CARBON-FREE EUROPE
A TECHNOLOGY-INCLUSIVE CLIMATE INITIATIVE

MEMO • Published October 28, 2022

Country Summary: Finland

Analysis of Net-Zero Pathways for the EU and UK

By Isabelle Chan, Lindsey Walter, Ben Haley, Katie Pickrell

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, 38% of Finland's energy supply came from fossil fuels (7% from coal, 7% from gas, and 24% from oil). Nuclear energy supplied 18%, and renewable energy sources, including biomass, provided 37%. When looking at Finland's emissions that same year, 31% came from the energy sector (primarily electricity generation), 35% from industry, 21% from transport, and 9% 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. **Finland's 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, Finland's estimated electricity mix is 62% wind, 22% nuclear, 10% existing hydro, and less than 1% gas. The Core pathway requires €116 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, Finland adds 29 GW of new onshore wind capacity.** This capacity addition is the 7th largest made by any EU + UK country.

3. **Finland adds 2 GW of new nuclear electric capacity by 2050, the 10th most added by any EU + UK country.** Finland's 3 GW of existing nuclear also remain in service through 2050.
4. **Finland's new nuclear capacity is used not only to generate electricity but also to produce hydrogen via high-temperature electrolysis.** Finland produces over 500 kilotonnes of high-temperature electrolytic hydrogen in 2050, the 6th most of any EU + UK country.
5. **Finland builds 10 GW of new electric transmission capacity and 2 GW of new hydrogen pipelines by 2050.** New electric transmission capacity ranges as low as 0 GW (when transborder transmission is constrained in the *Domestic Preference* pathway) and as high as 14 GW (in the 100% *Renewables* pathway).
6. **Finland has a significant biomass supply: 20 million dry tons in 2050, the 9th most of any EU + UK country.** That biomass, primarily from wood and forest residues, is mostly consumed domestically in existing industrial and heat applications through 2050. Finland does not become a large biofuel producer, ranking 26th among EU + UK countries in total biofuel production.
7. **Finland will need to increase the rate of renewables deployment over the coming decades to reach net-zero by 2050.** From 2011 to 2020, Finland built an average of 400 MW of renewable energy per year. To meet demand, the country will need to build between 600 to 1500 MW annually through 2050, increasing the historic build rate by a factor of 1.5 to 4x.

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 Finland's rank in each metric relative to all EU + UK countries, to identify segments of the decarbonised energy economy where Finland 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)	40%	38%	40%	23
	reduction in end-use gas demand (ktoe)	-99	17	-99	26
	reduction in end-use oil demand (ktoe)	-6,191	-5,109	-6,191	14
	zero-emission vehicles (million vehicles)	5	4	5	16
Electricity	new nuclear (GW)	2	2	4	10
	new solar (GW)	1	1	1	27
	new offshore wind (GW)	4	2	19	11
	new onshore Wind (GW)	29	19	30	7
Fuels	biofuels (ktoe)	101	100	522	26
	e-fuels (ktoe)	905	846	963	14
Hydrogen	electrolysis - high temperature (kilotonnes h2)	512	350	739	6
	electrolysis - low temperature (kilotonnes h2)	31	31	619	19
Other Resources	biomass (million dry tons)	20	20	26	9
Transmission and Pipelines	new electricity transmission (GW)	10	0	14	17
	new h2 pipelines (GW)	2	1	4	21

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