Book

The Netherlands 2024 : Energy policy review

Energy Policy Review

The Netherlands 2024

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Executive summary

The Netherlands' energy transition is accelerating rapidly, driven by a strong commitment to its climate framework. Since the National climate agreement in 2019, which included binding climate targets for 2030 and 2050, the shift in ambitions and the speed of the transition have been remarkable. Most notably, strong policy support has helped the Netherlands become a frontrunner in renewable electricity deployment, led by impressive growth in solar photovoltaics (PV) and wind power, notably offshore. Beyond the power sector, the Netherlands is also making good progress in electrifying heating and mobility. While there has been rapid growth in clean energy in recent years, the Netherlands continues to source most of its energy supply from fossil fuels. Close to half of electricity generation comes from natural gas and coal power, heating in buildings remains highly dependent on natural gas and the transport sector relies mostly on oil products. Fossil fuels must be displaced across all sectors if the Netherlands is to decarbonise the energy system in line with its climate targets.

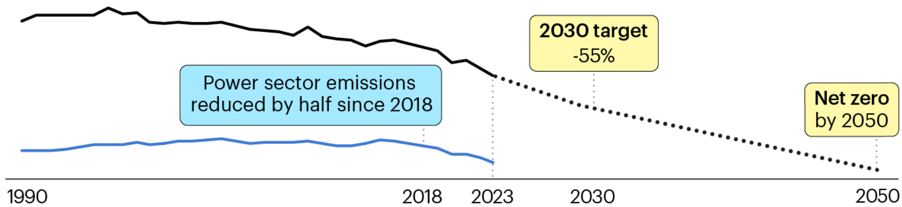
Greater emphasis on meeting existing energy and climate targets will provide long-term policy stability and help unlock private sector investment. The Netherlands should build upon existing policy frameworks and implement a well-designed mix of measures to stay on a trajectory towards its climate targets, including cost-effective incentives as well as regulations. The Netherlands should also build on the National Energy System Plan from 2023, which represents a strong basis for the energy transition until 2050. The plan would benefit from further coherence with existing conditions, including how grid congestion impacts the transition, and a greater focus on demand-side development. Overall, the goal should be to develop a comprehensive strategy with co-ordination across government and sectors to link the ambitions set out in the plans to the realities on the ground.

The Netherlands needs to tackle several challenges if it is to advance its energy transition to the next stage. These challenges include securing investments in new electricity generation, reducing electricity grid congestion, managing the transition away from natural gas, which has long been a cornerstone of the energy system, and increasing demand certainty on the hydrogen market. Addressing these interwoven challenges requires a holistic, system-wide approach. A successful energy transition in the Netherlands will, therefore, depend on effective co-ordination across government, industry and communities.

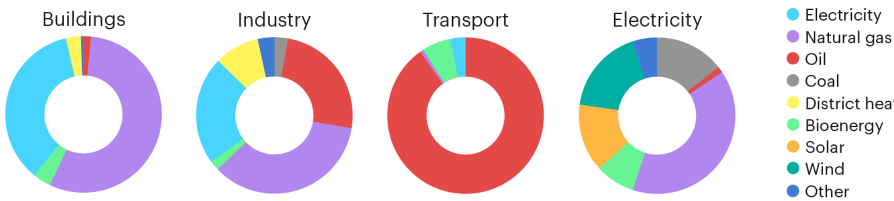
The rapid scale-up of clean electricity generation capacity must continue, to replace electricity from fossil fuels, and enable further electrification. The National Energy System Plan maps out a possible four-fold growth in electricity supply by 2050. For offshore wind, the Netherlands has set very ambitious targets to increase installed capacity from around 5 gigawatts (GW) today to 35 GW by 2035 and 70 GW by 2050. This requires a stable framework for long-term offshore wind development in co-ordination with the buildout of hydrogen production, which will consume much of the electricity generated. The tendering regime must be responsive to market realities, while collaboration with stakeholders on smaller tenders and non-price criteria should continue. Grid expansion must match the pace of offshore wind deployment, providing confidence in the timing and terms of new connections.

A clear, resilient vision of the role for nuclear will be important if the Netherlands is to realise its ambitions for new capacity. Nuclear energy projects demand long-term commitment and stability, emphasising the importance of broad political agreement and a strong public mandate. The Netherlands wants to expand its nuclear fleet with four new nuclear reactors, and while current targets offer a good starting point, a robust evidence base for nuclear energy's role in a decarbonised system is also essential. This review, therefore, recommends an assessment of nuclear power's potential contribution to flexibility, baseload security and inertia management, alongside a look into non-electric applications of nuclear energy to enable better integration in a decarbonised energy system.

34% reduction of **greenhouse gas emissions** since 1990

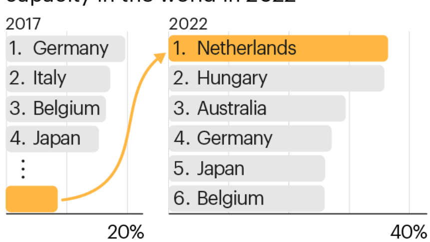


82% of total energy supply comes from **fossil fuels** in 2022



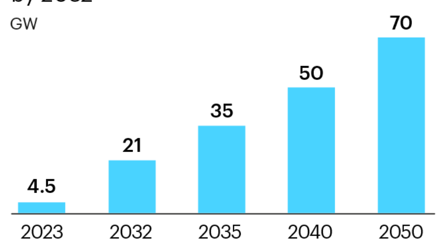
36%

Largest share of **solar PV** in electricity capacity in the world in 2022



4.5x

Target increase in **offshore wind capacity** by 2032



+15 000

Companies waiting for an **electricity grid** connection

3-4 GW

Hydrogen electrolysis capacity target by 2030

43%

Share of **electric vehicles** in new car sales in 2023

14.6 Billion EUR

Budget allocated to **nuclear energy** investment

Electricity capacity additions and demand growth will put further pressure on a constrained grid. The Netherlands' electricity grid was not built for the future profile of demand and supply, which includes an increasing role for variable and decentralised sources. As a result, grid congestion has become a major challenge to the clean energy transition and overall economic development. If the Netherlands is to decarbonise its energy system in line with the climate targets, it must find further solutions to grid congestion. In addition to accelerated grid expansion, policy and regulatory frameworks should incentivise increased flexibility and grid enhancement technologies, to maximise existing capacity. The National Grid Congestion Action Programme is a transparent and collaborative effort involving government and stakeholders to address the challenge of grid congestion.

Energy storage and flexibility will become increasingly important in an electricity system with higher shares of variable renewables. Batteries can contribute to balancing the electricity system and, if strategically placed and operated, effectively manage grid congestion. Connection tariffs could be adjusted to make battery investments more appealing, particularly for installations offering congestion management services by being located near supply or demand centres. Additionally, price signals should reflect local grid conditions as well as overall system needs. This can be achieved through further development of new contract forms and local flexibility markets.

The Netherlands is well placed to become a European hub for clean hydrogen, but investors are calling for more demand certainty. Great offshore wind resources and the existing position as an energy-trading hub provide the Netherlands with favourable conditions to becoming a large producer and importer of low-emission hydrogen. While demand for low-emission hydrogen is potentially large, not only to meet domestic needs but also to export to other markets, investors want more certainty, and final investment decisions for electrolyser projects are lagging. To reduce the risk for investors, more certainty is needed around the future demand for clean hydrogen, for example, through industrial decarbonisation strategies and obligations for the use of low-emission hydrogen in industries.

Natural gas is central to the energy story of the Netherlands, and it needs a transparent, orderly transition path for the future. The 2035 decarbonisation target for the electricity sector means that existing natural gas power plant infrastructure must be transformed or decommissioned within the next decade. A strategy that minimises costs while ensuring security of supply is vital. In the heating sector, heat pumps and district heating are the main options to replace gas boilers, but market development is uncertain. There is a need to clarify the role for hybrid heat pump solutions and engage with local authorities and energy communities to assess the role for district heating across the country while further incentivising energy efficiency, electrification and the use of low-emission gases.

While the energy transition is progressing quickly, the equitable distribution of costs and benefits needs further attention. The global energy crisis highlighted how high exposure to natural gas prices can create issues around affordability and fairness, with the risk that lower-income households and small businesses bear disproportionate costs. The Netherlands should develop a comprehensive vision for an inclusive energy transition, prioritising equity and affordability, alongside the National Energy System Plan and Regional Energy Strategies. A methodology for assessing the distributional impacts of policies would help address unintended consequences and foster public support. Ultimately, there is a need to ensure that the costs and benefits are distributed equitably both now and over time.

Policy recommendations for The Netherlands

1
Maintain a strong commitment to the energy and climate targets and implement well-designed policies to reach them.

2
Implement a people-centred approach to the energy transition, addressing distributional impacts.

3
Develop a coherent energy system strategy and ensure co-ordination to align plans and incentivise the market.

4
Clarify a pathway to ensure an orderly transition away from natural gas across different sectors.

5
Enhance transparency on the grid capacity and the cost of congestion to incentivise innovative solutions.

6
Improve locational and operational price signals for batteries and other flexibility assets to reduce grid congestion.

7
Create a stable framework for the long-term offshore wind development interlinked with the hydrogen ambition.

8
Increase demand certainty for low-emission hydrogen through obligations and industrial decarbonisation strategies.

9
Develop multi-administration nuclear plans backed by analysis on the role for nuclear in the energy system.

10
Assess the potential for nuclear energy for non-electricity applications to increase system flexibility.

Energy policy landscape

Energy and climate policy

Following a broad political agreement in 2019, the Netherlands enjoys a solid climate policy framework with legally binding emissions targets. In 2023, the government presented a vision for the long-term energy transition to 2050 and in 2024 it submitted its updated National Energy and Climate Plan (NECP) to the European Union (EU), outlining its policies to reach its energy and climate targets under the updated EU framework. In September 2024, the new four-party coalition presented a Government Programme with further changes to the energy and climate policy.

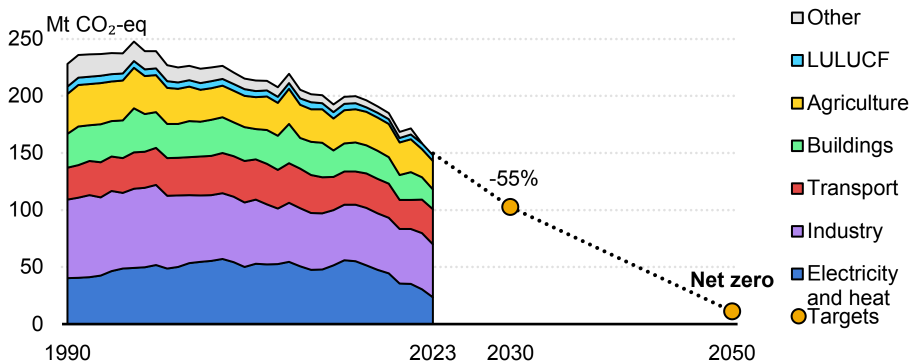
The climate framework

The 2019 Climate Agreement set legally binding national climate targets for the Netherlands for 2030 and 2050. The original target was to reduce GHG emissions 49% by 2030 compared to 1990 levels and 95% by 2050. These targets cover all GHG emissions in the country and were established as legal requirements in the Climate Act in May 2019. In 2021, the Netherlands increased its climate ambition and revised the 2030 target to 55% emissions reductions in line with the EU target.

Emissions reduction towards the climate target

The climate targets translate to GHG emissions at 103 Mt CO_2-eq by 2030 and less than 11 Mt CO_2-eq by 2050, compared to 221 Mt CO_2-eq in 1990 and 147 Mt CO_2-eq in 2023. The power sector emissions were reduced by half in the last five years, contributing most to total emission reductions. Industry was the largest source of emissions in 2023, followed by the power sector, transport agriculture and buildings.

Greenhouse gas emissions in the Netherlands by sector, 1990-2023 and targets for 2030 and 2050



IEA. CC BY 4.0.

Note: LULUCF: land use, land-use change and forestry.
Sources: UNFCCC (2024). Data for 2022 and 2023 are from CBS: https://www.cbs.nl/en-gb/figures/detail/84979ENG.

The Climate Act also established a legally binding framework for assessing progress towards the climate targets. The government must present a Climate Plan to be implemented in the next ten years. The first Climate Plan was based on the 2019 Climate Agreement and the second plan is scheduled for 2025. Furthermore, the Climate Act requires the Environmental Assessment Agency (PBL) to publish an annual Climate and Energy Outlook (Klimaat- en Energieverkenning, KEV). The KEV provides an overview of GHG emissions reductions and an assessment of the expected emissions in 2030, based on the current and planned climate and energy policies in the Netherlands.

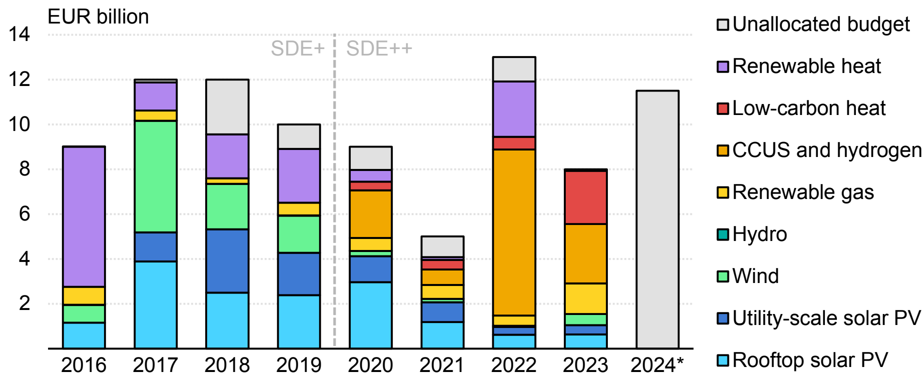
KEV 2022 indicated that the Netherlands was not on track to meet its 2030 target. In response, the government put forward the Climate Package in April 2023, setting out 120 measures directed at both demand and supply sectors. The total budget for implementing the Climate Package was EUR 28 billion until 2030, mostly financed by the Climate Fund. In KEV 2023, PBL demonstrated that if the measures presented in the Climate Package were implemented, the climate target was within reach for the first time, a good example of policy development driven by data and analysis. However, KEV 2024 states that with the current policy (established and proposed), the Netherlands is on track for a GHG emissions reduction of 44-52% by 2030 compared to 1990, and very unlikely to achieve the target of a 55% reduction. Additional policy that quickly delivers reductions is needed to come closer to reaching the target.

SDE++ supports emissions reduction

The main policy support mechanism for emissions reductions is the Sustainable Energy Transition Incentive Scheme (SDE+ and SDE++), administrated by the Netherlands Enterprise Agency (RVO). Established as a feed-in premium system in 2011, the SDE+ scheme supports companies and non-profit organisations in making renewable energy investments through competitive and technology-neutral auctions. In 2020, the scheme was expanded (SDE++) to support a wider range of technologies to reduce GHG emissions, including carbon capture and storage (CCS), renewable hydrogen, waste heat and heat pumps. Subsidies are awarded to technologies with the most cost-efficient per tonne of CO_2-equivalent emissions avoided and the subsidy levels are based on the unprofitable component of the technology that reduces GHG emissions compared to market value. Subsidies are granted for 12-15 years, depending on the technology.

The budget and allocation for the SDE++ scheme has varied over time. At EUR 11.5 billion, the 2024 budget is among the highest so far. Solar PV systems (utility and commercial scale) and wind power (onshore) received a large share of the SDE+/SDE++ scheme in 2017-21, but a small share in recent years. In a letter to parliament in May 2024, the government proposes to remove solar and onshore wind from the SDE++ technologies and instead introduce a two-way contract for difference (CfD) system to support new solar and onshore wind power generation.

Total budget for the SDE++ scheme in the Netherlands, 2016-2024

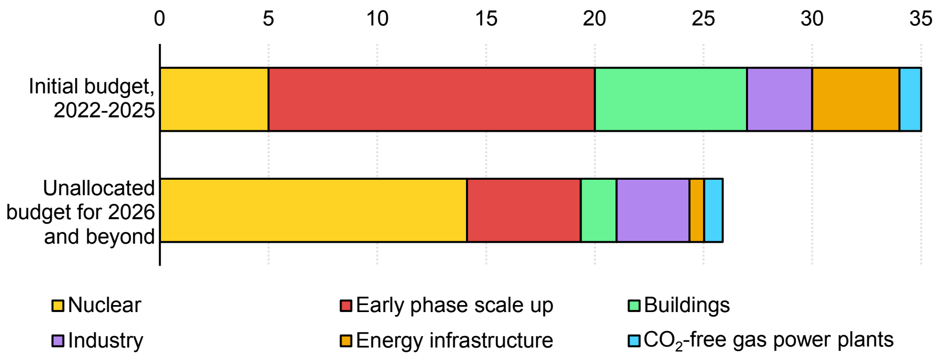


* Applications for the 2024 SDE++ started on 10 September 2024.
Sources: Netherlands Enterprise Agency (2024), Facts and figures SDE++, Government of the Netherlands (2023), Multi-year Climate Fund Programme 2024 Central Government.

The Climate Fund

Besides the SDE++ scheme, the Climate Fund is the primary mechanism for financing the energy transition. The two financing schemes are complementary, as the SDE++ supports the most cost-efficient solutions to reduce emissions, whereas the Climate Fund can support less mature technologies. The Fund is divided into six pillars, reflecting the government's decarbonisation priorities: 1) nuclear energy; 2) early phase scale up (including hydrogen); 3) buildings; 4) industry; 5) energy infrastructure; and 6) CO_2-free gas power plants. The initial total budget of the Climate Fund for the period 2022-30 amounted to EUR 35 billion, as reported in the Multi-year Programme 2025 Climate Fund. In addition, the government added EUR 9.5 billion for nuclear in 2024 and decreased the budget for hydrogen and batteries with EUR 1.23 billion. Part of the budget was spent in 2022-23, largely on hydrogen projects, and most of the remaining money has been allocated through the Multi-Year Programme Climate Fund for 2024 and 2025. Around EUR 26 billion remains to be allocated, primarily for nuclear.

Climate Fund allocation by pillar and status (EUR billion)



Source: Government of the Netherlands (2024), Multi-year programme 2025 Climate Fund.

Regional Energy Strategies programme

Outlined in the 2019 Climate Agreement, the Regional Energy Strategies programme helps facilitate the energy transition on a regional level. It gathers stakeholders in 30 regions to collaborate around the target to realise 35 terawatt hours (TWh) of new renewable electricity generation by 2030 while also enabling the necessary energy infrastructure and the transition to sustainable sources for heating in buildings. Local governments, in co-operation with network operators, the private sector and social organisations, are developing strategies to resolve barriers related to costs, spatial planning, social acceptance and the integration of renewables. The government provides technical and financial assistance for the development and execution of the strategies.

EU directives

Several EU directives have been updated recently, with large implications for member states. In July 2021, the European Commission presented the Fit-for-55 package to reach the climate target of 55% emissions reductions by 2030 (compared to 1990). As a response to the Russian Federation's (hereafter "Russia") invasion of Ukraine and the energy crisis in 2022, the European Commission presented the REPowerEU plan to phase out fossil fuel imports from Russia, which included further increased ambitions.

In 2023, the European Council and Parliament agreed on updates to several directives, including the Emissions Trading System (ETS), with a more ambitious emissions reduction target for 2030 in the existing system and the introduction of an additional system (ETS2) in 2027 that will address emissions from buildings, road transport and small industries. On the energy policy side, updates were made to the Renewable Energy Directive (RED), the Energy Efficiency Directive (EED), the electricity market design, and the gas and hydrogen market package.

The new RED (REDIII) includes more ambitious 2030 targets for renewable energy, including for hydrogen. The overall target for renewable energy in final energy consumption for the European Union as a whole is 42.5% (aiming for 45%). REDIII also sets national targets by sector, including a requirement that renewable fuels of non-biological origin (which includes renewable electrolytic hydrogen) should account for at least 42% of hydrogen use (for final energy and non-energy uses) in industry by 2030 and 60% by 2035, with conditions specified in two delegated acts. REDIII entered into force on 20 November 2023 and needs to be transcribed into national laws within 18 months.

The updated EED sets an indicative target for member states to reduce final energy consumption by 11.7% by 2030, compared to a reference scenario. For the Netherlands, this limits final energy consumption to 1 609 petajoules (PJ) in 2030. At the European level, this target is binding. The revised EED also increases the binding cumulative energy-saving requirement from an average of 0.8% of annual energy savings to 1.49%. For the Netherlands this translates into cumulative savings of 1 285 PJ over the period 2021-30. In the 2023 KEV, PBL concludes it is within reach under the condition that the implementation of the plans laid out in the 2023 Climate Package is fully effective. The new EED also mandates data centres, which is an important sector in the Netherlands, to publish information on their energy performance and sustainability.

The long-term vision for the energy transition

In December 2023, the government presented its National Energy System Plan with its vision for the energy system until 2050. The plan indicates how the government plans to build, save, distribute and connect energy resources for a sustainable and equitable energy system. To draft the plan, ministries consulted with a broad group of stakeholders and experts from the energy sector, user sectors and citizens.

The plan presents the development of the energy system based on five key choices: 1) maximising the renewable energy supply; 2) improving energy efficiency; 3) smart use of the energy infrastructure; 4) international co-operation; and 5) joint co-ordination. The strategy to maximise the renewable energy supply and supporting that through state funds is a deliberate choice to overcome the “chicken-and-egg” problem of investments of the supply side waiting for the demand side and vice versa. The assumption is that the demand side will follow the buildout of more renewable energy generation and infrastructure.

In March 2024, the government followed up with an Energy Infrastructure Programme. The report identifies the need for new national energy infrastructure towards 2050 and how that can be located. It focuses on the space needed for the national components of the onshore energy system for a climate-neutral energy system in 2050. This includes high-voltage grids and pipelines as well as large components such as batteries or electrolysers.

In April 2024, PBL released a report on trajectories for climate neutrality by 2050, looking at the long-term transition of the energy system. PBL concluded that it is technically feasible to reach a climate-neutral society, but it requires using all available solutions. The report also concluded that additional policies are needed in the short term to stay on track towards climate neutrality by 2050. KEV 2024 supports the same message and shows that the rate of emissions reduction with current policies is not sufficient to achieve climate neutrality by 2050.

The 2024 Government Programme

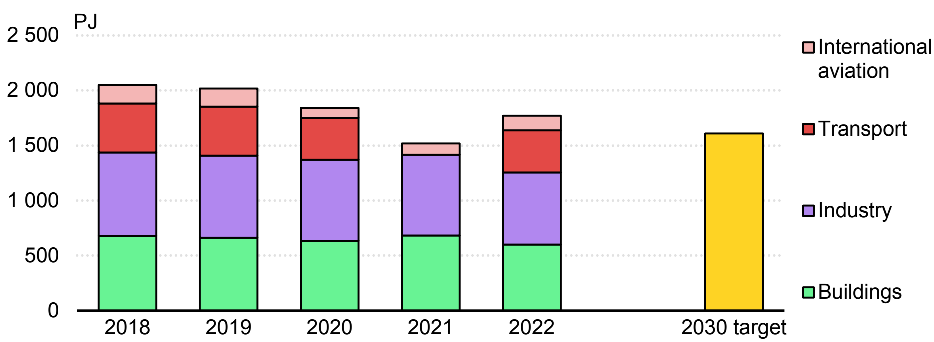
In September 2024, the four-party coalition presented a Government Programme, laying out the political priorities for the new government, following a Coalition Outline Agreement from May 2024. The government highlights the importance of political stability and maintaining existing targets. It also stresses the need for energy security and that the energy transition should focus on reducing dependency on unreliable countries while also ensuring that energy is affordable for citizens and businesses. Resolving grid congestion will be a priority.

While maintaining overall climate and energy targets, the agreements contain new priorities and propositions for policy and budgetary changes with implications for the energy transition. The government removed the earlier announced requirement to switch to a heat pump when replacing a boiler from 2026 and to reduce energy taxation on natural gas. For wind power, the government states its preference for building offshore, while also acknowledging interest from fisheries. There will be budget cuts for the SDE++ scheme with EUR 1 billion per year from 2026 and for the Climate Fund with EUR 300 million per year in 2025-28. More money is instead being directed towards the ambition for building four new nuclear reactors, with additional funds of EUR 9.5 billion for the years 2027-35, on top of the EUR 4.6 billion already available in the Climate Fund from 2023.

End-use sectors

Energy demand in the Netherlands has declined across all sectors over the last decade. In 2022, total energy use was around 1 800 PJ, down from above 2 000 PJ in 2018. To meet the EED target of maximum 1 609 PJ in final energy consumption by 2030, the Netherlands needs to improve energy efficiency further.

Total final energy consumption by sector in the Netherlands 2018-2022 and 2030 target



Notes: Industry includes manufacturing and other sectors (agriculture, construction, mining and quarrying). It does not include refinery and non-energy use (fuels that are used as raw materials and are not consumed as fuel or transformed into another fuel). International aviation is included in this figure because the European Commission included it when setting the target.

Source: IEA (2024), World Energy Balances.

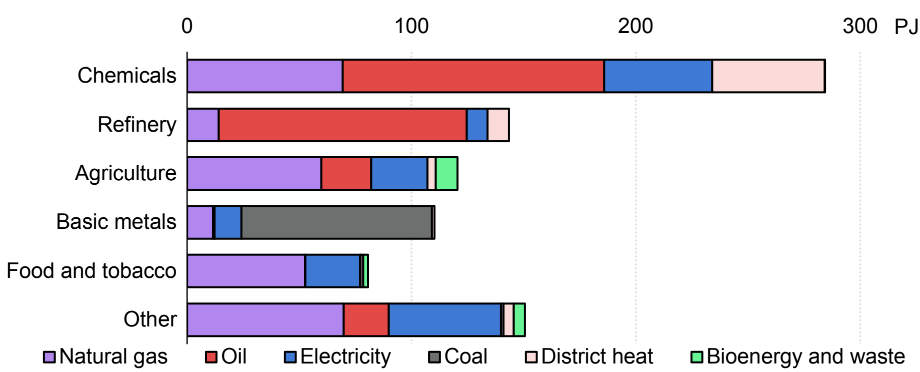
Industry is the largest energy-consuming sector, accounting for 40% of final energy consumption in 2022. Residential and service buildings (including data centres) accounted for 37% of final energy consumption and transport 23%. In addition, energy is used in refineries and steel production (operation of blast furnaces), which is counted as transformation rather than final consumption, and oil and gas that is used for non-energy purposes in, for example, chemical production.

Industry

The Netherlands has a large industry sector, which largely consumes fossil fuels. The chemicals industry and refineries are large oil consumers while steel production uses mostly coal. The Netherlands also has large agricultural, horticulture and food sectors that consume mainly natural gas.

To achieve climate goals, energy efficiency improvements and fuel switching are needed to significantly reduce emissions in all sectors. Industry sectors that use energy mainly for low-temperature heating (such as agriculture, food and tobacco) can largely electrify or switch to other less carbon-intensive energy sources such as biofuels or district heating. For other sectors such as chemicals, refinery and basic metals, the main options for reducing emissions are to use CCS or replace fossil fuels with low-carbon hydrogen. Specifically for the construction sector, the Netherlands has introduced a subsidy for Clean and Zero Emission Construction Equipment. The subsidy scheme can be used to buy or lease new clean construction equipment or to improve existing equipment.

Industrial energy demand by sector and fuel in the Netherlands, 2022



Notes: This chart includes consumption in refinery and steel industry that is not counted as final energy consumption in the previous figure. Non-energy used is not included.
Source: IEA (2024), Energy End-uses and Efficiency Indicators.

Industry clusters and strategies

Dutch industry is concentrated in regional clusters that enable collaboration and integration, including by providing residual heat from industrial processes to district heating networks or using carbon dioxide from industries in greenhouses. The Netherlands has five main energy-intensive industrial regions (Rotterdam/Moerdijk, Zeeland, the North Sea Canal Area, the Northern Netherlands and Chemelot) with specific industry focuses and energy requirements. Upon request from the government, these industrial clusters develop cluster energy strategies, describing developments for energy demand and emissions in each area. This work could be extended to decarbonisation strategies for different industry clusters or sectors. As an example, within the Fossil Free Sweden initiative, 22 different Swedish industry sectors have produced roadmaps to show how they can enhance their competitiveness by becoming fossil-free or climate-neutral.

Energy efficiency in industry

Energy management and energy audits are typical solutions for increasing energy efficiency to save money and reduce emissions. The EU EED mandates large industries to conduct energy audits every four years, and in 2023 the government updated the Energy Saving Obligation that legally requires companies to implement all energy efficiency measures with a payback period of five years or less. The new legislation extends the obligation to energy-intensive industry, including those under the EU ETS and the horticulture sector, and mandates a wider range of energy-saving measures, including fuel switching and small-scale renewable energy production. The Energy Investment Allowance provides tax rebates on company investments that improve energy efficiency and/or reduce emissions.

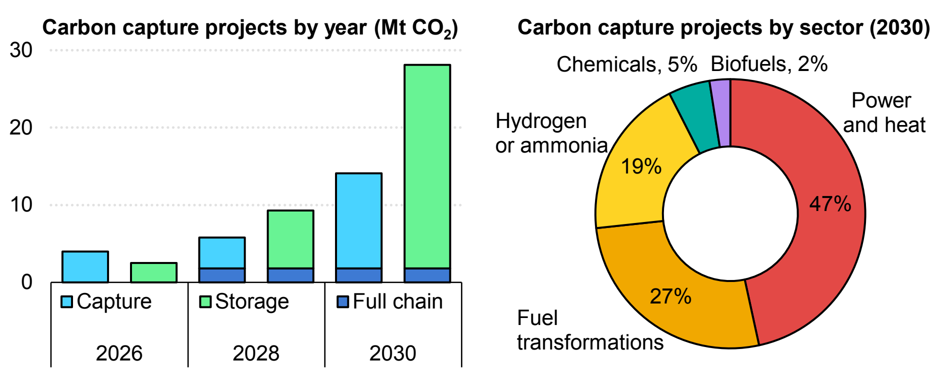
Carbon capture and storage

Carbon capture and storage (CCS) will be an important technology to decarbonise certain industry sectors, and the Netherlands has plans for several large projects. The industry sector includes many large point sources where CO_2 can be captured to be transported and stored, typically underground. After some setbacks in 2009 with the failure of the Barendrecht CCS projects, the Netherlands now hosts some world-leading commercial CCS projects. The most advanced projects aim to collect CO_2 from industries in the Port of Rotterdam and store it in depleted fields in the North Sea (see below). Some industries (such as the fertiliser plant Yara) aim to ship carbon to

Norway and store it within the Northern Lights project. There are also projects for direct air capture (for example Return Carbon, Skytree and Carbyon). Support to CCS projects can be provided through SDE++ auctions.

Several projects aim to collect CO_2 in the Port of Rotterdam and store it in depleted fields offshore. The Porthos project, a joint venture of EBN, Gasunie and the Port of Rotterdam Authority, aims to store 2.5 Mt CO_2 per year starting in 2026. A final investment decision for the project was reached in October 2023 and construction started in 2024. Four companies in the port area – Air Liquide, Air Products, ExxonMobil and Shell – have already booked all the storage capacity. The project has received financial support through SDE++ and EU funding. As of March 2024, the estimated total cost for the project was at least EUR 1.3 billion, against an initial expected cost of EUR 400 million, an increase caused by inflation and a rise in demand of pipeline construction materials and other components. Furthermore, the Aramis project aims to provide large CO_2 storage in another depleted reservoir further off the coast with a maximum capacity of up to 22 Mt CO_2 per year. Injection of CO_2 within the Aramis project timeline is expected in 2029-30.

CCS projects pipeline and 2030-projects in the Netherlands



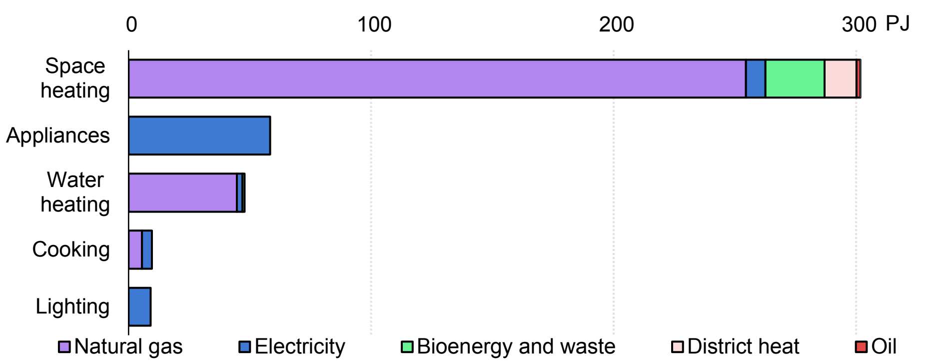
Source: IEA (2024), CCUS Projects Database.

The Delta Rhine Corridor project aims to build CO_2, hydrogen and ammonia networks connecting German cities with Chemelot and Rotterdam in the Netherlands, and possibly Antwerp in Belgium. The Dutch government declared it a project of national interest, and the Dutch licensing process started in May 2023. The plan was to start building the network in 2026 to get it operating in 2028-30. However, the Dutch government announced in June 2024 that the Delta Rhine Corridor project will be delayed by four years, due to difficulties with building infrastructure for cables and hydrogen and ammonia pipelines in parallel, and allocating sufficient land for all three lines. Carbon capture and utilisation (CCU) is already in place, capturing CO_2 from hydrogen and ethanol production, a fertiliser plant, waste-to-energy plants, or biomass power plants and delivering it to greenhouses.

Buildings

The Netherlands has the highest dependence on natural gas for heating among all IEA countries. In 2021, space heating accounted for more than 70% of end-use in residential buildings and natural gas covered 84% of this energy demand. Apart from natural gas, biofuels (8%), district heat (4%) and electricity (3%) are also used for space heating. When including appliances and other energy use in residential buildings, electricity accounted for 20% of total energy demand.

Energy breakdown in residential buildings in the Netherlands, 2021



Source: IEA (2024), Energy End-uses and Efficiency Indicators.

REDIII introduces binding targets for annual increases in the share of renewable energy in heating. For the Netherlands, this adds up to a target to increase the share of renewable heat from around 9% in 2022 to 27% by 2030.

Since 2018, there has been a ban for gas boiler installations in new buildings in the Netherlands and efforts are being made to replace gas heating in existing buildings. In the 2019 Climate Agreement, the Netherlands set a target of upgrading 1.5 million existing homes and other buildings to a sustainable heating system between 2022 and 2030 and increasing district heating connections by around 80 000 per year from 2025 to 2030. The Netherlands takes a district-oriented approach to decarbonising heating in buildings, in which municipalities draw up plans to improve the sustainability of heating to reach the targeted 1.5 million buildings. The Municipal Instruments Heat Transition Act from 2023 provides further legal instruments for the municipalities to ensure that the transition from natural gas to sustainable forms of energy in a neighbourhood runs smoothly and affordably.

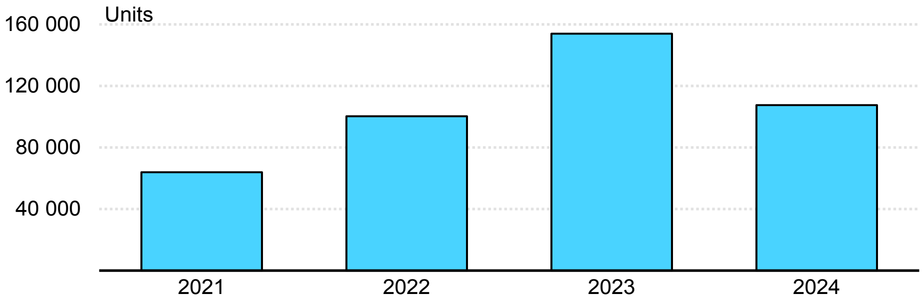
Heat pumps are replacing gas boilers

Since the 2018 ban for gas boiler installations in new buildings, heat pumps have become the main heating solution in new builds. Heat pumps are supported through a subsidy scheme that covers around 30% of the investment cost, and a subsidised loan is also available from the National Heat Fund.

In 2022, the government announced a new standard as of 2026 which requires a more sustainable heating system to be installed in buildings when an existing gas boiler needs to be replaced, focusing on hybrid heat pump solutions (that use a heat pump in addition to the existing gas boiler). To meet the expected surge of demand of heat pumps, companies have made investments in new production lines and in scaling up production capacity. However, in 2024, the government announced a roll-back of this obligation. Industry associations have expressed concerns that, if implemented, this roll-back would have negative economic, social and climate impacts, as companies have already made investments on increased heat pump production and installation capacity.

The active policy on replacing natural gas boilers with heat pumps has driven a rapid growth in heat pump installations in recent years, notably during the period of very high energy prices in 2022 and 2023. However, domestic heat pump sales in the first quarter of 2024 were less than half that in the same period in 2023.

Sales of domestic heat pumps in the Netherlands, 2021-2024



Source: Vereniging Warmtepompen (2024).

This follows a trend similar to that witnessed in many other countries in Europe, as natural gas prices decreased from the peaks of 2022, improving the business case for gas boilers. There are multiple reasons for the decline in heat pump sales, including a slowdown in the construction of new housing and uncertainties among consumers around the electricity grid capacity and the future political support for heat pumps. More clarity is needed on how to phase out natural gas in heating and the role for heat pumps, including hybrid solutions.

Energy performance in buildings

Energy performance in new buildings is regulated in building codes. The recently revised Energy Performance in Buildings Directive states that all new buildings should be zero emission as of 2030 and that the entire building stock should be zero emission by 2050.

Energy performance in existing buildings is targeted through support for renovations. The National Insulation Programme includes various measures to accelerate home improvements. Municipalities can set up their local insulation approach using national subsidies. For example, the Municipal Sustainability Scheme allows homeowners in participating municipalities to renovate their homes without the upfront costs. An inspector assesses suitable measures to improve the sustainability performance of the home and the municipality pays for the investments needed. The homeowners then repay the investment over 30 years via a tax levy. Furthermore, homeowners are nudged to take insulation and other sustainability measures through the website verbeterjehuis.nl.

An energy performance certificate (EPC) is legally required when selling or renting a property in the Netherlands. As of 2023, 61% of homes had a valid EPC, and 1.7 million homes, accounting for 21% of the total, were categorised as very efficient (A/A+ labels). This number has significantly increased in recent years, from around 660 000 homes in 2018, representing just 8% of the dwellings at that time.

District heating market

Over 500 000 homes in the Netherlands are connected to district heating systems, which accounts for around 6% of total dwellings. District heating connections are growing but the trend has slowed down recently, and the level is far from the 80 000 new connections per year in 2025-30 that was targeted in the 2019 Climate Agreement. In the 2023 National Energy System Plan, the government presents its vision for scaling up district heating networks using mainly local sustainable heat sources. It explores several scenarios, one of which targets a district heating supply of around 50 PJ by 2030, 100 PJ by 2040 and 150 PJ by 2050. It also states that the localisation of future district heating systems needs to be made clear to avoid a situation where it competes with individual sustainable heating systems such as heat pumps. The government supports the development of district heating networks by means of the Climate Fund. In the Spring 2024 budget, more than EUR 1 billion was allocated to support heat network investments.

District heating can be a cost-effective alternative to heat pumps in densely populated areas and can provide system benefits by avoiding the use of a congested electricity grid. If integrated well with the electricity system, district heating can contribute to flexibility, including by using large-scale heat pumps, when produced in co-generation heat and power plants, and combined with large-scale thermal storages. As stated in the National Energy Plan, the government aims to further develop and scale up heat storage connected to district heating.

For district heating to play an important role in decarbonising heat in the Netherlands, renewable heat sources and residual heat from industries and waste incineration need to replace the large-scale use of natural gas. In the 2023 Climate and Energy Outlook, PBL projects that the share of renewable and residual heat in district heating will increase from 45% in 2020 to 64% by 2030. Access to bioenergy sources in the Netherlands is limited, but new industries and hydrogen production provide opportunities for using more residual heat in district heating. Using renewable or residual heat sources needs to be more financially viable than natural gas for suppliers to make a switch. Sweden has phased out nearly all fossil fuels from its district heating production, driven largely by the CO_2 tax introduced in 1991.

Dutch district heating prices are regulated based on natural gas prices, where the maximum tariff is set annually by the regulator ACM and must not exceed the price for individual gas heating. Fuel costs increased during the energy crisis, especially natural gas prices, which has also impacted the district heating prices. The Amsterdam Association of Housing Associations recently decided to pause new connections to district heating networks due to increased costs. With a new Collective Heat Act, the government plans to replace the current price regulation with a model where tariffs are based on heat suppliers' actual costs rather than having maximum tariffs based on the price of natural gas. The proposal for the new Collective Heat Act is with the parliament, with a decision expected in late 2024.

Furthermore, the new Heat Act includes changing ownership structure and requiring that at least 51% of a district heating company's shares be publicly owned. This has been met with scepticism from the industry. As a response to the planned changes to ownership, Vattenfall stated in 2022 that it will not develop new heat networks and pause with expansion decisions for existing ones. Other companies have followed suit. A recent article states that 90% of all district heating networks under construction in the Netherlands have been paused. A clear political direction is needed for the development of district heating, to increase the trust among consumers and investors.

Service sector and data centres

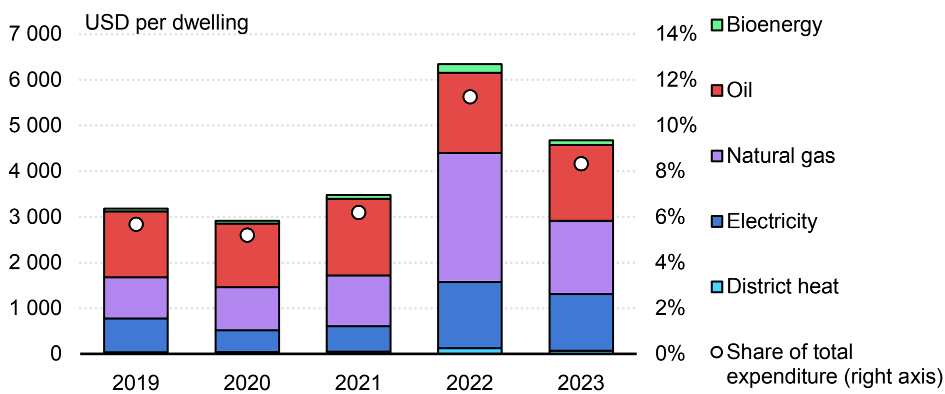
Residential buildings account for around 60% of total energy consumption in the buildings sector. The rest is non-residential buildings, which have partly similar challenges in terms of transforming gas consumption used in heating. However, the service sector, in particular data centres, also consumes a lot of electricity for appliances and cooling. Data centre electricity demand has increased steadily in recent years and accounted for over 3% of total electricity demand in 2021, and the data centre segment is expected to continue to grow, though grid congestion poses significant obstacles to this.

Energy affordability and distributional effects

Energy affordability has emerged as a major theme in recent years, as natural gas dependency made consumers vulnerable to the European energy crisis caused by

Russia's invasion of Ukraine. The Netherlands experienced the largest energy price increases among IEA Member countries in 2022, when energy expenditures nearly doubled and reached 13% of total household expenditures. The main reason was the increased cost for heating, due to the high shares of natural gas, but also higher electricity prices.

Energy expenditure per dwelling in the Netherlands, 2019-2023



Note: Includes expenditure for transport fuels and energy use from households (space heating and cooling, water heating, cooking, appliances).
Sources: IEA (2024), Energy Prices; IEA (2024), World Energy Balances; IEA (2024), Energy End-uses and Efficiency Indicators.

As in many other European countries, the Dutch government subsidised energy costs to protect consumers during the crisis. In 2023, it introduced a price cap for gas, electricity and district heating for households and other small-scale users. Up to a certain level of consumption, prices above a maximum tariff were rebated to users on their energy bills. Excise duties for transport fuels were also reduced from April 2022 to July 2023.

The period of significantly higher energy prices had notable effects on energy consumption and behaviour. The sales of smart thermostats rose by 32% in 2022, indicative of how households increasingly want to be able to use energy more efficiently and flexibly. Energy prices have declined since their peak in 2022 and in

2023 were no longer the most expensive in terms of household energy costs. Nonetheless, prices in 2023 were significantly higher than in 2021 and before the energy crisis.

The vulnerability that comes with the high dependence on imported gas is proof of the need to speed up the energy transition and improve efficiency and flexibility to secure affordable energy. Furthermore, all energy policies, particularly fiscal instruments such as taxes and subsidies, have distributional impacts on the population. Even when subsidised, investments in efficiency improvements or clean energy technologies still require upfront costs that not everyone can afford. Distributional effects should be taken into consideration when designing policies to avoid disproportionate negative impacts on vulnerable populations.

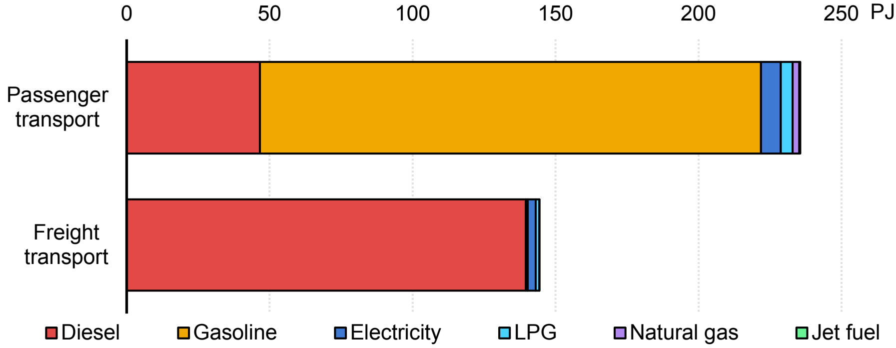
Transport

The Netherlands is decarbonising the transport sector through biking, trains and other public transport, and electromobility. The country is flat and densely populated, and biking has for a long time been a natural mode of transport, especially in urban areas. In recent years, the Netherlands has also improved the conditions for biking between cities on “bicycle highways”. The Dutch train system provides efficient links between cities and connects the Netherlands with other countries in Europe. Furthermore, the Netherlands also advanced electromobility and has a well built-out public charging system for EVs. In the 2019 Climate Agreement, the government sets the ambition for 100% of new cars sold to be emissions-free by 2030, which will further drive electrification.

Transport energy consumption still relies mostly on oil products

Despite the steady growth in EVs, the transport sector continues to rely largely on oil-based fuels. In 2022, oil accounted for 90% of total energy consumed in transport. The switch to EVs is becoming visible in the data, but electricity accounted for only 3% of transport energy demand in 2022. However, as an electric engine is more efficient than an internal combustion engine, electrification of transport also helps reduce total energy consumption in the sector.

Energy use in transport by subsector and fuel in the Netherlands, 2021



Notes: LPG = liquefied petroleum gas. The share of consumption for fuel tourism and off-road applications uses are excluded from the chart..
Source: IEA (2024), Energy End-uses and Efficiency Indicators.

The use of biofuels needs to increase to meet climate targets for 2030. Even if electrification is the main strategy to decarbonise transport, especially passenger cars and other light-duty vehicles, the transition of the vehicle fleet takes time. Increasing the use of biofuels is an effective way to reach emissions reductions within the existing vehicle fleet. According to PBL's *Climate and Energy Outlook 2023*, the REDIII targets and additional measures from the 2023 Climate Package will require biofuels used in transport to increase significantly, from 23 PJ in 2022 to 150 PJ in 2030. This will mainly be driven by an obligation on fuel suppliers to provide fuels with a lower GHG intensity. The Netherlands has multiple biofuel refineries with the capacity to produce over 80 PJ of biodiesel per year, much of which is exported. To reach 150 PJ, either domestic biofuel refinery capacity needs to increase or the additional demand will have to be covered by imports.

The Netherlands has also introduced a subsidy for hydrogen in mobility (SWIM). The scheme can be used by partnerships consisting of at least one hydrogen filling station operator and one freight or bus transport company to fund new or upgrades to existing hydrogen filling stations, to purchase hydrogen vehicles, or to convert existing vehicles to hydrogen.

Electromobility and infrastructure

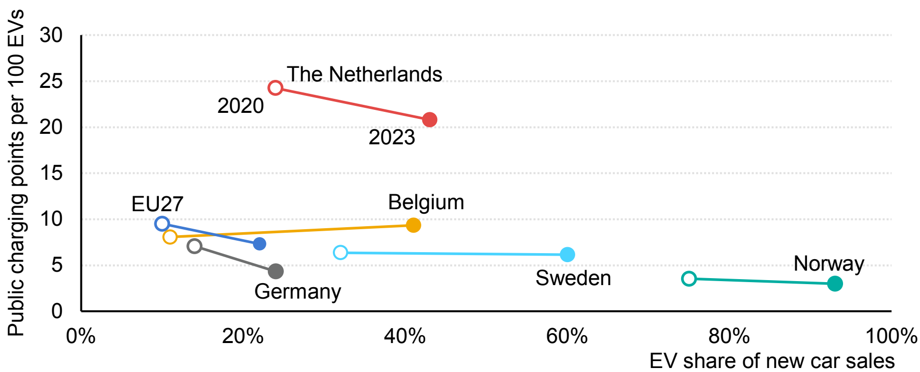
The number of EVs is steadily growing in the Netherlands. In 2023, total new EV sales were approximately 147 000 cars, up from 104 000 in 2022. The share of EVs in new car sales was 43% in 2023, up from 34% in 2022. This includes both battery EVs and plug-in hybrid EVs. The share is significantly higher than the EU average at 22% but lower than in the leading Nordic countries with EV shares of 93% in Norway, 71% in Iceland and 60% in Sweden.

The government provides financial support for EV purchases, but the size of the subsidy has been reduced. Private individuals who want to buy or lease an electric car can apply for a subsidy from RVO. When introduced in 2020, the subsidy provided EUR 4 000 in support when buying an EV. As of 2023, the level was reduced to EUR 2 950. The 2023 Climate Package included an additional EUR 2 000 subsidy for purchasing second-hand EVs. The coalition Outline Agreement from May 2024 states that EV purchases will continue to be supported until 2025, while also keeping in mind people using fossil fuel cars and a fair distribution of cost between different options. In addition to the subsidy for buying electric cars, the Netherlands has introduced a purchase subsidy for companies and non-profit organisations that want to buy or lease zero-emission trucks (AanZET).

The Netherlands has a large public EV charging network supporting the transition to electromobility. Public charging infrastructure is a necessary component in enabling electromobility, especially in densely populated areas where access to home charging at private parking spaces is limited. In the Netherlands, seven out of ten households rely on public parking for their cars. The government together with municipalities, provinces, network companies, businesses and industry associations developed a National Charging Infrastructure Agenda, which aims to make charging easy, smart and widely accessible. In 2023, the Netherlands had around one charging point per five EVs, making the public charging network one of the densest in the world. Only around 4% of the public charging points offer fast charging, reflecting the capacity limitations of the electricity grid.

The government supports businesses that invest in new charging infrastructure on private spaces, such as company premises, through a subsidy for private charging stations (SPRILA). To promote the buildout of charging points for heavy-duty vehicles, the government has introduced the Public Charging Infrastructure Heavy Transport Subsidy Scheme (SPULA). The SPULA subsidy scheme is aimed at entrepreneurs investing in publicly accessible charging stations for heavy vehicles. One requirement is that only renewable electricity be used for the charging stations. The government is also planning a truck toll to come in effect from 2026, to help fund some of the subsidy schemes directed at electrifying transport.

Trends for EV sales and charging infrastructure in selected countries, 2020-2023



IEA. CC BY 4.0.

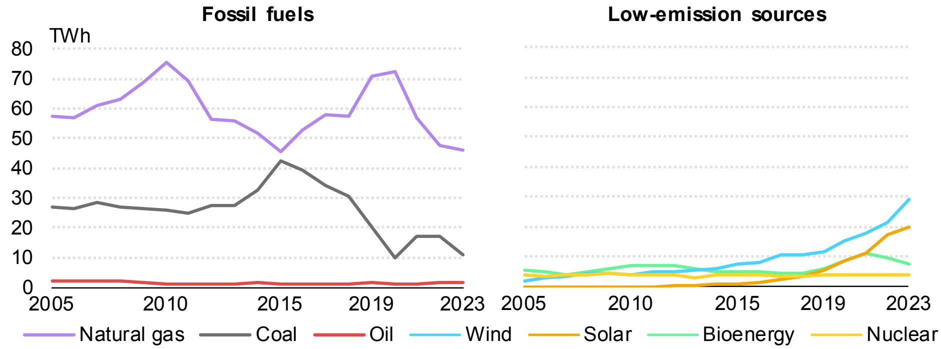
Source: IEA (2024), Global EV Data Explorer.

EV charging can lead to a surge in peak electricity demand, but if managed well, EV batteries and charging can become an important source of flexibility in the electricity system. As electricity grid congestion is already a major problem in the Netherlands, the potential for smart charging should be explored further. Within the National Charging Infrastructure Agenda, a working group is dedicated to exploring smart charging, which includes a Smart Charging Action Plan.

Electricity supply

The Netherlands is on a clear path towards decarbonising its electricity system. In 2022, fossil fuels still accounted for 55% of total power generation, but the Netherlands has, in a joint statement with six other European countries, set the ambition to decarbonise the electricity system by 2035. The rapid growth in solar and wind power supported by strong policy frameworks has enabled a reduction in electricity from natural gas and coal power and made the Netherlands a net exporter of electricity in recent years. Besides continued growth in renewable electricity, nuclear energy can also play a role, as the Netherlands has plans to expand its current single nuclear reactor with four new reactors.

Electricity generation by source in the Netherlands, 2005-2023

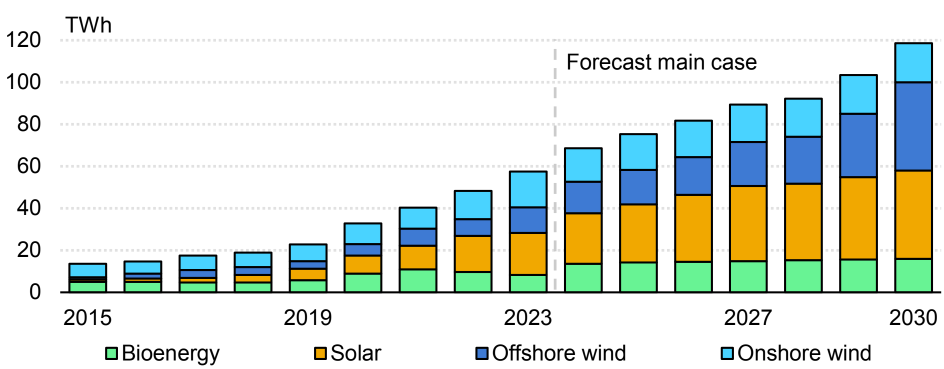


Source: IEA (2024), World Energy Balances.

Renewable electricity generation

The Netherlands has seen a very rapid growth in renewable electricity generation. In 2017, renewable electricity only accounted for 15% of total power generation in the Netherlands, the 6th-lowest share in the IEA. Just five years later in 2022, renewables had increased to 40% of total generation, above the IEA average of 31%.

Renewable electricity generation in the Netherlands, 2015-2023, and forecast 2024-2030



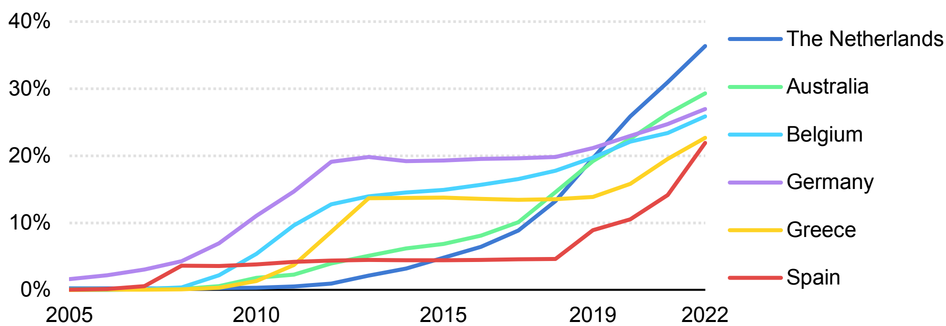
Source: IEA (2024), Renewable Energy Progress Tracker.

This impressive growth has come from wind power, which is the largest source of renewable electricity in the Netherlands, and solar power, which is close behind. The IEA forecast shows that the share of solar and wind in total power generation will increase further from 32% in 2022 to 57% by 2028. The growth will come from both wind, especially offshore, and solar, mainly distributed solar PV supported through the SDE++ (commercial scale) and net metering (households).

The Netherlands is world-leading in solar PV deployment

The Netherlands' growth in solar PV in recent years has been very impressive, reaching a share of solar PV in total installed capacity of over 35% in 2022. This was among the highest levels in the world, despite having far from the best conditions for solar energy. Solar PV has become a good investment, thanks to falling technology prices combined with strong policy support. In particular, distributed PV systems (e.g. rooftop installations) have increased rapidly, accounting for nearly three-quarters of the total growth in installed capacity, but utility-scale systems are also growing.

Solar PV per total installed capacity in selected countries, 2005-2022



Source: IEA (2024), World Energy Balances.

Investments in residential solar PV systems have been supported by net-metering regulation since 2004, which in practice allows PV owners to sell excess electricity back to the grid for an annual average price. Solar PV is also supported through the SDE++ scheme, in competition with other CO_2-abating technologies. The SDE funding for solar has decreased in recent years, though thanks to falling prices for PV installations, the total volume of solar receiving support can still be significant. However, the Netherlands has considered removing renewable electricity generation from the SDE++ scheme and instead introduce a CfD scheme for solar and onshore wind. The cost reductions in the technology and the rapid deployment in recent years should be taken into account when designing such support policies.

The net-metering scheme has been a strong driver of rooftop solar growth, but it also creates problems. As more and more PV owners deliver electricity to the grid during sunny hours, the electricity price falls, and the cost difference between the market price and the annual average price paid to the PV owners is covered collectively by all electricity consumers. This raises questions around fairness among different consumer groups, as owners of PV systems in general are among higher income groups in society. This is an issue that the government also has recognised. Furthermore, under the net-metering scheme, PV owners lack incentives to act in a way that benefits the grid (see Focus Area “Electricity grid congestion”). The Senate blocked an earlier proposal to phase out the net-metering scheme in February 2024, but the government now wants to abolish the scheme by 2027.

Wind power is growing, with large potential offshore

Wind power is growing rapidly, especially offshore, supported by an effective policy framework (see the policy spotlight below). In 2022, onshore wind produced 14 TWh and offshore wind 8 TWh. Onshore wind is limited by land available and local acceptance issues. These challenges are shared by other countries, but the Netherlands is particularly densely populated, and the government has declared a preference for offshore wind over onshore. Local and regional authorities are responsible for spatial planning in relation to energy projects and in the Regional Energy Strategies, each energy region describes how much wind power can be generated and where.

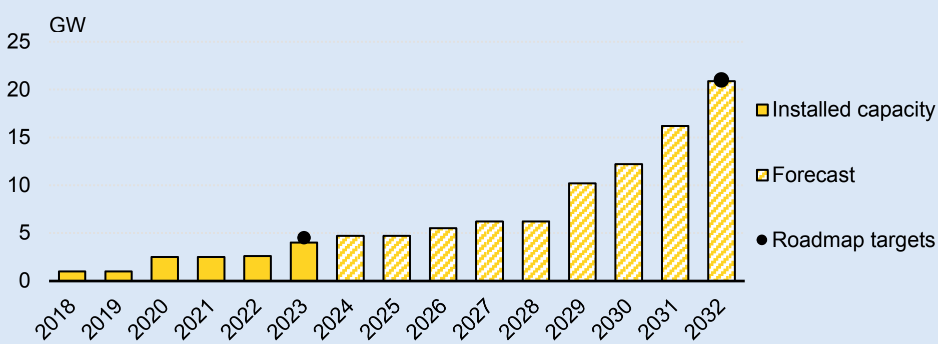
With favourable wind conditions in relatively shallow waters in the North Sea, and access to ports from where to ship the equipment, the Netherlands has great potential for offshore wind, which is forecast to produce more electricity than onshore wind already in 2024. The Netherlands is collaborating with eight other countries and the European Commission on the development for offshore wind in the North Seas Energy Cooperation. Offshore wind development also has clear synergies with development on the hydrogen market (see Focus Area “Hydrogen and offshore wind”).

Policy spotlight: Successful framework for offshore wind power

The government presents its plans for offshore wind in its Offshore Wind Energy Road Map, with targets for installed capacity, sites and timelines. TenneT supports the development by delivering the connection to the onshore grid. The first roadmap from 2013 targets 4.5 GW of installed capacity by 2023. In 2018, a target for 11.5 GW by 2030 was set, which in 2022 was increased to 21 GW as a response to the energy crisis in Europe. This target was later postponed to 2032 to account for recent market development.

The transparent framework with clear milestones supported by a structured buildout of the transmission grid has resulted in successful tendering processes and timely constructions of offshore wind farms. Since 2018, five wind farm sites have been granted subsidy-free permits in competitive auctions. The 2023 target of 4.5 GW was on time in terms of construction (though the grid connection happened in 2024), and the planned tender schedule outlines new capacity to meet the 2032 target, including upcoming tenders for the sites IJmuiden Ver Gamma and Nederwiek I, with a total capacity of 4 GW. Furthermore, recent auctions have included qualitative non-price criteria in which the bidders had to demonstrate that they can mitigate or restore the impact of the offshore wind farm on the maritime biodiversity. Extra points have also been provided for connecting the wind park to electrolysers, linking the offshore wind tendering to the hydrogen market.

Offshore wind development and targets in the Netherlands, 2018-2032



Source: Renewable Energy Progress Tracker – Data Tools - IEA and data from the Offshore Wind Energy Roadmap.

Nuclear

There is one operating commercial nuclear reactor in the Netherlands, which produces around 3% of total electricity generation. The reactor is a pressurised water reactor with a relatively small installed capacity of 482 megawatts (MW), located at the Borssele nuclear power plant. EPZ owns and operates the plant with a licence to operate until 2033. The Netherlands also has industries along the nuclear supply chain, including Urenco's facility producing enriched uranium for nuclear fuel and ULC-Energy B.V.'s development of the Rolls Royce small modular reactor (SMR) for the Dutch market.

The Netherlands plans to extend and expand its nuclear fleet. In a statement from December 2021, the government presented plans for extending the lifetime of the existing reactor at Borssele beyond its 2033 licence expiration and taking necessary steps to build two new nuclear power units. This reversed a previous decision to phase out nuclear power. In December 2022, the government clarified the ambition to build two third-generation nuclear reactors, each with a capacity of 1 000-1 650 MW, that could supply 9-13% of electricity generation by 2035. In 2024, the new government enhanced the focus on new nuclear power and set the ambition for another two large reactors to be built in addition to the two already planned.

Electricity grids and markets

The Dutch electricity grid is managed by the transmission system operator (TSO) TenneT and six distribution system operators (DSOs). TenneT is responsible for the high-voltage electricity grid (110-380 kilovolts [kV]), including connections of offshore wind parks to the onshore transmission grid and cross-border interconnectors to neighbouring countries. On lower voltage levels, the three largest DSOs Enexis Netbeheer, Liander and Stedin are the main operators. The DSOs also operate gas networks. All DSOs together with TenneT and Gasunie, the TSO for the natural gas grid, are members of the grid association Netbeheer Nederland.

Electricity grid development

The Netherlands is interconnected to Belgium, Denmark, Germany, Norway and the United Kingdom. Rapid growth in renewable electricity generation made the Netherlands a net exporter of electricity for the first time in 2020. In 2023, the

Netherlands had net exports of 6 TWh, with 25 TWh exported and 19 TWh imported. The largest exports went to Germany, Belgium and the United Kingdom.

The electricity transmission and distribution systems are financed through regulated grid tariffs. ACM regulates the revenues for TenneT and the DSOs through benchmarking against the neighbouring countries. The average Dutch household pays about EUR 300 in grid fees annually, of which roughly EUR 70 go to TenneT to pay for the transmission grid operation. The fee is set to increase significantly in 2024 to EUR 132 due to the high electricity prices from 2022 (as parts of the grid tariff reflect electricity prices after two years) but also to pay for the grid buildout and higher costs for grid balancing measures. According to TenneT, the grid tariff will continue to rise by an average of 11% per year (excluding inflation) over the next decade, with offshore grid investments accounting for over half of the increase.

Electrification of end-user demand requires a massive expansion of the electricity grid. Target Grid is TenneT's long-term vision of an integrated, onshore and offshore, cross-border electricity grid. It maps out the grid in 2045, including areas for offshore wind connections and high-voltage connections needed to meet the European climate targets. The basis for the analysis is projections for connection capacity that may need to nearly triple to be able to meet increased demand in industry (from 41 GW in 2019 to 104 GW in 2050), households (from 24 GW to 33 GW) and transport (from 2 GW to 56 GW).

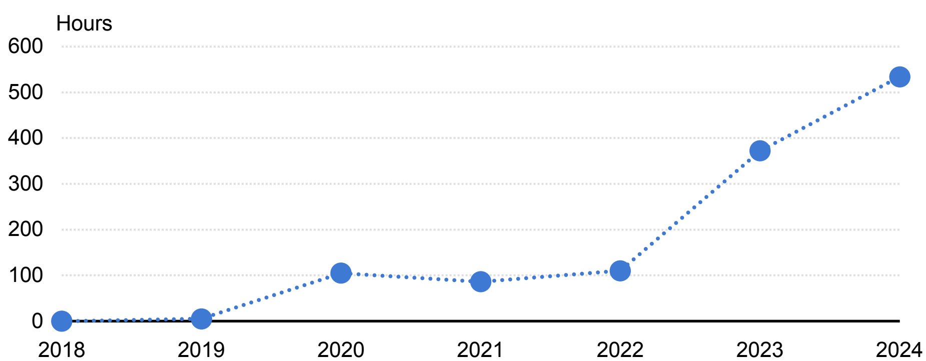
Electricity market development

The Netherlands is part of a European wholesale electricity market that links over 20 European countries. The wholesale market manages day-ahead and intraday electricity trading between interconnected European bidding zones. The Netherlands is a single bidding zone. The higher share of variable renewables requires more balancing capacity in the system. As a result, the role for flexibility in the energy system increases. To maintain stability on the grid, TenneT procures ancillary services including three types of balancing reserves, reactive power, redispatch and black start facility.

Since 2019, TenneT together with the DSOs operates a flexibility platform called GOPACS. The purpose is to give parties with flexibility potential easy access to a growing market for congestion services. GOPACS is not a trading platform but allows market players to monetise their available flexibility on energy-trading platforms ETPA and EPEX SPOT to help resolve congestion situations. As of April 2024, there were 752 connections for redispatch registered on the GOPACS platform.

Growth in renewables has a visible impact on the wholesale electricity market, which is experiencing negative wholesale prices more frequently, when the supply is greater than the demand on the market. The number of hours with negative electricity prices tripled from 2022 to 2023, reaching a total of 372 hours, and continued increasing in 2024 to over 500. While low electricity prices can benefit consumers, strong fluctuations and frequent negative prices have a negative impact on investments in new electricity generation. Negative prices indicate a lack of flexibility in the electricity system, which policy makers and market actors need to address.

Zero or negative wholesale price occurrences in the electricity market in the Netherlands, 2018-2024



Source: IEA analysis based on ENTSOE (2024), Transparency platform, collected through the Real-time Electricity tracker.

Fuels

Oil and natural gas remain the largest energy sources in the Netherlands, and the country is a major energy-trading hub. Furthermore, the Netherlands is a large consumer of hydrogen, which is becoming increasingly important as an energy source as well as feedstock for industrial processes.

While an increasing share of energy demand is being electrified, fossil fuels remain important for the Netherlands' energy supply. Natural gas is largely consumed domestically for heating in buildings, power generation and industry applications, whereas most oil products that are imported or produced in Dutch refineries are exported. The Netherlands is the largest exporter of oil products in Europe and has by far the highest share of total trade (imports and exports) compared to its domestic demand.

Natural gas

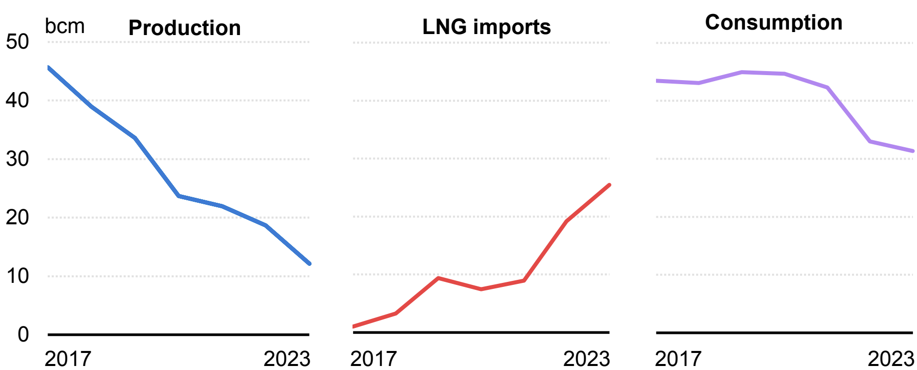
Natural gas remains an important fuel in the Netherlands, although consumption is declining. In 2022, natural gas accounted for 37% of energy demand in industry and 84% of residential space heating demand. Since the 2018 amendment of the Gas Act (Gaswet), new buildings are not fitted with gas connections. However, the pathway and timeline for replacing natural gas in existing heating systems with either district heating or electric heating in heat pumps needs to be clarified. Furthermore, natural gas accounted for 39% of electricity generation in 2022, but that share is decreasing as renewables grow and replace gas power. With the target of fossil-free power systems by 2035 and the current growth rate in solar and wind, the role for natural gas in power generation will continue to diminish. However, gas-fired power plants still play a role to provide flexible electricity generation.

With the closure of the Groningen gas field, the Netherlands has gone from being a major producer and large natural gas exporter to a net importer. The Groningen gas field in the north of the country is the largest in Europe and has, since it began operation in 1963, produced most of the gas consumed in the Netherlands. Following earthquakes linked to operation of the field that damaged many buildings in the region in 2018 and 2019, gas production in Groningen was rapidly reduced and ended completely in October 2023. In April 2024, the Senate approved a law to permanently close the Groningen gas field by 1 October 2024. The 2024 Government Programme confirms that there will not be any more gas production from the Groningen field. However, it also states that gas production in the North Sea will be scaled up, which today is very small.

Extensive gas infrastructure connects most households and commercial properties, industries, and gas power plants. The Dutch gas system is relatively unique as it has two separate networks for low calorific gas (L-gas) and high calorific gas (H-gas). The reason for this is that the Groningen gas has lower calorific value than most other natural gas and was supplied through a separate gas network to mainly household customers in the Netherlands and neighbouring countries. As many consumers relied on the L-gas that was produced in Groningen, there are nitrogen plants that turn imported H-gas into L-gas that can be supplied to the end users. The Netherlands also has a large amount of gas storage operated by commercial parties.

Thanks to numerous gas interconnections with its neighbouring countries, the Netherlands is a major hub for gas trade across Europe. The Dutch gas network is linked to the European gas network through interconnection points with Belgium, Germany and the United Kingdom. While imports used to come mainly via pipeline from Norway (via Germany) and Russia, liquefied natural gas (LNG) imports from a range of countries have become the main supply of natural gas to the Netherlands. The Gate LNG Terminal in the Port of Rotterdam has been in operation since 2011, and its capacity increased from 12 billion cubic metres (bcm) to 16 bcm per year with plans for a further 4 bcm expansion by 2026. In 2022, as a response to the energy crisis, a floating LNG terminal with a capacity of 8 bcm per year was developed in the Port of Eemshaven. The intention is to use the site in the future to import green hydrogen. Both the Rotterdam LNG terminal and the Eemshaven terminals are owned by a subsidiary of Gasunie and Vopak.

Natural gas flows in the Netherlands, 2017-2023



Source: IEA (2024), World Energy Balances.

Biomethane

Biomethane is a very small share of gas consumption in the Netherlands today, but is set to increase, as fossil fuels need to be replaced. With the Biomethane Programme, the government aims to increase biomethane production from around 0.3 bcm in 2022 to at least 2 bcm (equivalent to 70 PJ) by 2030. To achieve this, the Programme focuses on establishing a strong business case and providing long-term certainty for companies in the sector.

The main instruments being implemented are the blending obligation and financial support for biomethane production. The blending obligation, set to start in 2026, is expected to contribute 1.1 bcm of biomethane by 2030. To support the development of gasification, the Climate Fund is providing backing for early-stage scaling projects to help mitigate technical and financial risks. The SDE++ scheme further allocated EUR 750 millions in 2023 and EUR 1 billion in 2024, targeting areas including biomass fermentation and gasification technologies. Additionally, biomethane production is supported through innovation programmes such as the Demonstration of Energy and Climate Innovation and the Renewable Energy Transition.

Hydrogen

The Netherlands is already a large consumer of hydrogen, produced from fossil fuels (primarily natural gas) and used in different industry sectors. The Dutch industry sector consumes around 1.5 million tonnes of hydrogen annually, making the country the second-largest user of hydrogen in Europe after Germany and the largest per capita. Around two-thirds of the hydrogen is consumed in refineries and as feedstock in ammonia production. Two companies dominate the market: Yara, a fertiliser producer, and OCI, a global supplier and distributor of nitrogen, methanol and hydrogen-based products. A large share of hydrogen is produced directly from natural gas while around one-third comes from other industrial processes.

Low-emission hydrogen produced from electrolysis using fossil-free electricity or from natural gas with CCS accounts for an insignificant share of the production today but is set to increase as clean hydrogen will play an increasingly important role in the energy transition (see Focus Area “Hydrogen and offshore wind”). The 2019 Climate Agreement includes an ambition to scale up electrolysis capacity to 500 MW by 2025 and 3-4 GW by 2030. In 2020, the government reinforced this target in its Hydrogen Strategy. The National Hydrogen Programme, consisting of public and private participants, presented in 2022 the Hydrogen Roadmap, which included a more ambitious target of 6-8 GW of electrolytic capacity by 2030.

Oil products

In 2022, oil accounted for 37% of total energy supply and 43% of final energy consumption, surpassing natural gas as the main energy source in the country. Most of the oil products were consumed for non-energy use as a feedstock in chemical and petrochemical industry (41% of total oil consumption in 2021), in transport (39%), and for energy purposes in industries (16%). In addition, the Netherlands has a large oil consumption for international bunker fuels, especially marine bunkers in the Port of Rotterdam.

While nearly all crude oil is imported, the Netherlands is a large producer and exporter of oil products. Crude oil is imported from a range of countries and the Netherlands is a major trading hub for both crude oil and oil products. It has six refineries, five of which are in the Port of Rotterdam, producing a range of oil products including marine fuels and feedstock to the local petrochemical industry. Furthermore, the Netherlands has around 140 biorefineries, mainly supplying biocarbon-based chemicals to the industry, liquid biofuels and biomethane.

Coal

The largest share of the coal consumed in the Netherlands is used in coal-fired power plants. Although coal power generation has more than halved from a peak in 2015, coal still accounted for 14% of total electricity generation in the Netherlands in 2022. However, the Dutch parliament passed a law in December 2019 on the prohibition of the use of coal in the production of electricity by 2030. There are four remaining coal power plants; the oldest one will close in 2024 and the other three before 1 January 2030. Coal mining has been shut down since the 1970s and the Netherlands depends entirely on imports for its coal supply.

Besides power generation, coal is used in industry, mainly in steel production. Emissions from coal consumption in industry falls under the EU ETS and will as such have to be reduced and finally eliminated. Tata Steel has plans to switch from coal to a direct reduction process using hydrogen.

Recommendations

1. Maintain a strong commitment to the energy and climate targets and implement well-designed policies to reach them.

Effective energy and climate policy requires long-term stability and political commitment that provides certainty for investors, industry and the public. With the 2019 Climate Act, the Netherlands has set ambitious and legally binding targets for emissions reductions to 2030 and 2050, and a clear framework for assessing progress towards those targets through PBL's annual Climate and Energy Outlook (KEV). KEV 2023 showed that the targets are within reach, but only if all stated policies, including from the 2023 Climate Package, are implemented. However, recently announced fiscal and regulatory policy changes, such as reducing the tax on natural gas and removing the heat pump obligation when replacing a natural gas boiler, risk slowing down the transition. The government should build on previous policy development and implement a well-designed mix of measures to stay on a trajectory towards the climate targets, including cost-effective incentives as well as regulations to provide policy certainty. This should be clarified in the next Climate Plan, scheduled for 2025. Furthermore, the KEV should continue to be used as guidance when assessing the need for additional policy measures. Support in terms of subsidies should be assessed based on market maturity.

2. Implement a people-centred approach to the energy transition, addressing distributional impacts.

The Netherlands has managed a remarkable acceleration in the energy transition in recent years. However, rapid changes also come with challenges in terms of who is paying for this transition and who is reaping the benefits. The extremely high energy prices during the energy crisis of 2022-23 have put the question of affordability high on the agenda. To ensure the necessary buy-in for the energy transition from all parts of society, it is crucial that the transition does not come at the expense of people with lower incomes or small businesses. To date, energy policy development has been focused on delivering fast results, without properly addressing distributional impacts or ensuring equitable access to support. Interventions to increase the energy efficiency of homes and buildings have been focused on homeowners. Subsidies on EVs or heat pumps require upfront capital and are therefore limited to those with higher incomes. The net-metering system for solar PV has similarly transferred money from all electricity consumers to the people who could afford the investment. To protect vulnerable consumers, subsidies and other energy policies should be better targeted and take distributional implications into account.

The government should deliver an overall vision for a people-centred energy transition that sits alongside the National Energy System Plan and the Regional Energy Strategies. In doing so, the government should develop a methodology for assessing distributional implications, as part of policy design, implementation and evaluation, to address unintended consequences. This should be delivered through co-ordinated engagement with local communities, citizen groups and other stakeholders to develop equitable policy interventions and broad-based public support. Mobilising the public will be key to securing buy-in for new energy infrastructure, which today struggles with local acceptance issues. Consumers also need to be empowered and engaged to deliver the demand-side response needed to balance the electricity system and manage grid congestion.

3. Develop a coherent energy system strategy and ensure co-ordination to align plans and incentivise the market.

The Netherlands has an ambitious plan to decarbonise the energy sector as outlined in the National Energy System Plan. To date, there has been tremendous progress, with the Netherlands becoming a frontrunner in renewables deployment. However, there is a lack of coherence between the long-term plans and the current situation, which exacerbates grid congestion and encourages competition between low-carbon energy sources. There is also a strong focus on the future supply of renewable energy, with less clarity on the demand side. Industrial decarbonisation remains a key challenge here that needs to be addressed to deliver on the climate goals and create more certainty on the demand for clean energy sources. To sustain the pace of the transition, interventions across the energy system need to be aligned and carefully calibrated to manage the complex interplay of supply and demand, delivering clarity for investors and mitigating market externalities. Therefore, the government should build on the National Energy System Plan and develop a coherent energy system strategy, with co-ordination across government and sectors, to link the ambitions set out in the plan to the realities on the ground. A co-ordinating body, which could be within existing ministry structures, should be defined to drive alignment, co-ordinate interventions and support energy system-wide improvements.

4. Clarify a pathway to ensure an orderly transition away from natural gas across different sectors.

Natural gas remains a large energy carrier in the Netherlands, especially in electricity and heat production. To decarbonise the electricity sector by 2035 in line with stated ambitions, the existing natural gas fleet needs to either switch to biomethane or e-methane, add carbon capture, be repurposed to be able to use low-emission hydrogen, or close within the next ten years. In the heating sector, natural gas boilers should be replaced with heat pumps and fossil-free district heating.

The government should develop a pathway with a clearly communicated timeline and sequencing to orderly replace natural gas with carbon-neutral options to achieve the climate targets. For electricity generation, the transformation should be guided by a strategy to minimise system costs and ensure security of supply and flexibility in a system with large shares of variable renewable generation. For heating, the government should clarify the role for hybrid heat pump solutions while further incentivising energy efficiency improvements, electrification and the use of low-emission gases. Furthermore, the government should engage with local authorities and energy communities to assess the role for district heating across the country. The Netherlands should also work towards its target of 2 bcm/yr biomethane production by 2030, which would accelerate the phase-out of natural gas, including in hard-to-abate sectors. A Biomethane Action Plan should be developed in close co-operation with all stakeholders, including the biomethane industry, farmers, gas transmission and distribution system operators.

Focus areas

Policy makers are focusing on certain key areas to guide the Netherlands in its energy transition. Grid congestion in the electricity system is a major bottleneck that slows the energy transition of multiple sectors that rely on electrification, and it needs both short-term and long-term solutions. For sectors that cannot solely rely on direct electrification, hydrogen is becoming the preferred decarbonisation option. However, market uncertainties remain a barrier to the development of hydrogen projects. Furthermore, both direct and indirect electrification require a boost of clean electricity generation. The Netherlands has a well-defined roadmap for offshore wind deployment with large growth potential and synergies with hydrogen development, but the sector faces challenging market conditions. The government also wants to grow the nuclear fleet with new reactors, which requires a long-term plan with a clear view on the future role for nuclear in the energy system and a well-designed support scheme that attracts market investments.

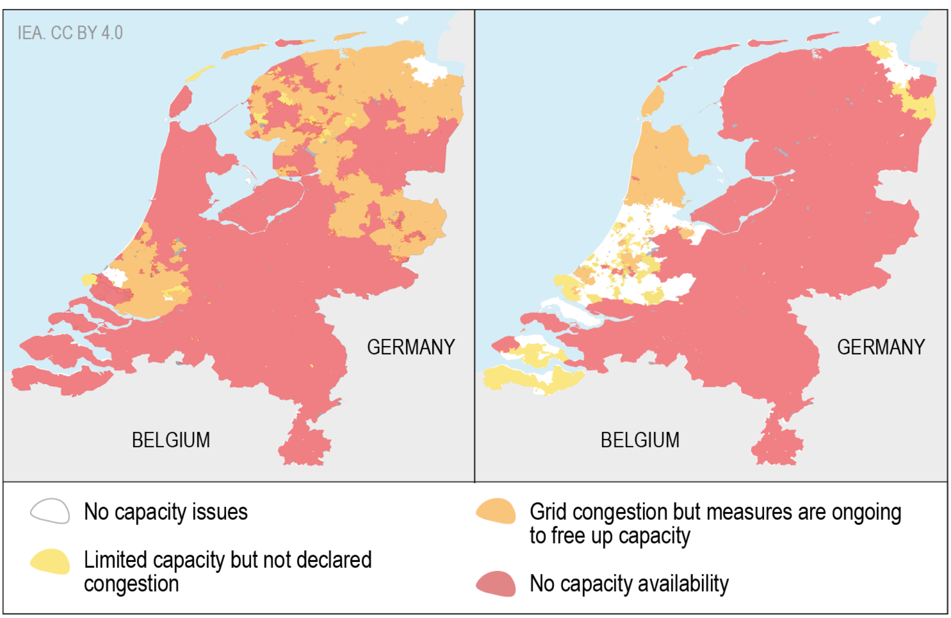
Electricity grid congestion

The Dutch electricity grid was not built to accommodate all the distributed renewable electricity that is now being generated on windy and sunny days, or to supply all the new demand from data centres and industries, heat pumps, and EV chargers. When the grid capacity is insufficient to safely transfer electricity from a generator to a consumer, the grid becomes congested. This causes long waiting times for new connections, which slows down the energy transition and affects the economy overall. Without resolving the grid congestion, connections of new renewable generation and electrification of energy demand cannot progress at the rate needed, and decarbonisation goals will not be met. The government is aware of the problems, and much is being done to improve the situation, but further measures are needed.

Grid congestion is increasing

The first reports of major grid congestion came in 2018, and the issue has only grown since. As of September 2024, most of the grids in the Netherlands are considered congested, and the waiting list for new or increased connections includes around 10 000 large users (consumers or batteries) and 7 500 large generation projects (bigger than household scale). Although that list may contain many double bookings as companies can submit several applications for the same connection in multiple locations, the waiting list is growing at a rapid pace. As a result, new grid connections are delayed, including housing projects and industry plans that are not able to be developed. The Climate and Energy Outlook 2023 raises grid congestion as a serious barrier to growth in renewable energy and to the electrification needed to reach the climate targets.

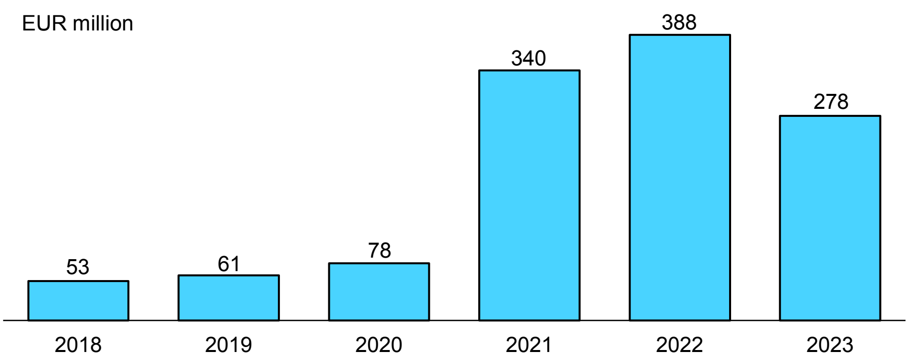
Grid congestion map for consumption (left) and feed-in (right) in the Netherlands, October 2024



Source: Netbeheer Nederlands, Electricity grid capacity map.

Grid congestion causes additional costs for consumers through increased grid charges to pay for Tennet's congestion management measures. TenneT's costs for congestion measures, including redispatch, restrictions contracts and reactive power agreements, reached EUR 388 million in 2022, over 6 times the cost in 2020. As the congestion costs are linked to the electricity price, part of the increase was due to high electricity prices in 2022, and the cost fell to EUR 278 million in 2023 as energy prices in Europe declined. Nevertheless, the high cost for grid congestion measures in recent years indicates the scale of the problem. In addition to the direct costs for congestion measures, there are indirect costs for various parts of the economy when new connections are delayed. The total societal cost of grid congestion is difficult to measure, but undoubtedly large, and provides motivation for taking strong measures.

Costs of total grid congestion measures in the Netherlands, 2018-2023



Source: IEA analysis based on TenneT (2024), Annual Market Updates.

In addition to delays for new connections, grid operators also risk being unable to supply growth in existing connections. When most electricity demand comes from conventional appliances, such as water boilers and washing machines, the peak demand per household is usually short and evens out in a distribution area so that the total grid capacity is sufficient. However, new installations of heat pumps and EV chargers result in higher electricity demand sustained over longer periods. The grid operators are not able to limit or control autonomous growth within the existing connections and, if not managed, this leads to risks of power cuts. In most provinces, the low-voltage grid can still serve small consumers, but a recent consultancy report suggests that its capacity will be filled up in two to five years. Solving this will require a combination of increased grid capacity, better assessment of coincidental peak load from new equipment and more flexibility to reduced peak consumption.

Policy spotlight: The Grid Congestion Action Programme (LAN)

The government and other stakeholders are working together to find solutions for grid congestion. In December 2022, the Minister of Climate and Energy presented a National Grid Congestion Action Programme (LAN). The LAN was prepared and endorsed by a broad set of stakeholders from both the public and private sectors, including relevant ministries in the government and regional provinces, grid operators, the regulator, and several industry clusters and organisations. Through the LAN, the government is working closely with these stakeholders to develop solutions across various areas.

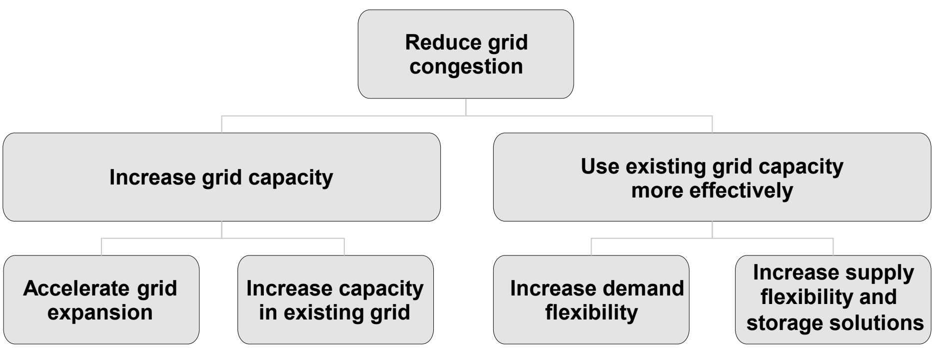
The LAN focuses on three main objectives: 1) faster construction of grid extensions; 2) better use of the grid through smart solutions; and 3) smarter insight into what happens with the grids. Within each objective, the LAN contains a large number of actions, with dedicated working groups responsible for implementation and reporting on progress. The first progress report on the LAN, published in June 2024, highlights taken and planned measures to accelerate grid buildout, optimise the use of existing grid, and improve data collection and unlocking. The regulator is also working to improve the grid congestion situation. In April 2024, ACM presented its plan with measures to combat grid congestion, directed at both existing and new connections, some of which have already been implemented.

One output has been the updated congestion map from Netbeheer Nederland. The map is publicly available and shows the status for the grid down to local areas, with different colours indicating the level of congestion. The map also provides information on available and required transport capacity and the number of requests in a queue. One map shows the grid status for connecting new electricity generation and another for connecting new consumption. Clearly presenting available connection capacity in such maps is a great first step towards managing grid congestion, and other countries' experience can provide inspiration on how to improve them further. In Estonia, the TSO presents a capacity map that includes a high level of detail on the network improvements required, and the expected timing and cost of the improvements. A report from RAP and Ember concludes that information on planned grid upgrades is a key gap in most existing capacity maps. Another example is Japan's Welcome Zone Map, where TEPCO provides an innovative search engine that streamlines the connections process for large consumers seeking a 66 kV network connection by allowing users to input specific criteria.

Grid congestion is particularly acute in Flevoland, Gelderland and Utrecht, and the government has developed additional measures for these regions. Proposed measures include rerouting power around congested parts of the grid; limiting the use of existing interconnection capacity across the borders with Belgium and Germany; incorporating grid-supported battery storage; and deploying flexible electricity generation capacity, including potentially adding new gas-fired generation that would be operated by the local DSO Stedin. Some of these measures can cause higher emissions, especially the deployment of fossil fuel-fired capacity, but the government considers that the measures' benefits outweigh the costs.

Besides building grids, the government and other stakeholders need to look for further ways to increase the capacity in existing grids and use the existing capacity in more effective ways through various flexibility measures.

Illustration of ways to reduce grid congestion



IEA. CC BY 4.0.

Accelerate grid expansion

Slow grid expansion is becoming a bottleneck for transitions to net zero emissions globally. IEA analysis shows that while investments in renewables globally have nearly doubled since 2010, investments in grids have barely changed. In many countries, including the Netherlands, the regulatory framework has focused on cost optimisation of the electricity system rather than maximising the benefits of large electrification. This should be improved to enable a more proactive planning and expansion of electricity grids.

Improved permitting and regulation are important to speed up the expansion of the electricity grid. Complex permitting processes create long lead times for all infrastructure projects, which is especially challenging for a densely populated country such as the Netherlands. Accelerating grid buildout is one of the LAN's three action areas, with several completed or ongoing measures, often focused on improved co-ordination and co-operation, including a progress report every six months where TenneT presents acceleration options for national projects, and a pilot project run by TenneT for proactive construction of new grids before final permitting is in place.

To improve the allocation of new grid capacity, ACM has introduced a framework to change the principle of "first-come first-served" so that, starting 1 October 2024, the system operators can prioritise projects that solve or limit congestion in the grid, such as battery systems. The next priority is security, such as national defence and the police, followed by other projects with social value, such as schools and hospitals. Another aspect that could help speed up processing the connection queue would be to assess how mature a project is and give priority to projects that are more certain to be realised. This approach is used in Sweden, where a new industry standard on project maturity has been developed based on guidelines from the TSO.

Increase capacity in the existing grid

Capacity in the existing grid can be increased through various grid enhancement measures such as reconductoring, voltage uprating, dynamic line rating (DLR) and advanced network operation practices. Innovative grid enhancement solutions can increase the existing capacity faster and at a lower cost than building new lines and should, therefore, be a priority when looking to solve grid congestion.

Reconductoring means replacing the existing power line cables with others that can carry more power. Voltage uprating means to increase the voltage level to increase the capacity in the existing grid by changing the insulators and upgrading or changing the grid towers. TenneT is working on upgrading the existing 380 kV high-voltage grid in phases until 2026. Distribution lines can also be upgraded, and more work is needed to increase the capacity in existing low- and medium-voltage grids. Netbeheer Nederland has proposed a neighbourhood-by-neighbourhood approach to strengthening low-voltage grids, mentioned in the LAN. Good examples can also be found in other countries, such as Ireland, where the DSO ESB Networks is currently uprating the 10 kV medium-voltage network to 20 kV, leading to four times higher capacity on the medium-voltage network and reduced losses in the system.

DLR is a technical solution to optimise how much electricity can flow through power lines at any given period of time. With measurements in real time of how much the use of the grid in combination with weather and temperature causes the lines to droop, DLR can help the grid operator to assess the actual available capacity, instead of making assumptions that need to be on the safe side. The Danish TSO Energinet has reported that DLR combined with weather forecasting has increased its transmission capacity by as much as 30% in certain areas and days of high wind power generation. TenneT is using DLR and installing smart sensors in the high-voltage grid to measure the temperature and the hanging of the lines. So far, TenneT has focused on the 380 kV grid, but has plans to continue with the 110 kV grid.

Advanced network operation can be used to mitigate congestion by revealing latent capacity in existing grids and maximising the use of that capacity. Inspiration can be drawn from other network operators' work, such as National Grid's work on advanced power flow controllers and Transpowers' work on system protection schemes, or work with risk-based operations decision making and virtual power lines.

Increase demand-side flexibility

Demand-side flexibility can come from both existing and new connections, including large industrial users and aggregated smaller users in industries or households. It requires smart equipment that can use an energy storage (e.g. from an EV battery or from heat stored in an industry or a building) and respond to price signals on the electricity market or to new grid contracts, reflecting the need for flexibility in the system. Important aspects to consider for increasing flexibility in the electricity system is the time frame of flexibility provided (daily, weekly, seasonal) as well as the maturity of the technology and the time it takes to deploy it.

ACM is increasing the mandate and responsibility for system operators to use the existing grid more efficiently. This includes introducing new tariffs and contract forms to incentivise flexibility and reduce consumption during peak hours. From 1 January 2025, all large users connected to TenneT's national high-voltage grid will get a discount if they reduce their consumption during peak hours. Those users that still use all the available connection capacity during peak hours will instead pay more. For new connections, system operators can offer non-firm contracts to enable faster connections to those that agree to not always have access to the full capacity. This can be offered to individual connections and is also explored in the form of energy hubs, where several industries in an area can share a grid connection and agree among themselves how to distribute the available capacity. From 1 April 2025, system operators will be able to offer contracts that restrict large-scale users to use their connections at all during certain busy hours, in exchange for lower tariffs.

Operators of flexible assets need to get the right market access and price signals. TenneT's Industrial ValueFlex Tool enables industrial users to assess the potential revenue from flexible operation on different electricity markets. Furthermore, the grid operators in the Netherlands have developed GOPACS, a platform for facilitating more flexibility to benefit the grid during peak hours. Market parties with recognition as being a congestion management service provider (CSP) and that are in the right area can participate whenever a grid operator calls for flexibility resources on GOPACS. Around 60 companies are registered with a CSP recognition. Further expansion of flexibility markets should be explored. Netbeheer Nederland is also working on a proposal for an alternative network tariff model that incentivises consumers to use electricity outside peak hours by providing a lower rate.

The growing number of heat pumps provides opportunities for flexibility if operated in a smart way. Over 90% of Dutch households have smart meters installed, which provides a good starting position. However, getting access to real-time data and making good predictions on local electricity demand and generation remains a challenge, especially on low-voltage levels. The LAN progress report includes several measures that could significantly contribute to electricity system flexibility, including providing more anonymous and aggregated wholesale consumer data and encouraging smart steering of heat pumps.

Smart EV charging that adapts to the available grid capacity is another opportunity. In addition to charging that avoids constraining the grid during peak hours, EV batteries can also be used to feed electricity back into the grid. A forward-looking approach is needed when investing in charging infrastructure to ensure that chargers are connected and can be used in a flexible way. One of the National Charging Infrastructure Agenda's working groups has developed a Smart Charging Action Plan to accelerate a large-scale roll-out of smart charging networks, with the ambition to have smart charging in 60% of all charging sessions by 2025. The Action Plan includes a list of actions needed to meet this ambition. Progress has been mainly in private charging, whereas charging in the public domain requires further attention.

Increase supply-side flexibility and storage solutions

Natural gas-fired power plants are the main source of flexibility in the Dutch electricity system today. However, as the electricity sector decarbonises, more flexibility is needed from other sources, including fossil-free power plants, energy storages, interconnections and sector couplings. According to Netbeheer Nederland's scenario study of the energy system development until 2050 carried out in 2023, batteries will be the biggest source of flexibility in the Netherlands, especially in the long-term perspective towards 2040 or 2050, followed in most scenarios by interconnectors.

In June 2023, the government presented its Energy Storage Roadmap, which maps actions to be taken to advance energy storage up to 2035 and beyond. The Energy Storage Roadmap considers all forms of storage, distinguished in electricity, molecular and thermal storage. The systems approach for energy storage is commendable, as the different energy sectors need to be further integrated in the future and different storage technologies can complement each other. For electricity storage, the Energy Storage Roadmap states that batteries are needed to support the power grid and outlines 30 actions, partly overlapping with the National Network Congestion Action Program. Most actions had a deadline already in 2023 or 2024.

Batteries provide storage capacity that can be used for balancing the electricity system and to help solve local grid congestion problems. The government has allocated EUR 440 million from the 2023 Climate Package for battery storage. Large installations of battery parks have increased rapidly, and the market interest is very big with 70 GW of battery capacity requesting connection to the Dutch grid as of August 2024, accounting for two-thirds of total capacity on the waiting list for high-voltage connections in the Netherlands. However, the list contains an unknown amount of overlap and TenneT expects 5.2-12.7 GW of battery installations by 2030. The new regulation that prioritises connections that can help solve grid congestion and the new non-firm contracts for flexible connections should benefit the growth in battery systems connected to the grid.

Owners of grid-scale battery storage systems earn revenue from participating in ancillary services markets, from arbitrage on the energy-only market (i.e. buying electricity when it is cheap and selling it later at a higher price) or from providing grid services paid for by the network companies. Providing ancillary services typically gives the highest revenue, but if the markets are well-designed, there are opportunities for revenue stacking for battery systems by providing multiple services. Ideally, this will benefit the whole system, but since the electricity markets are nationwide, situations can occur where battery storages are operated in a way that worsens local grid congestion. To avoid this, the contracts and price signals available to the battery operator need to reflect the situation for the local grid as well as the national system. In the LAN, TenneT and other parties are working on how to integrate batteries without creating additional grid congestion.

Small-scale household battery systems can mitigate the negative effect that solar PV generation can have on the grid. However, under the current net-metering scheme, PV owners lack incentives to support grid balancing, as they get the same value for the sold electricity regardless of the current market price or available capacity on the grid. A growing share of residential solar generation cannot be fed into the grid and TenneT has introduced new measures for curtailment. Furthermore, several Dutch utilities have started to add charges for new contracts with solar PV, such as Eneco's feed-in costs of 11.5 cents per kWh for variable contract customers with solar panels. The net-metering system is set to terminate by 2027, which is a welcome development. Without it, PV owners should get clearer incentives for operating their equipment in a way that benefits the grid and for investing in battery storage systems to be able to use more of the generated electricity generated locally.

Recommendations

5. Enhance transparency on the grid capacity and the cost of congestion to incentivise innovative solutions.

The Netherlands publishes transparent and open data on congested areas in the grid in a congestion map. These data are at an impressive level of geographic detail, clearly showing the availability of capacity for new generation and demand connections, and the size of the connection waiting lists. However, the waiting list is affected by users seeking connection at multiple locations. The government and regulator should consider increasing the cost for applications and giving connection priority to mature projects, to improve transparency in the waiting list. Furthermore, there is scope for improving the congestion map to make it more useful for different actors who are looking for grid connections or can provide innovative solutions to the congestion issue. Inspiration can be drawn from other countries that have developed similar capacity maps. The causes and total costs of congestion should be clearly identified, and in congested areas, the congestion map should include a roadmap to resolve the issues with a schedule for planned grid upgrades. As the total costs of congestion are very high, the policy and regulatory framework should incentivise increased flexibility and grid-enhancing technologies to maximise the use of the existing grid, alongside an accelerated buildout of new grids.

6. Improve locational and operational price signals for batteries and other flexibility assets to reduce grid congestion.

With the rapid growth of renewables, energy storage and flexibility solutions will become more important in the Netherlands. Batteries can provide balancing services to the electricity system, and if located and operated in the right way, can also be an important asset to manage grid congestion. Up to 70 GW of battery systems are on the waiting list for grid connection in the Netherlands, which is an astonishing number, even if figures are partly duplicated. This provides great potential for flexibility and grid congestion services. The connection tariffs should be adjusted to make battery investments more attractive, especially when located and operated in a way that offers congestion management services, such as being close to production or consumption. Furthermore, batteries and other flexibility assets need clear price signals that reflect the local grid conditions, in addition to the overall system. Battery storages can be operated in a way that benefits overall system stability but worsens local grid congestion. To avoid this, the government should assess ways to achieve clear locational and operational price signals that incentivise congestion management services, including new contract forms and local flexibility markets through the GOPACS platform.

Hydrogen and offshore wind

Hydrogen will be crucial for the energy transition and the Netherlands is well placed to become a hydrogen hub for Europe. This good starting position includes large demand for low-emission hydrogen to meet both domestic consumption and to supply export markets, and great potential for increased hydrogen production, especially from offshore wind. The Netherlands also has a large existing infrastructure that can be used for hydrogen purposes, including the domestic gas network and storage, and import and trade facilities in the ports. The challenge is to get the necessary investments in place to exploit these favourable conditions in an effective way.

Hydrogen demand outlook

The refineries and fertiliser industries in the Netherlands are already large consumers of hydrogen, mainly produced from fossil fuels. A significant amount of low-emission hydrogen will be needed to replace this. The REDIII targets of 42% renewable hydrogen in industrial consumption by 2030 and 60% by 2035 will be challenging to meet and have a big impact on the hydrogen demand. Furthermore, the EU ETS will basically phase out all unabated CO_2 emissions from industry in the 2040s, which will further increase the long-term demand for low-emission hydrogen.

New hydrogen applications in industry and transport will increase the demand further. Hydrogen as a feedstock can enable decarbonisation of hard-to-abate sectors such as steel and chemicals production. The steel company Tata Steel has plans to switch from using coal in blast furnaces to using hydrogen in a direct reduced iron process. The company aims to have the first direct reduced iron plant operating by 2030, initially using natural gas but switching to hydrogen once it is sufficiently available. The government's Hydrogen Strategy and the Hydrogen Roadmap also foresee an increase in demand for hydrogen for decarbonising parts of the transport sector, including in heavy-duty road transport, shipping and aviation.

In addition to domestic consumption, there will be a large demand for low-emission hydrogen in other European countries, notably Germany. In the 2023 update to the German National Hydrogen Strategy, the German government targets 95-130 TWh of low-emission hydrogen consumption by 2030, which equals 2 700-3 900 kilotonnes (kt) hydrogen, roughly twice as much as total current hydrogen consumption in the Netherlands. The German strategy sets a target for domestic electrolyser capacity of 10 GW, which would not be able to meet the domestic demand. According to the German Hydrogen Import Strategy, 50-70% of the hydrogen needed by 2030 will have to be imported, and the share is assumed to increase further after 2030. This provides large export opportunities for the Netherlands.

Hydrogen supply outlook

There is large potential for hydrogen production connected to renewables in the Netherlands and in particular synergies between electrolysis and offshore wind development, but also from fossil fuels with CCS. The government and other actors provide support for low-carbon hydrogen production and infrastructure.

Hydrogen from offshore wind and carbon capture and storage

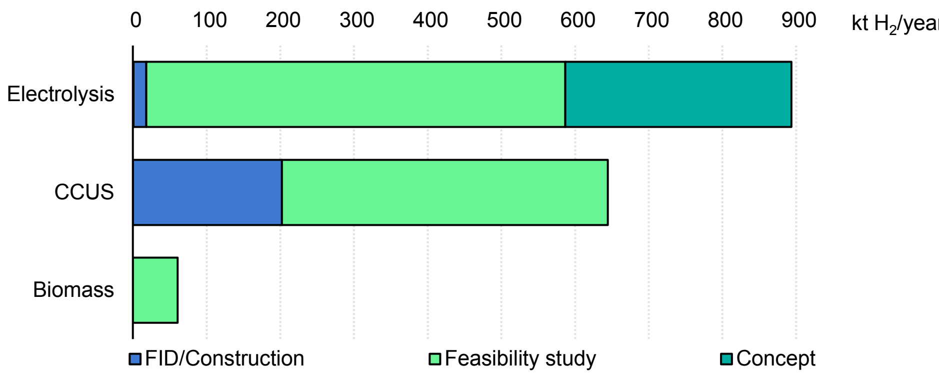
Offshore wind power in combination with hydrogen production can be a competitive advantage for the Netherlands. The government targets 21 GW of installed offshore wind capacity by 2032 and continued growth to 70 GW by 2050. The potential for offshore wind power is great, but the development needs to go hand in hand with electricity demand growth, to which hydrogen production will be an important driver. The next phase of the offshore wind roadmap will need to be better integrated with hydrogen production and with the expansion of interconnection capacity with surrounding countries through hybrid projects and energy hubs.

So far, a few projects have reached construction phase or a FID. In Holland Hydrogen 1, Shell is building a 200 MW electrolyser connected to the offshore wind farm Hollandse Kust (noord). Total Energies and RWE have recently agreed on a FID in the OranjeWind project, which will integrate a 795 MW offshore wind farm into the Dutch energy system, including through electrolysers. Some larger projects combining offshore wind with hydrogen production are currently subject to feasibility studies or in a conceptual phase. One example is the NorthH2 Project, a consortium of Eneco, Equinor, RWE and Shell which targets hydrogen production on a gigawatt scale around 2030-35, with potential to grow further to 10 GW of electrolyser capacity, using electricity from new offshore wind farms in the North Sea.

Low-emission hydrogen can also be produced from fossil fuels in combination with CCS, and the Netherlands is well placed for building the infrastructure needed for capturing, transporting and storing CO_2. The CCS option for hydrogen production will be a useful complement to hydrogen from electrolysis but should not replace it. In the project pipeline for low-emission hydrogen, CCS-based production accounts for the main share of projects that have reached a FID, including two large hydrogen production facilities planned by Air Liquide and Air Products in connection with the Porthos CCS project and one plant under construction by the fertiliser producer Yara

Sluiskil. If all plans for hydrogen production from electrolysis and from natural gas and CCS are realised, the Netherlands could produce over 1 500 kt of low-emission hydrogen by 2030, enough to meet the current domestic hydrogen demand.

Low-emission hydrogen production by supply technology planned by 2030 in the Netherlands



Source: IEA (2024), Hydrogen Production and Infrastructure Projects Database.

Support for hydrogen projects

The government provides financial support for hydrogen projects and has allocated EUR 7.5 billion for hydrogen initiatives over 2023-30. The majority is allocated to onshore and offshore electrolysis, with EUR 6.9 billion in total. Large-scale renewable hydrogen production via electrolysis (at least 0.5 MW) can apply for support through the OWE scheme, managed by RVO. The scheme offers opportunities for both investment support of up to 80% of the investment cost and operational support for a period of 5-10 years. A new round of the OWE scheme is planned for 2024, with an increased budget of EUR 997 million.

Hydrogen projects can also apply for funding through the SDE++ scheme, which can provide a feed-in premium for low-carbon hydrogen production over a 12-15 year period. However, the SDE++ is technologically neutral, meaning hydrogen production needs to provide the most cost-efficient emissions reduction solutions, where electrolysis so far has struggled to compete with other technologies.

The Netherlands also participates in the H2Global platform. Launched in 2022, this platform promotes the development for clean hydrogen through double market-based auctions. The company Hintco serves as a government-backed intermediary between buyers and sellers and enables long-term purchase contracts on the supply side to meet short-term sales contracts on the demand side. The government subsidises the cost differential between the two auctions. The H2Global platform is a good example of a support scheme designed to reduce risks. In November 2023, the Netherlands and Germany signed an agreement to provide EUR 300 million each in a joint tender for renewable hydrogen starting in 2027, using the double auction mechanism provided by Hintco. Furthermore, the Netherlands participates in the European Union's IPCEI programmes on hydrogen, where projects across the hydrogen value chain can apply for funding from the European Union and participating member states. The European Commission has granted several Dutch projects IPCEI status.

Market uncertainties

Despite seemingly great conditions for a growing hydrogen market and subsidies available, FIDs are not being taken at the pace necessary, especially for electrolytic hydrogen production. Slow development for low-emission hydrogen demand also raises questions for offshore wind, and there is a case for further co-ordinating support for these areas.

The hydrogen market is not developing fast enough

Being a first mover on the market for low-emission hydrogen does not seem to be an attractive choice. Although the project pipeline for low-emission hydrogen production has the potential to meet most or all domestic hydrogen consumption by 2030, so far few of the projects have been realised. Of 93 projects under consideration for hydrogen production by 2030, 15 are operational and only an additional 11 have reached a FID. Most of the potential capacity is still undergoing feasibility studies or remains in a conceptual phase, especially for electrolytic hydrogen. A recent example is Uniper's H2Maasvlakte green hydrogen project in the Port of Rotterdam, where the FID has been delayed.

Hydrogen suppliers want to secure long-term offtake agreements to get certainty for their investments. This presents a chicken-and-egg problem, where investors lack the certainty of future demand to make the FID, while large consumers lack certainty in future price development and requirements for low-emission hydrogen before taking long-term decisions. Hydrogen consumers may also wait to sign offtake agreements, hoping that prices for low-emission hydrogen may decrease over time. This requires more attention to demand-side policy, to complement the existing supply-side subsidies. One way to create more certainty around the future demand is to introduce demand-side obligations for low-emission hydrogen, linked to the targets set by the REDIII. The government is working on concepts for introducing both an industry quota and industry demand subsidies.

Offshore wind development also faces challenges

After having successfully reached the roadmap target for 2023 and finalised new auctions in 2024, the offshore wind industry is now facing more challenging market conditions that make the future development less certain. Higher interest rates, increased material costs, tighter supply chains and a more uncertain electricity market bring financial risks to investors. As a sign of this, the Dutch utility company Eneco, together with its partner Equinor, decided to pull out of the offshore wind tender for the IJmuiden Ver (Alfa and Beta). In a white paper, Eneco claims that due to deteriorated market conditions, the current Dutch approach to offshore wind does not provide sufficient certainty for investors and is not future-proof. To reduce the financial risk for investors, the government chose to split the tender for the IJmuiden Ver Gamma and Nederwiek I wind farms, scheduled for the autumn of 2025, into four areas of 1 GW each, compared to the previous 2 GW tenders.

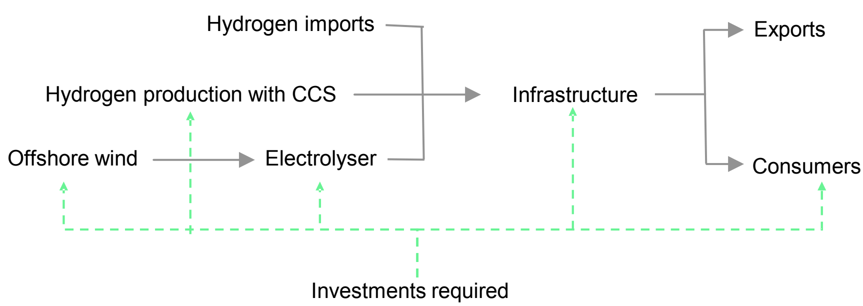
The Netherlands has a supply-driven strategy for offshore wind deployment, based on the expectation that demand for renewable energy will continue to grow. However, despite the large potential for hydrogen demand in the region, offshore wind investors seem to lack certainty around the speed of the electrification and hydrogen development, and thus the future demand for electricity. If electricity demand is not growing at the same pace as the ambitious offshore wind targets, this leads to risks of underutilised and costly infrastructure. Investors also need clear market conditions around the use of the wind power plants and the terms and conditions of the grid connection.

As more offshore wind projects are being developed, it becomes increasingly important to balance different interests in the maritime areas, including ecology and fisheries. The government has indicated that it will first look at identifying space for fisheries when incorporating new wind energy areas in the Partial Revision of the North Sea Programme. While taking this industry into account, the government needs to continue enabling strong policy and planning conditions for offshore wind to be able to maintain a rapid buildout in line with the targets, both in the short term to 2032 and the long-term targets until 2050. To manage different maritime interests, including fisheries, the Netherlands can continue to develop its successful non-price criteria in the offshore wind auctions, in close co-operation with the relevant stakeholders.

A case for co-ordination of hydrogen and offshore wind policy

Investments in offshore wind power, electrolysers and equipment on the hydrogen user side are interdependent. Uncertainty on both the supply and demand sides can be reduced through more co-ordinated support across the value chain. The situation is similar for hydrogen produced from fossil fuels with CCS.

Illustration of the Netherlands' hydrogen value chain



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A consultancy study by Guidehouse identifies uncertainty around interdependencies between the electricity system and other sectors, including green hydrogen, as a key challenge for offshore wind in the Netherlands. The report suggests a joint offshore wind and industry roadmap that can form the basis for a joint yearly schedule for offshore wind roll-out, industry electrification and green hydrogen uptake until 2040.

The government has co-ordinated the support systems for wind and hydrogen by introducing connection to electrolyser as a non-price criterion in offshore wind tenders. However, current policy support systems are mostly directed to different parts of the value chain, and a more co-ordinated approach and support mechanism that include electricity generation should be explored. As an example, Eneco suggests introducing combined tenders for offshore wind and hydrogen for some sites.

Hydrogen infrastructure

The National Hydrogen Network

Continued buildout of hydrogen infrastructure is needed to facilitate the market development. The government has appointed HyNetwork Services, a state-owned subsidiary of Gasunie, to build and operate a national hydrogen network and allocated EUR 50 million from the Climate Package to support this. The national hydrogen network will connect the imports, production and storage sites with five industrial clusters in the country and with export pipelines. It will be built in phases according to a roll-out plan, where the initial goal to be fully operational by 2030 has been postponed by a few years. Having clear plans for the buildout of a national network will provide more certainty for investors all along the supply chain.

Repurposing natural gas pipelines provides a good opportunity for building out hydrogen infrastructure faster and at a lower cost, and the large natural gas network with two parallel systems presents an opportunity for the Netherlands. Gasunie anticipates that 85% of the national hydrogen network planned by 2030 will be repurposed natural gas pipelines from the L-gas network. Repurposing the existing gas network for hydrogen needs to be done in a controlled way without jeopardising the energy security for customers that rely on natural gas.

The Dutch gas market and network operations are regulated by ACM. There is no specific legislation for hydrogen, which means that the existing laws on gas regulation apply also for hydrogen projects. In terms of future hydrogen regulation, ACM favours an approach that can be adapted to the market and infrastructure development. ACM finds it important that market participants be given flexibility in launching new initiatives, especially in the development phase, while also protecting current and future customers from abuse of market power.

International collaboration

Besides the domestic hydrogen network being developed, Gasunie is collaborating with large industries (BASF, OGE and Shell) to build the Delta Rhine Corridor connecting the import terminal at the Port of Rotterdam with industry clusters in the Netherlands, Belgium and Germany. The plan was to start building the network in 2026 to make it operational in 2028-30. However, the Dutch government announced in June 2024 that the Delta Rhine Corridor project will be delayed by four years due to difficulties with building infrastructure for cables and hydrogen and ammonia pipelines in parallel, and allocating sufficient land for all three lines. This delay and the updated roll-out plan for the national hydrogen network indicate that the first new infrastructure projects can take longer than anticipated.

In the Hydrogen Strategy, the government clarifies the need for a regional European and global approach to scaling up hydrogen. To facilitate large-scale hydrogen imports, the government works together with TNO, an independent, not-for-profit research organisation, on the Sustainable Hydrogen Import Program for the Netherlands. The Netherlands also actively participates in regional and global collaborations such as the Clean Energy Ministerial Hydrogen Initiative, and has signed bilateral and multilateral agreements on hydrogen with strategic partner countries around the world, including Australia and Spain. Gasunie is also one of the partners in the European Hydrogen Backbone initiative, collaborating around developing infrastructure and a European market for low-carbon hydrogen. The large demand for low-carbon hydrogen provides a clear case for co-operation rather than competition between countries with large hydrogen production and consumption.

Integration with the electricity system

Hydrogen can be supplied from offshore wind either by transporting the electricity to shore for onshore electrolysis or by using offshore electrolysis and transporting the hydrogen onshore via pipelines. The business case for electrolysers today requires a high utilisation rate, and the industry prefers an onshore installation to enable continuous hydrogen production. The offshore electrolysis technology is still under development but can be a more attractive alternative if the price of the equipment decreases, as it requires less available land and grid connection onshore. However, offshore hydrogen pipelines are a new technology that requires demonstration. A state-backed Dutch pilot project for offshore electrolysis is planned to start operation in 2024, in which green hydrogen will be blended with natural gas and transported to the coast via the existing gas pipeline.

Electrolysis requires large amounts of electricity but can become a flexible resource in the electricity system. With access to large-scale hydrogen storage in salt caverns and old gas fields, electrolytic hydrogen production can adapt to price signals on the electricity market while maintaining a stable hydrogen supply to consumers. Such flexibility will be needed for electrolysers to work well with the growing offshore wind power generation. The government has allocated EUR 250 million from the Climate Package to investments in hydrogen storage caverns. The Netherlands' flagship hydrogen storage project, HyStock, involves four underground salt caverns with a total capacity of 20 000 tonnes of hydrogen. It is Gasunie's first large-scale hydrogen storage facility, with the first cavern set to be operational by 2028. A systems perspective is needed to ensure that the full value of a hydrogen storage and other large-scale energy storage, including its role for the electricity grid, is reflected correctly on the market.

Hydrogen infrastructure development needs to be co-ordinated with the electricity system to allow efficient energy system and sector coupling. The TSOs Gasunie and TenneT have together investigated how the energy system can continue to function well in the future. In a 2019 study, they present an outlook for the infrastructure until 2050 and assess the requirements and limitations of a future energy system based on solar and wind energy. The study was followed by a second report on Pathways to 2050, based on an integrated energy system model. Gasunie and TenneT concluded that the development of the energy transmission infrastructure for electricity, hydrogen and methane needs to be planned timely in an integrated way to find optimal solutions for a faster and affordable energy transition. Furthermore, the government is working on the Energy Infrastructure Plan North Sea 2050 to clarify the infrastructure required for achieving the long-term targets for offshore wind. A first version of this plan is expected in the first quarter of 2025.

Recommendations

7. Create a stable framework for the long-term offshore wind development interlinked with the hydrogen ambition.

The Netherlands' high offshore wind ambitions will require effective tendering processes also after the current roadmap to 2032. To maintain a stable investment environment, it needs to be clear under which circumstances the offshore wind farms will operate during their full licence time, including the terms and conditions of the grid connection and the capacity that can be used. Grid expansion needs to keep up the pace of the offshore wind deployment, and timelines should be adjusted accordingly. If installed offshore wind capacity surpasses the absorption capacity of the grid, solutions must be available to guarantee demand beyond the grid to ensure the business case. The tendering regime should be adapted to the reality to avoid failing tendering processes that could compromise the timing of the ambitious roadmap. Current good practices to create smaller tenders and consulting the sector and other stakeholders should be maintained. The long-term targets for offshore wind depend on strong market development for hydrogen and the roadmaps of both must be carefully linked to ensure large-scale electrolysis can capture the production of the offshore wind energy in excess of the grid capacity. The government should assess further combining support for hydrogen with the policy framework for offshore wind. Building on the North Seas Energy Cooperation Action Agenda, the Netherlands and its regional partners should also assess potential synergies in the North Sea between national low-emission hydrogen projects and industrial hubs.

8. Increase demand certainty for low-emission hydrogen through obligations and industrial decarbonisation strategies.

The Netherlands has set ambitious targets for clean hydrogen development and has many electrolyser projects in the pipeline. However, final investment decisions are not being taken at the rate needed. To reach the target of 3-4 GW of electrolyser capacity by 2030, the Netherlands will need to increase demand certainty for low-emission hydrogen and ensure an integrated approach to support mechanisms along the entire value chain. Demand certainty is crucial for the conclusion of long-term offtake agreements, which in turn is key for project developers to reach a FID. The Netherlands should transpose the requirements in REDIII into national law and introduce an obligation for renewable hydrogen in industrial sectors to increase demand certainty. The government is already working on this, which is promising. Furthermore, the government should develop cross-sectoral industrial decarbonisation strategies to provide clarity on the role of low-emission hydrogen in the future. These could build on the existing cluster energy strategies developed in the industry clusters.

New nuclear in the energy system

The role for nuclear in the energy transition is getting more attention in several European countries, including the Netherlands. In the long-term scenarios for the energy system in the Netherlands, nuclear power capacity increases to 2.5-3.5 GW by 2035 and 3.5-7 GW by 2050. The Dutch government has confirmed plans to extend the operating lifetime for the Borssele reactor and to build two new large conventional reactors. In addition, the government wants to see two more reactors and has also expressed an interest in SMRs. The government has increased the budget available in the Climate Fund to support nuclear investments. Furthermore, the Dutch parliament passed a motion in November 2024 requesting the government to increase the nuclear ambition for 2040 and 2050. However, uncertainties remain around where to site and connect new reactors, how to finance investments, and what role nuclear will play in the future electricity system.

Nuclear is getting renewed attention

Nuclear power can make an important contribution to power sector decarbonisation globally and to overall power system adequacy. It requires less space per produced unit of electricity than wind and solar and can complement renewables by providing critical services to electricity systems. However, nuclear comes with other risks and environmental considerations around the fuel production and waste treatment, and the view on nuclear in different countries depends on local conditions in the power system and geography, as well as political and public acceptance.

New nuclear plans in Europe

To meet climate ambitions and energy security considerations, several European countries are now planning for new nuclear. This includes lifetime extensions and capacity increases in existing reactors as well as new builds. The Flamanville 3 reactor was connected to the French national grid on 21 December 2024 and France has announced plans to build six new large reactors starting in 2028, with further plans to pursue an additional eight reactors, for a total of 14 new potential reactors. In the United Kingdom, two reactors are under construction at Hinkley Point C, and the country has advanced plans for additional reactors. The Czech Republic has finalised a tender for two new reactors at the Dukovany power plant and is considering two additional reactors at another site. Poland plans to build large reactors with a total capacity of 6-9 GW by 2040, and Sweden targets two new reactors by 2035. However, recent European nuclear projects in Finland, France and the United Kingdom and have struggled with significant delays and budget overruns, and challenges and uncertainties remain.

Plans for new nuclear in the Netherlands

The government is working on a technical feasibility study for two new conventional large-scale nuclear reactors aimed for operation by 2035. The Borssele site is considered the preferrable option for the new reactor due to its existing nuclear infrastructure and waste storage facilities. Once the location and the technical requirements are decided, the government plans to initiate a tendering process. The three companies KHNP, EDF and Westinghouse are all potential suppliers for the new reactors and feasibility studies are carried out with them individually.

The two additional nuclear reactors targeted by the government require more analysis. While some aspects in the ongoing technical feasibility study can be applied also to additional reactors, the question around potential locations and environmental impact needs to be investigated further, as the Borssele site is not able to host more than the two planned reactors. Furthermore, the timeline, financing and organisational structures also need to be addressed.

To support the development of additional reactors beyond the two planned, the new government increased the Climate Fund's budget for nuclear energy by EUR 9.5 billion, on top of the EUR 4.6 billion available budget. Most of this is not yet allocated, but some funding for nuclear is available in the Climate Package from 2023, with EUR 117 million to research and feasibility studies for new nuclear power plants, EUR 10 million for investigating the safe extension of Borssele's operational life, EUR 65 million to enhance Dutch nuclear knowledge, and EUR 65 million to support the development of SMRs.

The role for nuclear in the energy system

A country's nuclear strategy should be based on a clear understanding and agreement around the long-term role for nuclear in the energy transition. Nuclear is an important source of dispatchable low-emission electricity in many countries, providing system benefits to help balance the system. However, in a system with very high shares of wind and solar power, as is targeted in the Netherlands, flexible power supply is needed more than steady baseload. The choice of technology should reflect the system requirements and support mechanisms should be designed to deliver the system needs in a cost-effective way for consumers.

There are assessments of the role for nuclear in the future energy system in the Netherlands, including the National Energy System Plan. A 2024 study by the Dutch research institute TNO concludes that a sustainable energy system without nuclear power in the Netherlands is possible, but comes with 1-2.5% higher system costs. However, the results from such modelling exercises depend on assumptions around various costs and technology development, with many uncertainties. Furthermore, other parameters are hard to model, including energy security aspects, environmental impact and risks, use of available space, and public perception and acceptance. With the current rapid change in the energy system and the ongoing technology development, more analysis is needed to ensure investment decisions in additional reactors are based on a clear understanding of the options and the role for nuclear in the future energy system.

Small modular and advanced reactors under development

SMRs and new advanced reactor models have potential benefits around cost, safety, and electricity system and market integration. Unlike large conventional reactors that are custom-made to a certain site, SMRs can be produced in factories and assembled on-site, leading to potential cost reductions and shorter construction times. Standardisation can enhance quality control, reduces the risk of construction delays and allows for economies of scale if produced in large numbers. The lower investment cost is also easier to accommodate on market-based terms. Furthermore, smaller reactors distributed across various locations have less impact on the electricity system during an unforeseen outage, compared to large conventional reactors. An example of the vulnerability of centralised nuclear production is France's experience during the energy crisis of 2022, when the nuclear fleet was running around half capacity due to maintenance issues and the discovery of stress corrosion in some reactors. This led to an increased reliance on natural gas power in Europe, despite unprecedented gas prices.

However, the SMR technology has yet to prove its market readiness, as demonstrated by the recent closure of the NuScale project with six planned 77 MW modules in the United States scheduled to start operations in 2029. The initial cost estimate at USD 58/MWh in 2020 had more than doubled to USD 119/MWh by 2023 due to increased material and equipment cost. The Canadian utility company Ontario Power Generation is planning the construction of a 300 MW SMR from GE-Hitachi (using conventional light water technology) at the Darlington nuclear site, which if it goes according to the plans will be in operation by 2029 as the first commercial SMR in an IEA country.

Many new SMR concepts are being developed around the world, including both conventional light water reactors and more advanced technologies using, for example, lead or molten salt as coolant. Advanced nuclear reactors have several potential benefits, such as smaller size, higher efficiency or being able to use nuclear waste as fuel, but those concepts are further away from being market-ready than conventional technology. Challenges to the SMR development remain, especially around proving the technology's reliability and business case.

New applications for nuclear energy

Nuclear energy can be used for supplying other energy demand besides electricity. Many SMR designs operate at high temperatures and can offer a low-emission alternative to fossil fuel co-generation of power, heat and hydrogen for industrial customers. Industries such as chemicals, steelmaking and ammonia production could commercially benefit from this technology. Locating SMRs near industrial hubs could enhance the competitiveness of nuclear-based hydrogen by reducing transport and distribution costs.

District heating presents another potential application. Heat can be supplied from a co-generation power plant, where the ratio of electricity and heat generated could change depending on the market conditions, thereby increasing the potential for flexibility in the nuclear plant. It can also be produced in a reactor designed specifically for supplying heat at lower pressures and temperatures suitable for district heating systems. In Finland, the company Steady Energy, a spin-off from the VTT Technical Research Centre, is currently developing the LDR-50 reactor designed for district heating purposes. The units will generate 50 MW of thermal energy and are compact to be suitable for urban environments.

Nuclear applications beyond electricity provide opportunities for new business cases and more flexible roles for nuclear in the energy system. However, the financial viability of nuclear energy for such applications remains to be proven in comparison with other options. Renewable electricity and heat pumps offer feasible alternatives for both hydrogen production and heating, and the cost-effectiveness of nuclear energy compared to these options depends on technological advancements, regulatory frameworks and market dynamics.

The role for the government in supporting nuclear

The need for state involvement in planning and financing

Investments in new nuclear power projects do not occur without government involvement to set long-term market conditions and reduce the substantial project risks. Given the long-term nature of nuclear investments, plans for new nuclear reactors need to be underpinned by broad political agreement and strong public support.

Attracting investment in nuclear energy requires ways to manage risks related to construction, technology, politics, regulation, operations and market fluctuations. Nuclear plants are very capital-intensive, especially large conventional reactors, with long lead times and complex construction works, which directly affect capital costs. Significant delays in recent projects and substantial market risks post-construction further complicate investments. SMRs encounter challenges related to their early stage of development, including the high costs associated with first-of-its-kind technology and regulatory uncertainty. Designing effective support policies involves mitigating risks associated with each technology and avoiding reducing the incentives for investments in other parts of the electricity system.

Other countries can provide insights on nuclear financing

Historically, nuclear projects have mostly relied on state ownership or regulated monopoly structures to guarantee revenues and reduce investor risk. More recently, market-based mechanisms such as CfDs have been tried. Experience from other countries can help the Netherlands develop a policy that provides good investment conditions for nuclear. The IEA is also working on a report on financial mechanisms for nuclear power, expected to be published in early 2025.

The United Kingdom has looked deeply into nuclear financing and introduced the Nuclear Energy (Financing) Act in 2022, which established the Regulated Asset Base (RAB) model. Under the RAB model, project owners are provided with a regulated revenue stream during construction, commissioning and operation of a new nuclear plant. The RAB model will be used in Sizewell C project and the UK government estimates that this could significantly reduce consumer costs compared to the previous CfD model used for the Hinkley Point C project.

The Czech Republic is planning a combination of support policies for its new Dukovany reactor, with a subsidised state loan to cover a majority of the construction costs, a two-sided CfD to provide price certainty for 40 years, and a protection mechanism against unforeseen events or policy changes. The European Commission has approved this support package. The Swedish government has explored various risk-sharing models to support nuclear investments and is considering a similar combination of providing low-interest state loans and a two-sided CfD worth around 70 EUR/MWh for 40 years.

The Dutch government has let the company KPMG assess possible financing structures for the construction of two new nuclear reactors that balance financial risks between the public and private sectors. In a report from 2023 they conclude that state involvement seems necessary, including during the construction phase. The report assesses the RAB model, a CfD model, the Finnish Mankala model (where energy-intensive industry clusters make the investment and receive a tax reduction for the electricity produced) and a system with power purchase agreements between power producers and consumers. Based on stakeholder discussions, the RAB model or a combination of different support structures seemed most suitable.

Recommendations

9. Develop multi-administration nuclear plans backed by analysis on the role for nuclear in the energy system.

Delivering nuclear energy is a long-term endeavour which requires a stable policy and regulatory environment with long-term financial certainty to provide clear signals to support skills and supply chain development across the sector. In democratic countries, no government can build a new nuclear reactor in a single term. The different stakeholders involved in such huge investments need to see a clear plan for nuclear development in the country based on long-term political agreements that create stability. While the government's recent targets for nuclear energy production are helpful signalling, there is a need to develop the evidence base for the role of nuclear in a decarbonised energy system.

As the Dutch energy system has a large and growing share of renewable energy, the government should model and assess the role of nuclear power in providing flexibility and the need for secure baseload energy to manage inertia in the energy system. This should be translated into a multi-year roadmap and the government should communicate the results to develop cross-party consensus around the role of nuclear in the Dutch energy system, providing long-term certainty for the sector and investors.

10. Assess the potential for nuclear energy for non-electricity applications to increase system flexibility.

Nuclear power can be leveraged to deliver flexibility in the energy system in three main ways: 1) ramping reactor power output; 2) coupling the reactor to thermal energy storage; or 3) coupling the reactor to a flexible thermal application such as district heating or a thermal industrial process. Coupling the nuclear reactor to a flexible thermal application is the most valuable and cost-effective because it creates two markets, both electricity and thermal demand that nuclear energy can sell into when prices in one market are low or negative. In this way, flexible nuclear energy can also act as a grid balancing resource instead of inflexible base load.

The government should conduct a feasibility study on the non-electric applications of nuclear energy to understand its potential to provide flexibility, grid stability and enable better integration in a decarbonised energy system to complement the intermittency of renewable energy. The study should include different reactor concepts and address locational options in line with the energy system development. Government investment in a demonstration project of nuclear energy for thermal applications can help prove the concept and derisk investment.

Annexes

Acknowledgements

The IEA review team visited The Hague on 9-13 September 2024 and met with government officials and public and private sector stakeholders across the energy sector. This report is based on information from these meetings, the review team's assessment of the Netherlands' energy policy and detailed research by the IEA. The members of the review team were team leader Lars Georg Jensen (Denmark); Derek Carroll (Ireland/Eirgrid); Jordan Cox (Nuclear Energy Agency); Alisha Lakhani (United Kingdom); Georges Lanners (Luxembourg); Jo Robbelein (Belgium); and Oskar Kvarnström, Gergely Molnár and Alessio Scanziani from the IEA Secretariat.

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Abbreviations and acronyms

CCS	carbon capture and storage
CCU	carbon capture and utilisation
CCUS	carbon capture, utilisation and storage
CfD	contract for difference
CSP	congestion management service provider
DLR	dynamic line rating
DSO	distribution system operator
EED	Energy Efficiency Directive
EPC	energy performance certificate
ETS	Emissions Trading System
EU	European Union
EUR	euro
EV	electric vehicle
FID	final investment decision
GHG	greenhouse gas
H-gas	high calorific gas
IEA	International Energy Agency
IPCEI	Important Projects of Common European Interest
KEV	Climate and Energy Outlook
L-gas	low calorific gas
LAN	Grid Congestion Action Programme
LNG	liquefied natural gas
LULUCF	land use, land-use change and forestry

NECP	National Energy and Climate Plan
PBL	Environmental Assessment Agency
PV	photovoltaics
RAB	Regulated Asset Base
RED	Renewable Energy Directive
RVO	Netherlands Enterprise Agency
SDE	Sustainable Energy Transition Incentive Scheme
SMR	small modular reactor
SPULA	Public Charging Infrastructure Heavy Transport Subsidy Scheme
TSO	transmission system operator
UK	United Kingdom

Units of measurement

bcm	billion cubic metres
GW	gigawatt
kt	kilotonne
kV	kilovolt
kW	kilowatt
Mt CO_2-eq	million tonnes carbon dioxide equivalent
MW	megawatt
PJ	petajoule
TWh	terawatt hour

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The Netherlands 2024

Energy Policy Review

Government action plays a pivotal role in ensuring secure and sustainable energy transitions and combatting the climate crisis. Energy policy is critical not just for the energy sector but also for meeting environmental, economic and social goals. Governments need to respond to their country's specific needs, adapt to regional contexts and help address global challenges. In this context, the International Energy Agency (IEA) conducts Energy Policy Reviews to support governments in developing more impactful energy and climate policies.

This *Energy Policy Review* was prepared in partnership between the Government of The Netherlands and the IEA. It draws on the IEA's extensive knowledge and the inputs of expert peers from IEA member countries to assess The Netherlands' most pressing energy sector challenges and provide recommendations on how to address them, backed by international best practices. The report also highlights areas where The Netherlands' leadership can serve as |an example in promoting secure clean energy transitions. It also promotes the exchange of best practices among countries to foster learning, build consensus and strengthen political will for a sustainable and affordable clean energy future.