CARBON-FREE EUROPE
A TECHNOLOGY-INCLUSIVE CLIMATE INITIATIVE

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Country Summary: Netherlands

Analysis of Net-Zero Pathways for the EU and UK

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Overview of Modelling Analysis

Carbon-Free Europe (CFE) modeled five potential pathways for the EU and UK to achieve net-zero emissions by 2050. The ***Core*** pathway is the least constrained, allowing countries to use all available clean energy technologies and assuming high levels of energy efficiency and electrification. This is the most feasible, cost-effective pathway to net-zero. The other four pathways are designed to explore how different policy and implementation constraints impact the route to carbon-neutrality. To learn more about the other pathways and our full analysis, visit www.carbonfreeeurope.org.

Today's Energy System

In 2019, 90% of the Netherlands' energy supply came from fossil fuels (9% from coal, 45% from gas, and 36% from oil). Nuclear energy supplied 1%, and renewable energy sources, including biomass, provided 8%. When looking at the Netherlands' emissions that same year, 32% came from the energy sector (primarily electricity generation), 30% from industry, 17% from transport, and 19% from residential and commercial buildings. 2019 is a good baseline year to understand Europe's long-term energy demand and supply since impacts from the pandemic have heavily skewed data from 2020-2021. 2019 is also the most recent year for which Eurostat data is available.

Key Takeaways: The *Core* Pathway in 2050

1. The Netherlands' most feasible and cost-effective pathway to net-zero is the *Core* pathway, which uses every available clean energy technology, including nuclear power and carbon capture. In this pathway, by 2050, the Netherlands' estimated electricity mix is 80% wind, 10% nuclear, 7% solar, and 3% gas. The Core pathway requires €300 billion of investment through 2050 in key technologies, including electricity generation and storage, clean fuels, direct air capture, and heat pumps.
2. **By 2050 in the *Core* pathway, the Netherlands adds the 2nd largest offshore wind capacity of any EU + UK country.** Our model estimates that the Netherlands adds 66 GW of new offshore wind capacity**.** When non-renewable energy sources are not allowed (in the *100% Renewables* pathway), new offshore wind capacity is over 100 GW in 2050.

3. **The Netherlands has the 6th largest battery storage addition made by any EU + UK country.** The Netherlands complements its increased intermittent wind generation with 11 GW of new battery storage in the *Core* pathway.
4. **The Netherlands builds the 7th most new nuclear of any EU + UK country.** The Netherlands adds 8 GW of new nuclear electric capacity by 2050 and maintains its existing 500 MW of nuclear generation, which remains in service through 2050.
5. **The Netherlands builds 31 GW of new electric transmission capacity, the 5th most of any EU + UK country.** However, if transborder transmission is constrained, as seen in the *Domestic Preference* pathway, new transmission capacity is limited to 5 GW.
6. **The Netherlands becomes the largest producer of e-fuels among the EU + UK countries, producing 9,700 kilotonnes of oil equivalent (ktoe) in 2050 in the *Core* scenario.** The Netherlands produces approximately 20% of total e-fuels in 2050 in the EU + UK. This e-fuel production is almost entirely ammonia to meet shipping fuel demand.
7. **In the *Core* pathway, the Netherlands adds 35 GW of hydrogen pipelines by 2050, the 2nd most of any EU + UK country.** The Netherlands is not a leading producer of hydrogen, ranking 16th of all EU + UK countries in total hydrogen production. However, its location positions the Netherlands to import hydrogen from the UK and Norway, both large hydrogen producers, and transport it to demand centers in continental Europe.
8. **The Netherlands will need to increase the rate of renewables deployment over the coming decades to reach net-zero by 2050.** From 2011 to 2020, the Netherlands built an average of 1.7 GW of renewable energy per year. To meet demand, the country will need to build between 2 to 4 GW annually through 2050, increasing the historic build rate by a factor of **1 to 2.5x**.

Key Energy Metrics

The table below shows key energy system metrics from the ***Core*** pathway, which is the most cost-effective, feasible trajectory to net-zero. The table also shows a range for each metric. That range is generated by comparing the ***Core*** pathway to four other modelled pathways designed to evaluate specific constraints.

The ***Slow Demand Transformation*** pathway imposes delays in electrification of surface transportation, heating, and industry. The ***100% Renewables*** pathway relies strictly on renewables, phases out nuclear power, and prevents carbon capture and sequestration. The ***Limited Renewable Siting*** pathway restricts the deployment of wind and solar to reflect land-use and siting constraints. The ***Domestic Preference*** pathway prioritises domestic energy supplies and reduces transborder transmission lines and pipelines.

We provide a range for each metric in the table to indicate which model results are highly sensitive to constraints, and which are consistent across all scenarios such that they represent low-regret strategies. We also show the Netherlands' rank in each metric relative to all EU + UK countries, to identify segments of the decarbonised energy economy where the country has an opportunity to lead.

Key Energy System Metrics from Net-Zero Analysis

Category	Metric	Core Case	Min	Max	EU + UK Rank
Demand Transformation	electrification share (% of final demand)	35%	30%	35%	25
	reduction in end-use gas demand (ktoe)	-11,669	-8,556	-11,669	5
	reduction in end-use oil demand (ktoe)	-26,120	-17,932	-26,120	6
	zero-emission vehicles (million vehicles)	12	12	12	7
Electricity	new battery storage (GW)	11	5	14	6
	new nuclear (GW)	8	8	8	7
	new solar (GW)	15	12	16	12
	new offshore wind (GW)	66	53	111	2
	new onshore Wind (GW)	4	2	4	21
Fuels	biofuels (ktoe)	1,438	1,432	4,012	15
	e-fuels (ktoe)	9,769	2,653	9,958	1
Hydrogen	electrolysis - high temperature (kilotonnes h2)	6	6	736	14
	electrolysis - low temperature (kilotonnes h2)	235	235	3,448	12
Other Resources	biomass (million dry tons)	6	6	6	20
	geologic sequestration (million tons CO2)	2	2	3	16
Transmission and Pipelines	new electricity transmission (GW)	31	5	31	5
	new h2 pipelines (GW)	35	8	35	2

Table 1: https://www.carbonfreeeurope.org/modeling