national law to strengthen nuclear safety. Major changes included strengthening the authority and safety management of the ANVS, and the transparency and safety of existing nuclear facilities. The Netherlands introduced the 2013/59/Euratom Board of Directors guidelines in national legislation as well, which laid down basic safety standards for protection against exposure to radiation. On 6 February 2018, the Act on the Basic Safety Standards of Radiation Protection and its basic regulations came into force.

The Dutch government sees reliable and affordable electricity generation as an important factor in achieving the Climate Agreement's emissions reductions and is open to a variety of low-carbon electricity generation options, including nuclear power. Any company that meets all of the prerequisites (for instance, nuclear safety and security, sufficient financial reserves for plant decommissioning and waste processing) can receive a permit for the construction of a nuclear power plant. However, as with power plants using fossil fuels, there is no state funding for constructing or operating nuclear power plants.

On 28 June 2019, the government noted in a letter to parliament on the Climate Agreement that various studies have shown nuclear power to be a potential cost-effective option for 2050 and that a positive business case may be possible for nuclear electricity generation in the long term. However, the government indicated that given the long payback period, additional nuclear power in the Netherlands seems unlikely by 2030 (MEACP, 2019).

Three sites in the Netherlands have supporting government clearances and zoning in place to allow for the construction of new nuclear power plants. These sites are located at Tweede Maasvlakte, Eemshaven and a third site is close to the existing Borssele plant. Another option to support a continuing role for nuclear power in the Netherlands would be an extension of Borssele plant operations beyond 2033, when it is scheduled to close according to Dutch law. A lifetime extension of the Borssele plant could prove of great benefit to maintain the low-carbon generation from the plant and the know-how of the Dutch nuclear sector, especially in terms of operating a power reactor. Lifetime extensions are generally less expensive than construction of new plants and there is precedent for extending the lifetime of nuclear power plants up to 80 years.

In 2017, the United States Nuclear Regulatory Commission defined the subsequent license renewal (SLR) process, which allows extension of nuclear plant operations up to 80 years. Since the introduction of the SLR process, four reactors around the same age as Borssele have been granted lifetime extensions for 80 years of operation (US NRC, 2020). An extension of the Borssele plant lifetime would require a change to the current law and a safety review by the ANVS. The SLR process defines an enhanced safety review and could serve as a template when examining the option of a lifetime extension for the Borssele plant.

Waste storage and disposal

The Central Organisation for Radioactive Waste (COVRA) is the only organisation in the Netherlands allowed by law to transport, manage and store spent fuel and radioactive waste. COVRA is a non-profit organisation owned by the Dutch state. COVRA operates the Netherlands' only storage site for spent fuel and radioactive waste in Vlissingen. According to the polluter-pays principle, upon delivery of waste, COVRA charges the generator of waste all costs related to waste management, including long-term disposal. Once waste is transferred to the COVRA storage site, COVRA takes over all liabilities for the waste, including the financial responsibility. For standardised waste streams of low- and intermediate-level radioactive waste, fixed tariffs are published on COVRA's website. These tariffs are adjusted annually and published in the Dutch consumer price index of Statistics Netherlands (IAEA, 2019).

The operators of Dutch nuclear reactors and COVRA agreed to jointly build a facility for treatment and long-term storage of spent fuel and high-level waste at the COVRA site. This building was commissioned in 2003 and is receiving high-level waste from the production of medical radioisotopes and spent fuel from Dutch reactors. Final waste disposal is foreseen after 2100. Due to economies of scale, it is envisioned that all radioactive waste (including high-, intermediate- and low-level radioactive waste) will be placed in a single geological disposal facility (ANVS, 2019). More information on COVRA can be found in the Netherlands' national reports to the Joint Convention on the Safe Management of Radioactive Waste and the Safe Management of Spent Fuel (ANVS, 2017).

Nuclear safety

Guaranteeing nuclear safety is the highest priority in Dutch nuclear policy. The government requires that all operational reactors take into account lessons learnt from the 2011 Fukushima Daiichi accident, as well as the outcomes of the 2011-12 "stress test" for nuclear power plants in the European Union. Based on the post-Fukushima stress test in 2011 and the periodic safety reviews, the licensee of the Borssele nuclear power plant implemented a number of safety improvements from 2012 to 2019. The National Report of the Kingdom of the Netherlands for the Eighth Review Meeting for the Convention on Nuclear Safety provides details on the implemented safety measures (ANVS, 2019).

The Netherlands has a decades-long history of nuclear safety reviews. For more than 20 years, licences for nuclear plants have required regular safety reviews. Under the NEA, a review of operational safety aspects must be performed every two years, while a more comprehensive safety review must be conducted every ten years. The comprehensive safety review involves reviewing a plant's design and operation in the light of new developments in research, safety, risk acceptance and other key benchmarks.

The agreement to extend the operation of the Borssele plant until the end of 2033 included several conditions above the requirements of the NEA and the existing licence. One of these requirements is that the Borssele plant will continue to meet the standard of being among the top 25% safest water-cooled water-moderated reactors operating in Canada, the EU and the United States. This is known as the benchmark agreement. The Borssele Benchmark Committee was established to assess whether the Borssele plant complies with this requirement. The committee reports its findings every five years. Both the first report (2013) and the second report (2018) concluded that the Borssele plant meets the benchmark agreement requirements (ANVS, 2019).

The Dutch policy on nuclear safety is periodically assessed within the framework of the Convention on Nuclear Safety (CNS). Policy relating to the management of radioactive waste and spent fuel is assessed under the Joint Convention Treaty. These assessments oblige each contracting party to apply widely recognised principles and tools in order to maintain a high level of safety at nuclear power plants. It also requires each contracting party to report on the national implementation of these principles at regular review meetings. In 2019, the national report of the Netherlands to the eighth CNS review meeting was published showing that the Netherlands meets all obligations of the articles of the convention (ANVS, 2019).

Nuclear industry and RD&D

The Netherlands is a significant player in the nuclear industry for fuel enrichment and production of radioisotopes, and also has a small but significant nuclear research programme. There is one nuclear enrichment facility in the Netherlands located in the town of Almelo. The facility is operated by Uranium Enrichment Corporation Ltd (Urenco), which is owned by the Dutch state, the British state, and by the German energy companies RWE and E-On. Urenco supplies a major part of global demand for low-enriched uranium and the enrichment plant in Almelo accounts for more than a quarter of Urenco's production capacity. The company ET-NL in Almelo supplies all centrifuges for the enrichment plants of Urenco and Orano (ANVS, 2019).

The Dutch nuclear programme started in 1955 with the construction of the High Flux Reactor (HFR) in Petten. This research reactor is owned by the European Commission Joint Research Centre and operated by the international nuclear service provider, Nuclear Research and Consultancy Group. The HFR is one of the most important producers of medical radioisotopes in the world. In 2019, it supplied around 70% of the European demand for radioisotopes and around 30% of the global demand. To maintain Dutch leadership in the production of radioisotopes, the government is considering deployment of a new research reactor (named PALLAS) in order to replace the HFR, which has been operating for over 60 years (ANVS, 2019).

The PALLAS reactor is intended for production of medical radioisotopes, nuclear research and irradiation services. In 2014, the national government and the province of North Holland together provided a loan of EUR 80 million to finalise the licensing and design of PALLAS. Currently the project is in a pre-licensing phase with the ANVS. The plan is to have PALLAS in operation around 2025, at which point the HFR would be decommissioned (EC, 2018).

The Higher Education Reactor of the Technical University in Delft is a 2 MW reactor used for research on reactor physics, neutron beam physics, radioisotopes and radiochemistry. Through the Optimized Yield for Science, Technology and Education of Radiation (OYSTER) Programme, the Higher Education Reactor aims to answer fundamental research questions in the fields of health, energy and materials. A number of new instruments have been developed through OYSTER, including the neutron diffractometer PEARL, which allows scientists to can carry out energy research into hydrogen storage and new battery materials. In addition, the flexible irradiation facility is being used to explore new production routes for medical radioisotopes (ANVS, 2019).

Assessment

The Netherlands has a small but diverse nuclear programme. The only nuclear facility generating electricity for the grid is the 482 MW Borssele nuclear power plant. There are two operational research reactors, hot cell facilities, radiological laboratories, an enrichment plant and a central national radioactive waste storage facility. Because of this diversity and to allow maximum flexibility, specific requirements for nuclear installations are listed in each facility's license and are tailored to the characteristics of each installation.

The Netherlands has successfully followed up on the recommendation given in the IEA 2014 Energy Policy Review to create a new regulatory body for nuclear safety. In August 2017, the government established a new and independent regulatory body, the ANVS, which is responsible for most requirements stemming from national legislative, regulatory and organisational provisions for nuclear safety and security and radiation protection.

In line with the 2014 recommendations, the Netherlands also confirmed that adequate financial provisions have been taken for long-term storage and final disposal of spent fuel and radioactive waste, and for dismantling of the Borssele Nuclear Power Plant. All radioactive waste is managed and stored at the COVRA facility. A polluter-pays principle ensures that funding for storage and eventual disposal is collected when waste is delivered. The payment levels for waste storage have been set to allow for construction of a final disposal repository to be commissioned after 2100.

A new research reactor, PALLAS, is under consideration to replace the current Petten Labs research reactor (HFR). Pre-licensing activities are ongoing with the ANVS. Given the long-standing expertise the Netherlands has in nuclear research and development, and the production of radioisotopes, the continuation of nuclear research programmes is of great importance for the health sector and research on energy, materials, radiation protection and waste management.

According to Dutch law, the Borssele plant is required to shut down at the end of 2033, which corresponds to a 60-year lifetime. A lifetime extension of the Borssele plant could prove of great benefit to maintain the low-carbon generation from the plant and the know-how of the Dutch nuclear sector, especially in terms of operating a power reactor. An extension of the Borssele plant's lifetime would require a change to the current law and a safety review by the ANVS. The subsequent license renewal process of the US Nuclear Regulatory Commission defines an enhanced safety review for extending reactor lifetimes up to 80 years and could serve as a template when examining the option of a lifetime extension for the Borssele plant.

The government acknowledges the role nuclear energy can play in the transition to a carbon-neutral energy system. Three sites in the Netherlands have supporting government clearances and zoning in place to allow for the construction of new nuclear power plants and the country has a robust system for the storage and disposal of nuclear waste. These measures would likely help to reduce the risk, cost and time for constructing new plants. If a company meets all of the prerequisites (nuclear safety and security, sufficient financial reserves for plant decommissioning and waste processing, among others), it can receive a permit for the construction of a nuclear power plant. There is no government funding for nuclear power plants. As such, the decision to invest in any new nuclear plants will be based primarily on their ability to earn the desired return on investment through competition in the electricity market.

To help support cost-effective operation of nuclear plants, the government could examine if the electricity market properly values the system services needed to maintain electricity security, including capacity availability and frequency control services. The market should allow providers of these services, including nuclear power plants, to be compensated in a competitive and non-discriminatory manner. This could include allowing flexible operation of nuclear power plants, within safety limits, to supply ancillary services. The government should examine how the benefits of nuclear power relating to energy security and emissions reductions can be better valued in the electricity market.

The government can also help to create a supportive environment for investment in new nuclear plants. Risks related to project delays and cost increases can be mitigated efficiently and transparent licensing processes also ensure safety and security. The government can also support favourable risk management and financing frameworks that facilitate mobilisation of capital for new and existing plants at an acceptable cost, taking into consideration the risk profile and long horizons of nuclear projects.

The Netherlands' nuclear research programme could target accelerated innovation in new reactor designs with lower capital costs and shorter construction times and in technologies that improve the operating flexibility of nuclear power plants to facilitate the integration of growing wind and solar capacity into the electricity system. Electricity from nuclear power can also be used to produce low-carbon hydrogen and, in contrast to variable generation from PV and wind, can supply an almost constant source of low-carbon electricity, which would help to maximise electrolyser output and reduce hydrogen production costs. Other non-electric applications might be possible, for example, residual heat from nuclear power plants can be used for district heating, as demonstrated in other countries. With new nuclear technologies becoming available, the government could stimulate research to investigate whether these options provide opportunities for the Netherlands.

Recommendations

The government of the Netherlands should:

- ☐ Consider facilitating a lifetime extension of the Borssele nuclear power plant beyond 2033 to maintain the plant's contribution of low-carbon electricity and Dutch knowledge of nuclear power.
- ☐ Examine how the energy security and emissions reduction benefits of nuclear power can be better valued in the electricity market and establish a level playing field with other low-carbon energy sources.
- ☐ Ensure timely authorisations in the development of the PALLAS research reactor project in order to carry on with the radioisotope production programme.

Annex 11.1 Division of government responsibility over the Dutch nuclear sector

Ministry	Responsible for
Infrastructure and Water Management	– Nuclear Energy Act and policy on nuclear safety and radiation protection and radioactive waste, the related emergency preparedness, security and safeguards, insofar as these relate to the environmental aspects of radiation protection. – Interdepartmental co-ordination of preparations for and the responses to nuclear accidents involving category A facilities, including radiation-related measures and crisis communication. – Financial security of nuclear reactors, together with the Ministry of Finance. – ANVS' performance.
Social Affairs and Employment	– Policy, legislation, regulations and supervision regarding radiation protection for workers.
Health, Welfare and Sport	– Policy, legislation, regulations and supervision regarding radiation protection for patients and of public health against the undesirable effects of radiation on product and food safety. – Policy regarding care for those who have been exposed to radioactivity. – Emergency preparedness in the case of nuclear accidents in areas for which it is responsible, such as public health and food safety.
Economic Affairs and Climate Policy	– Energy policy, including nuclear energy policy. – Emergency preparedness in the case of nuclear accidents in areas for which it is responsible, such as energy distribution and telecommunication (partly responsible). – State Supervision of Mines in connection with supervision to monitor compliance with nuclear energy legislation for the mining industry. – Support for applied nuclear energy research.
Justice and Security	– Co-ordination of preparedness and response through the national crisis control organisation. – Co-ordination of national security, including counterterrorism. – Policy regulating public order and security.
Agriculture, Nature and Food Quality	– Policies, legislation, regulations and supervision regarding radiation protection in relation to food quality and animal welfare (including agricultural measures). – Netherlands Food and Consumer Product Safety Authority in connection with supervision to monitor compliance with nuclear energy legislation on product and

Ministry	Responsible for
	food safety.
Defence	– Fissionable materials, nuclear facilities and equipment, radioactive materials and devices emitting ionising radiation that are intended for use by the armed forces and that are exempted from licence requirements under the Nuclear Energy Act.
Foreign Affairs	– Policies on non-proliferation and for the international co-ordination of nuclear safety and radiation protection, and the associated crisis control, security and safeguards.
Education, Culture and Science	– Policy for education, science and vocational training. – Academic system including Delft University of Technology (licensee under the Nuclear Energy Act). Delft University of Technology is responsible for the research reactor on its campus. – Scientific research, unless it concerns research that the ANVS requires for the performance of its duties, in which case responsibility rests with the ANVS.
Finance	– Legislation concerning liability for any losses resulting from accidents at nuclear facilities. Concerns the implementation of the Nuclear Accidents (Liability) Act. – Financial security of nuclear reactors, together with the Ministry of Infrastructure and Water Management. – Supervision carried out by Customs, for compliance with the Nuclear Energy Act. – Shareholder status of COVRA and URENCO.
Interior and Kingdom Relations, together with the ANVS (responsible for co-ordinated preparation and execution)	– The Buildings Decree and its provisions concerning ionising radiation. – Availability of information (local and national) on exposure to radon in homes and other buildings and the associated health risks, the importance of radon measurements, and the available technical means to reduce existing radon concentrations.

Source: IAEA (2019), *Country Nuclear Power Profile*, https://cnpp.iaea.org/countryprofiles/Netherlands/Netherlands.htm.

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ANNEX A: Organisations visited

Review criteria

The Shared Goals, adopted by the International Energy Agency (IEA) Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews conducted by the IEA. The Shared Goals are presented in Annex C.

Review team and preparation of the report

The IEA in-depth review team visited the Netherlands 18-22 November 2019. The review team met with government officials, energy suppliers, market participants, interest groups, consumer associations, research institutions and other stakeholders. The report was drafted based on information obtained in these meetings, the review team assessment of Dutch energy policy, the government response to the IEA energy policy questionnaire and subsequent research by the IEA.

The members of the team were:

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The review was prepared under the guidance of Mr. Aad van Bohemen, Head of the Energy Policy and Security Division, IEA. Mr. Peter Journeay-Kaler managed the review and is the author of the report. Mr. Pharoah Le Feuvre wrote the chapter on renewable energy. Ms. Malisol Ohirko and Ms. Sama Bilbao y Leon wrote the chapter on nuclear. Ms. Lucie Girard wrote the chapters on oil and natural gas.

An assessment of Dutch fossil fuel subsidies conducted jointly by the IEA and the OECD was undertaken in parallel to the IEA energy policy review of the Netherlands. Ms. Assia Elgouacem and Ms. Nathalie Girouard from the OECD participated as review team members in sessions related fossil fuel subsidies and reviewed the section of this report related to fossil fuel subsidies.

Mr. Oskar Kvarnström, Ms. Jihyun Selena Lee, Mr. Alessio Scanziani, Ms. Clémence Lizé, Ms. Dahyeon (Lisa) Yu, Ms. Lilly Lee and Ms. Michelle Lim prepared and drafted the sections relating to energy data contained in each chapter. Helpful comments, chapter reviews and updates were provided by the following IEA staff: Mr. Simone Landolina, Mr. Alejandro Cesar Hernandez, Ms. Randi Kristiansen, Ms. Kristine Petrosyan, Mr. Jason Elliott, Mr. Simon Bennett, Mr. Carlos Fernandez Alvarez, Mr. Brian Motherway, Mr. Michael Oppermann, Mr. Olivier Lejeune, Mr. Jean-Baptiste Dubreuil, Mr. Gergely Molnar, Ms. Sara Moarif, Mr. Luca Lo Re, Ms. Chiara D'adamo, Mr. Niels Berghout, Mr. Jose Miguel Bermudez Menendez, Mr. Peter Levi and Ms. Samantha McCulloch.

Special thanks to the IEA Secretariat with regard to the data, publication and editing. Ms. Astrid Dumond ensured the preparation of the design of the report with figures, tables and maps. Ms. Roberta Quadrelli and Mr. Faidon Papadimoulis provided support on statistics. Ms. Therese Walsh managed the editing process, Ms. Astrid Dumond and Ms. Isabelle Nonain-Semelin managed the production process. Ms. Tanya Dyhin managed the design process. Mr. Jad Mouawad and Mr. Jethro Mullen supported the press launch. Ms. Jennifer Allain was the editor.

Organisations visited

Ministry of Economic Affairs and Climate Policy

Ministry of Infrastructure and Water Management

Ministry of the Interior and Kingdom Relations

Ministry of Foreign Affairs

Netherlands Enterprise Agency

PBL – Netherlands Environmental Assessment Agency

Energie Beheer Nederland B.V.

GasTerra

Gasunie

Netbeheer Nederland

TenneT

ACM – Authority for Consumers & Markets

Energie Nederland

The Netherlands Petroleum Stockpiling Agency (COVA)

Business and employers' organisation VNO NCW

Vereniging Energie Milieu Water (VEMW) (Association for Energy, Environment and Water)

NVDE Nederlandse Vereniging Duurzame Energie (Netherlands Association for Renewable Energy)

CIEP – Clingendael International Energy Programme

VNPI Vereniging van Nederlandse Petroleum Industrie (Dutch Petroleum Industry Association)

Natuur en Milieu

Greenpeace

ANNEX B: Energy balances and key statistical data

Unit: Mtoe

SUPPLY		1973	1990	2000	2010	2016	2017	2018
TOTAL PRODUCTION		**56.8**	**60.6**	**58.5**	**71.2**	**46.0**	**41.7**	**36.4**
Coal		1.1	-	-	-	-	-	-
Peat		-	-	-	-	-	-	-
Oil		1.6	4.1	2.7	1.6	1.6	1.5	1.5
Natural gas		53.8	54.5	52.8	64.7	38.1	33.1	27.8
Biofuels and waste[1]		-	1.0	1.9	3.4	4.4	4.8	4.8
Nuclear		0.3	0.9	1.0	1.0	1.0	0.9	0.9
Hydro		-	0.0	0.0	0.0	0.0	0.0	0.0
Wind		-	0.0	0.1	0.3	0.7	0.9	0.9
Geothermal		-	-	-	0.0	0.1	0.1	0.1
Solar/other[2]		-	0.0	0.0	0.0	0.2	0.4	0.5
TOTAL NET IMPORTS[3]		**5.6**	**5.6**	**18.6**	**11.2**	**25.7**	**31.3**	**37.5**
Coal	Exports	1.4	0.6	0.4	0.1	0.1	0.2	0.1
	Imports	2.9	8.7	8.1	7.8	10.2	9.4	8.3
	Net imports	1.5	8.1	7.7	7.6	10.1	9.2	8.2
Oil	Exports	41.8	58.0	61.8	101.5	114.8	113.2	111.4
	Imports	83.5	90.9	104.4	145.8	156.0	152.7	151.1
	Int'l marine and aviation bunkers	-12.3	-12.4	-16.1	-16.9	-15.5	-15.4	-14.9
	Net imports	29.4	20.5	26.6	27.5	25.7	24.2	24.8
Natural gas	Exports	25.3	25.8	29.7	42.7	42.9	40.2	39.0
	Imports	-	2.0	12.5	18.5	33.1	38.9	43.6
	Net imports	-25.3	-23.8	-17.2	-24.2	-9.9	-1.4	4.6
Electricity	Exports	0.1	0.0	0.3	1.1	1.7	1.6	1.6
	Imports	0.0	0.8	2.0	1.3	2.1	1.9	2.3
	Net imports	-0.1	0.8	1.6	0.2	0.4	0.3	0.7
TOTAL STOCK CHANGES		**-0.3**	**0.4**	**-2.3**	**0.3**	**1.9**	**1.3**	**-1.0**
TOTAL SUPPLY (TPES)[4]		**62.0**	**66.5**	**74.8**	**82.7**	**73.6**	**74.2**	**72.9**
Coal		2.9	8.2	7.8	7.5	10.1	9.1	8.2
Peat		-	-	-	-	-	-	-
Oil		30.5	24.9	27.4	29.9	27.4	27.9	27.0
Natural gas		28.5	30.7	35.0	40.1	30.0	31.0	30.7
Biofuels and waste[1]		-	1.0	1.8	3.6	3.6	3.7	3.9
Nuclear		0.3	0.9	1.0	1.0	1.0	0.9	0.9
Hydro		-	0.0	0.0	0.0	0.0	0.0	0.0
Wind		-	0.0	0.1	0.3	0.7	0.9	0.9
Geothermal		-	-	-	0.0	0.1	0.1	0.1
Solar/other[2]		-	0.0	0.0	0.0	0.2	0.4	0.5
Electricity trade[5]		-0.1	0.8	1.6	0.2	0.4	0.3	0.7
Shares in TPES (%)								
Coal		*4.6*	*12.3*	*10.4*	*9.1*	*13.8*	*12.3*	*11.3*
Peat		-	-	-	-	-	-	-
Oil		*49.1*	*37.5*	*36.6*	*36.1*	*37.2*	*37.5*	*37.0*
Natural gas		*46.0*	*46.2*	*46.8*	*48.4*	*40.8*	*41.8*	*42.1*
Biofuels and waste[1]		-	*1.5*	*2.4*	*4.3*	*4.9*	*4.9*	*5.4*
Nuclear		*0.5*	*1.4*	*1.4*	*1.2*	*1.4*	*1.2*	*1.3*
Hydro		-	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Wind		-	-	*0.1*	*0.4*	*1.0*	*1.2*	*1.2*
Geothermal		-	-	-	*0.0*	*0.1*	*0.1*	*0.1*
Solar/other[2]		-	*0.0*	*0.0*	*0.1*	*0.2*	*0.5*	*0.7*
Electricity trade[5]		*-0.2*	*1.2*	*2.2*	*0.3*	*0.6*	*0.4*	*0.9*

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Footnotes to energy balances and key statistical data

1 Biofuels and waste comprise solid biofuels, liquid biofuels, biogases and municipal waste. Data are often based on partial surveys and may not be comparable between countries.

2 *Other* includes ambient heat used in heat pumps.

3 In addition to coal, oil, natural gas and electricity, total net imports also include biofuels and waste.

4 Excludes international marine bunkers and international aviation bunkers.

5 Total supply of electricity represents net trade. A negative number in the share of TPES indicates that exports are greater than imports.

6 *Industry* includes non-energy use.

7 *Other* includes residential, commercial and public services, agriculture/forestry, fishing, and other non-specified.

8 Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.

9 Losses arising in the production of electricity and heat at main activity producer utilities and autoproducers. For non-fossil fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 33% for nuclear and 100% for hydro, wind and solar photovoltaic.

10 Toe per thousand US dollars at 2015 prices and exchange rates.

11 "CO_2 emissions from fuel combustion" have been estimated using the IPCC Tier I Sectoral Approach methodology from the *2006 IPCC Guidelines*. Emissions from international marine and aviation bunkers are not included in national totals.

ANNEX C: International Energy Agency "Shared Goals"

The member countries* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants. In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

1. Diversity, efficiency and flexibility within the energy sector are basic conditions for longer term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. The environmentally sustainable provision and use of energy are central to the achievement of these shared goals. Decision makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the polluter-pays principle where practicable.

4. More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. Improved energy efficiency can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle, from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. Undistorted energy prices enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. Free and open trade and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. Co-operation among all energy market participants helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at the meeting of 4 June 1993 Paris, France.)

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.

ANNEX D: Glossary and list of abbreviations

In this report, abbreviations and acronyms are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention, this glossary provides a quick and central reference for the abbreviations used.

Acronyms and abbreviations

ACM	Authority for Consumers and Markets
Bpm	vehicle registration tax
BEV	battery electric vehicles
C	Centigrade
CCS	carbon capture and storage
CCUS	carbon capture, storage and utilisation
CEP	Clean Energy Package
CEPS	Central European Pipeline System
CHP	combined heat and power
CO_2	carbon dioxide
COVRA	Central Organisation for Radioactive Waste
CWE	Central Western European
DEI+	Demonstration Energy and Climate Innovation grant scheme
DSO	district system operator
DSR	demand-side response
EED	Energy Efficiency Directive
EEO	energy efficiency obligation
EIA	environmental impact assessment
ESD	Effort Sharing Decision
ETD	Energy Tax Directive
ETS	Emissions Trading Scheme
EU	European Union
EV	electric vehicle
FCEV	fuel cell electric vehicle
FFS	fossil fuels subsidies
GDP	gross domestic product
GDP PPP	gross domestic product in purchasing power parity
GHG	greenhouse gas
GO	guarantee of origin
GOPACS	grid operator platform for congestion solutions
GTS	Gasunie Transport Services B.V.
HFR	High Flux Reactor
IAEA	International Atomic Energy Agency

IEA	International Energy Agency
IKIA	Integral Knowledge and Innovation Agenda
IMO	International Maritime Organization
KEV	Climate and Energy Outlook
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LULUCF	land use, land-use change and forestry
MIA	Environmental Investment Rebate
MMIP	multiannual mission-driven innovation programme
MRB	annual road tax
NEA	Dutch Emissions Authority
	Nuclear Energy Act
NECP	National Energy and Climate Plan
NEEAP	National Energy Efficiency Action Plan
NEMO	nominated electricity market operator
NESO	National Emergency Stockholding Organisation
NOVE	Dutch Association for Independent Fuel Suppliers on Land and Water
NWE	North Western Europe
ODE	Surcharge for Sustainable Energy Act levy
PBL	Netherlands Environmental Assessment Agency
PHEV	plug-in hybrid electric vehicle
PLEF	Pentalateral Energy Forum
PPP	purchasing power parity
PV	photovoltaics
R&D	research and development
RD&D	research, development and deployment (or demonstration)
RED	Renewable Energy Directive
RSC	regional security co-ordinator
RVO	Netherlands Enterprise Agency
SER	Social and Economic Council
SMR	steam methane reforming
SPS	State Profit Share (levy)
SSM	State Supervision of Mines
TFC	total final consumption
TFEC	total final energy consumption
TNO	Netherlands Organisation for Applied Scientific Research
TPES	total primary energy supply
TSO	transmission system operator
USD	United States dollar
VAMIL	Arbitrary Depreciation of Environmental Investments
VELIN	Dutch Association of Pipeline Owners

VRE	variable renewable energy

Units of measure

bcm	billion cubic metres
b/d	barrels per day
CO_2-eq	carbon dioxide-equivalent
GJ	gigajoule
GW	gigawatt
GWh	gigawatt hour
kb/d	thousand barrels per day
km	kilometre
km^2	square kilometre
kW	kilowatt
kWh	kilowatt hour
m	metre
m^3	cubic metre
mb	million barrels
mcm	million cubic metres
MJ	megajoule
ML	million litres
Mt	million tonnes
Mt CO_2	million tonnes of carbon dioxide
Mt CO_2-eq	million tonnes of carbon dioxide-equivalent
Mtoe	million tonnes of oil-equivalent
MW	megawatt

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The Netherlands 2020

Energy Policy Review

The IEA regularly conducts in-depth peer reviews of the energy policies of its member countries. This process supports energy policy development and encourages the exchange of best practices and experiences to help drive secure and affordable energy transitions.

The Netherlands is aiming for a rapid transition to a carbon-neutral economy that supports strong economic growth and energy security. To drive this transition, the government's energy and climate policy focuses on bringing down greenhouse gas emissions, with targets to reduce them by 49% by 2030 and by 95% by 2050, compared with 1990 levels. The country's 2019 Climate Agreement defines policies and measures to support the achievement of these emissions reductions and was developed through a collaborative process involving parties from across Dutch society.

The Netherlands has made notable progress on its transition to a carbon-neutral economy. Thanks to increasing energy efficiency, energy demand shows signs of decoupling from economic growth. In addition, the share of energy from renewable sources doubled between 2008 and 2019. However, the Netherlands remains heavily reliant on fossil fuels and has a concentration of energy- and emission-intensive industries that will be hard to decarbonise. In this report, the IEA provides a range of energy policy recommendations to help the Netherlands smoothly manage the transition to an efficient and flexible carbon-neutral energy system.