CIP view on Europe's 2050 power and hydrogen markets

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Europe's journey Net Zero transition - an integrated energy system

Four drivers leading EU's green transition setting an ambitious political direction, but practical implementation delays transition

Drivers

Race to Net Zero: Climate Change

Energy independence

Renewable Energy Cost Competitiveness

Growth & jobs of the green transition

Political Ambitions

Global Policy Objectives

Paris Accord *(2015)*

European Policy Objectives

Esbjerg Declaration *(May 2022)*

Marienborg Declaration *(August 2022)*

EU Green Industrial Plan *(Feb 2023)*

Ostend Declaration *(April 2023)*

Global Industry Competition

Inflation Reduction Act *(July 2022)*

Delayed implementation

Complexities

Is it possible to reach Net Zero by 2050?

What are the effects on consumer prices?

How can stability in the energy mix be maintained?

What is the role of offshore wind power?

Where can green hydrogen be sourced?

CIP view on Europe's 2050 power and hydrogen markets

A model-based approach developed with insight from industry leaders

Joint modelling effort to understand Europe's[2] pathways to net zero by 2050

Model inputs[1]

Demand: Power, heat and hydrogen demand

Economic: Fuel and CO_2 prices, cost of capital

Technology: capacity factor, efficiency, meteorology

System constraints: reserve capacity, max renewables build-out p.a.

"Balmorel" Hourly techno-economic optimization until 2050

Model outputs[1]

Optimal capacity additions per power tech. / transmission line

Optimal generation dispatch and power flows

Electricity and hydrogen supply cost

CO_2 emissions

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An integrated European energy system

Notes: 1) Not exhaustive; **2)** The model covers EU 27 countries and UK.

Overview of model assumptions

Drawing inputs from diverse sources to shape an industry-aligned perspective

Model inputs

Diverse sources

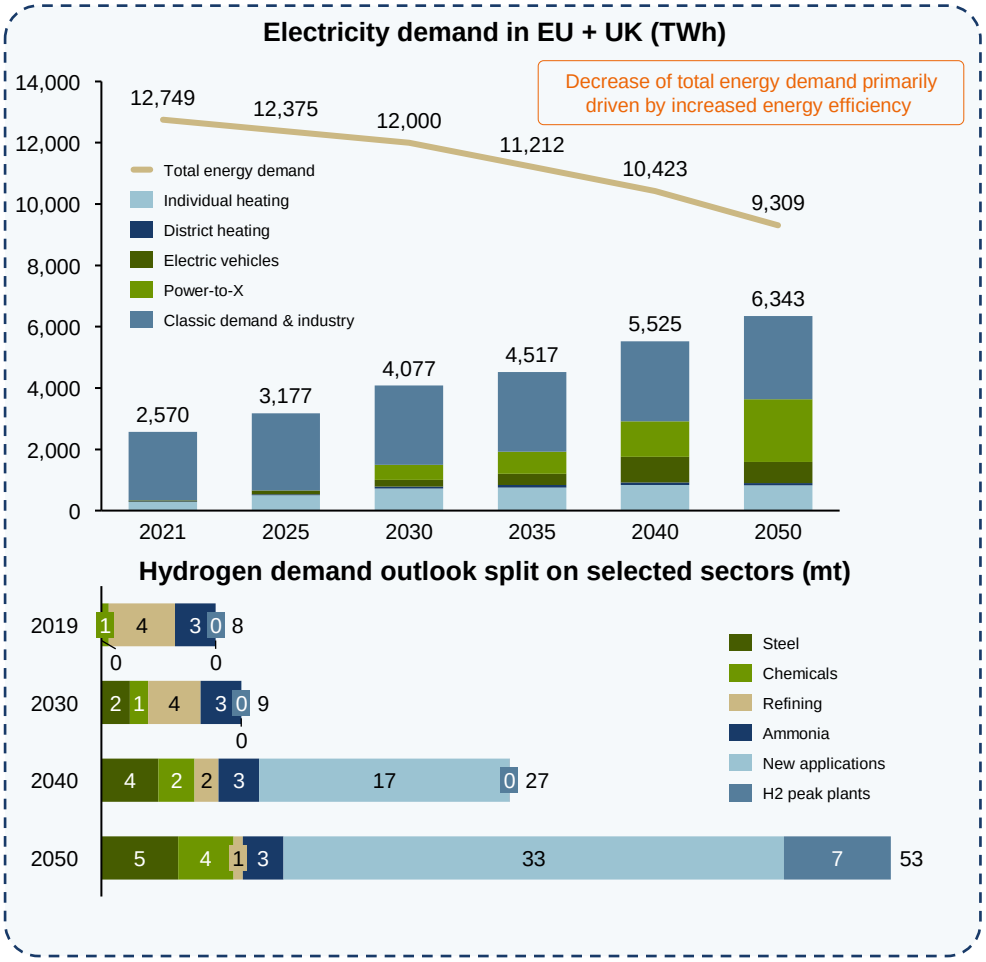
Demand: Power, heat and hydrogen demand[1,2]

Economic: Fuel and CO_2 prices, cost of capital[3,4]

Technology: capacity factor, efficiency, meteorology[4,5]

System constraints: Transmission & RES build-out restrictions[1]

Example of key assumption



Sources 1) ENTSO-E TYNDP (European Network of Transmission System Operators for Electricity Ten-Year Network Development Plan (https://2022.entsos-tyndp-scenarios.eu/wp-content/uploads/2022/04/TYNDP2022_Joint_Scenario_Full-Report-April-2022.pdf **2)** European Commision RePowerEU Mix Scenario **3)** IEA World Energy Outlook 2022 Announced Pledge Scenario **4)** Danish Energy Agency Technology Catalogue **5)** 4Coffshore database + more **6)** OFW CAPEX assuming average water depth of 40-50m + average length from shore of 70km **7)** GT = Gas turbine and comprise of range between Combined Cycle gas turbine and Simple Cycle gas turbine

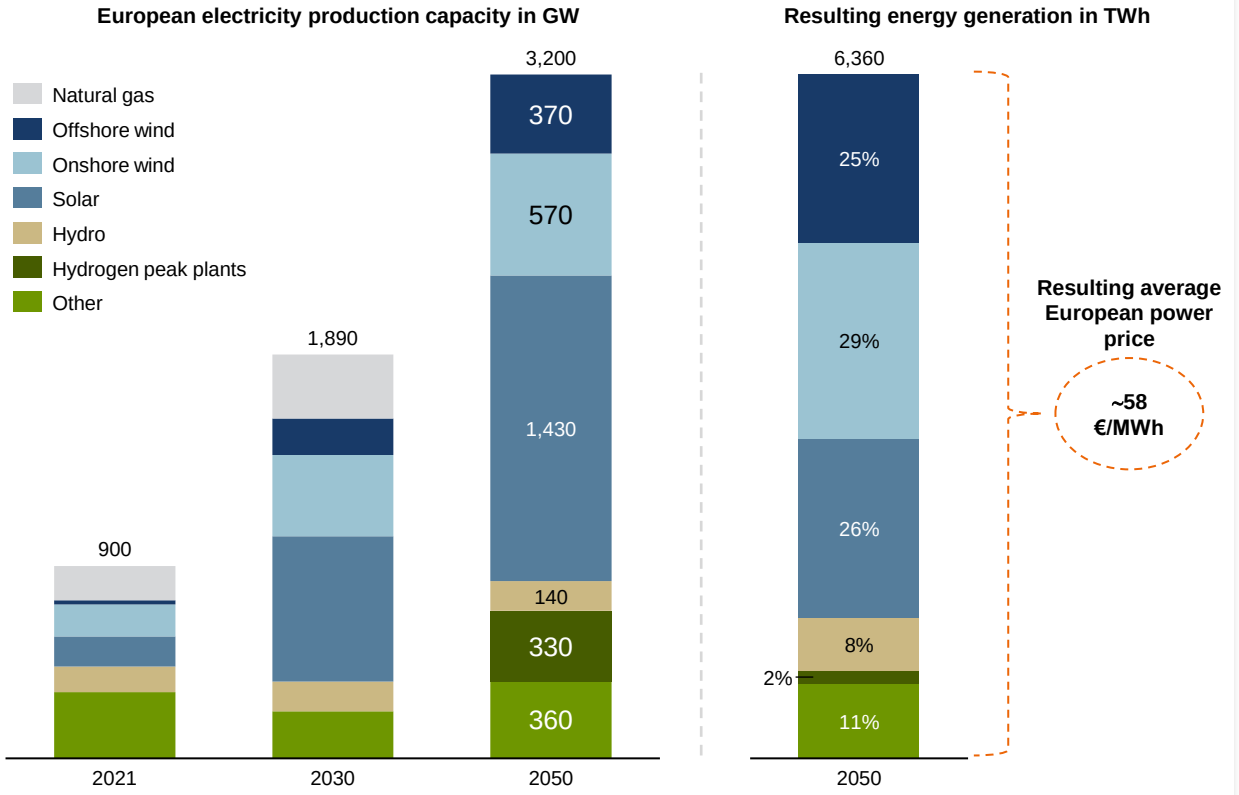
Europe’s Net Zero transition supplied by power from wind and solar PV

Offshore wind play a vital role in Europe’s Net Zero transition supplying ~25% of all European electricity in 2050

Power production capacity buildout and resulting energy generation

Offshore wind has important role in reaching Net Zero

370 GW of OFW
Can supply 25% of total electricity in 2050



Conclusions

Solar PV, onshore wind and offshore wind to supply ~80% off all Europe’s electricity by 2050 supplying “roughly” 1/3 European power production each

Benefits from offshore wind:

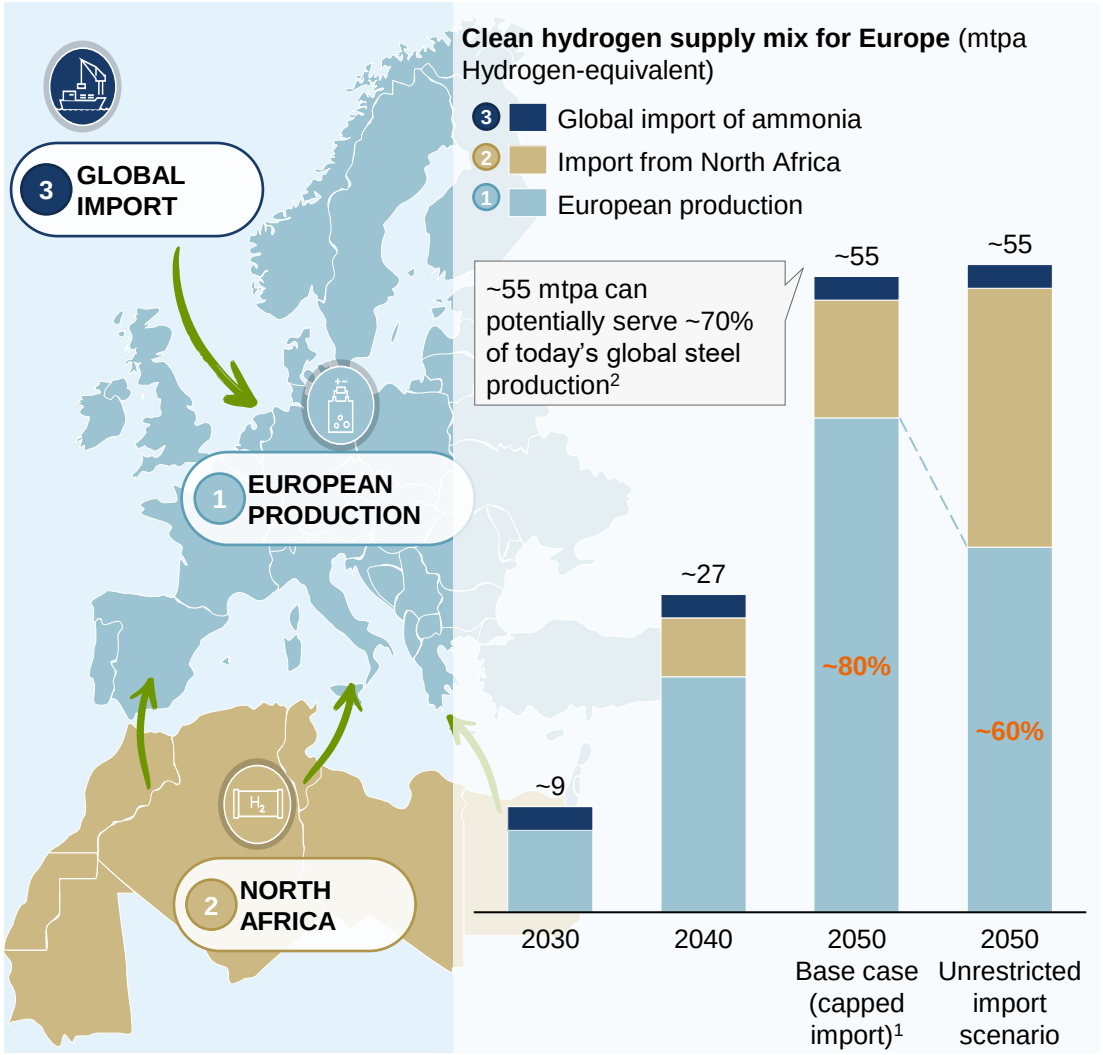
- Stabilization of supply due to high-capacity factor
- Interconnector points for integration of transmission systems between countries

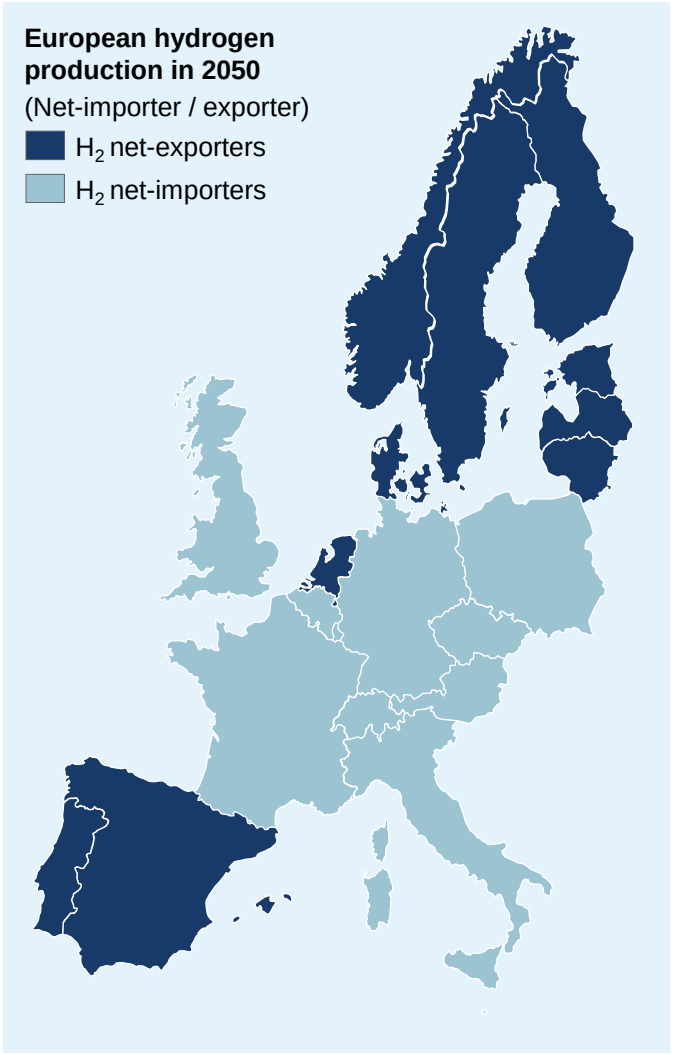
In Northern Europe, offshore wind provides a competitive alternative to PV + storage for supply of electricity during night and winter times

Important Information: The model-based insights presented are based on historical data and current market trends and are intended for informational purposes only. They should not be construed as financial advice or a guarantee of future market performance.

European production to account for majority of Europe's hydrogen supply

European-based hydrogen production to account for ~60-80% of total supply in 2050, North Sea, Baltic Sea and Iberia to be main exporters of cheap European hydrogen





Notes: 1) European import hydrogen at competitive prices from North Africa expected to be capped by political motives such as energy dependency or industry policies – in this case capped at 10 mtpa hydrogen from 2040 forward; **2)** Calculation based on 'Decarbonising primary steel production: Techno-economic assessment of a hydrogen based green steel production plant in Norway' (Bhaskar et al., 2022).

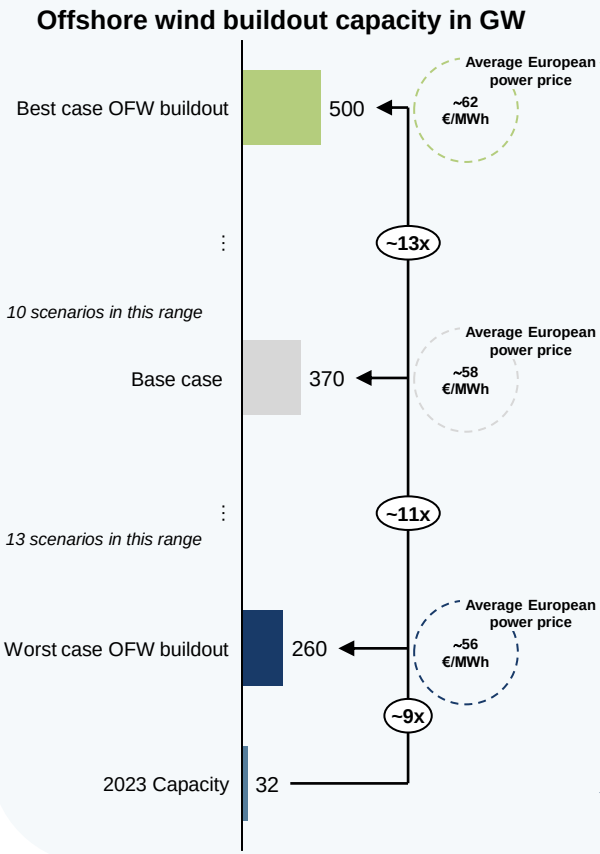
European offshore wind buildout is robust across all tested scenarios

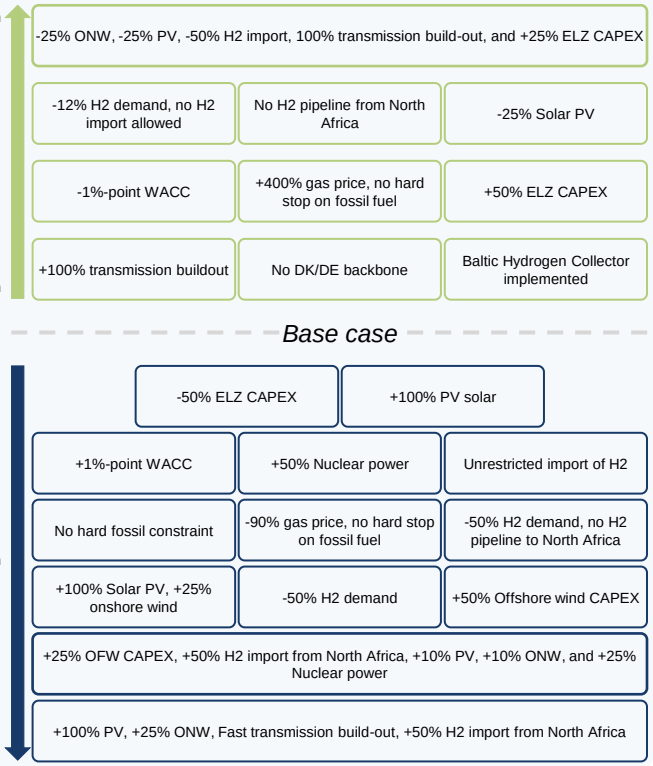
Solar PV, onshore wind and offshore wind each supplying ~1/3rd of Europe's power by 2050

Overview of scenarios and impact of such on offshore wind build-out

European offshore wind buildout is robust

~260-500 GW offshore wind across +20 tested scenarios





Examples of tested scenarios

Russian Natural gas

Low impact on offshore wind build out from reduced natural gas prices. Tested at 10% of IEA long term pricing resulting in ~320GW offshore wind

Increased investment cost

General increase in investment cost (+1% WACC) does not impact offshore wind buildout

More PV buildout

Increasing PV allowance by 100% has minor impact on offshore wind buildout reducing it by ~ 3%

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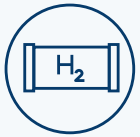
EU’s Energy Production and Infrastructure remains stable towards 2050…

… but today, the biggest challenge is to establish adequate amounts of power generation to supply a heavily increased demand

1. **The electricity demand is expected to more than double towards 2050**

2. **The electrification requires a substantial buildout of power generation**

3. **Hydrogen production will happen as a positive and essential biproduct from the increased buildout**



4. **Increased reliance of power and hydrogen requires an integrated European energy infrastructure**

Promote a supporting regulatory and political foundation

Promoting a supporting regulatory & political foundation to enable green transition

Industrial Policies

- Governments to stimulate renewable energy generation and industrial policy measures ensuring long-term certainty for energy prices
- Governments to strategically set an ambition for key technologies e.g. electrolyzers, offshore wind and digitalization of grids

Regulatory Challenges

Auction design	Need for simple permitting & auction models on national and international level; Increase funds for hydrogen bank
Regulatory clarity on GHG	Need to finalize GHG legislation; including RED III; Low Carbon Hydrogen Delegated Act
Permitting for generation	Ensure permitting deadlines and parallelized, digital consenting processes with as few public interfaces as possible

Transmission

Financing	New models for private capital into transmission should be investigated alongside unbundling regulatory frameworks
Hydrogen	Need to develop regulatory framework for hydrogen transmission and production
Permitting for transmission	Creation of fast tracks for permitting of transmissions build-out, incl. power grids and hydrogen pipelines

Supply Chain

Speed, Price & Viability	Clarify regulation for local content requirements in renewable energy supply chain (‘*Sustainability & Resilience Criteria*’)
Financing	Support schemes promoting frontier technologies such as floating offshore wind, green hydrogen and carbon capture & utilization to power hard-to abate sectors.

With the ambition to have Europe deliver on green ambitions, CIP will invite European stakeholders from industry, policy-makers & investors to discuss joint solutions

Over the next 12 months, CIP invites industry, think tanks & legislators to an open discussions to address key challenges across Europe