



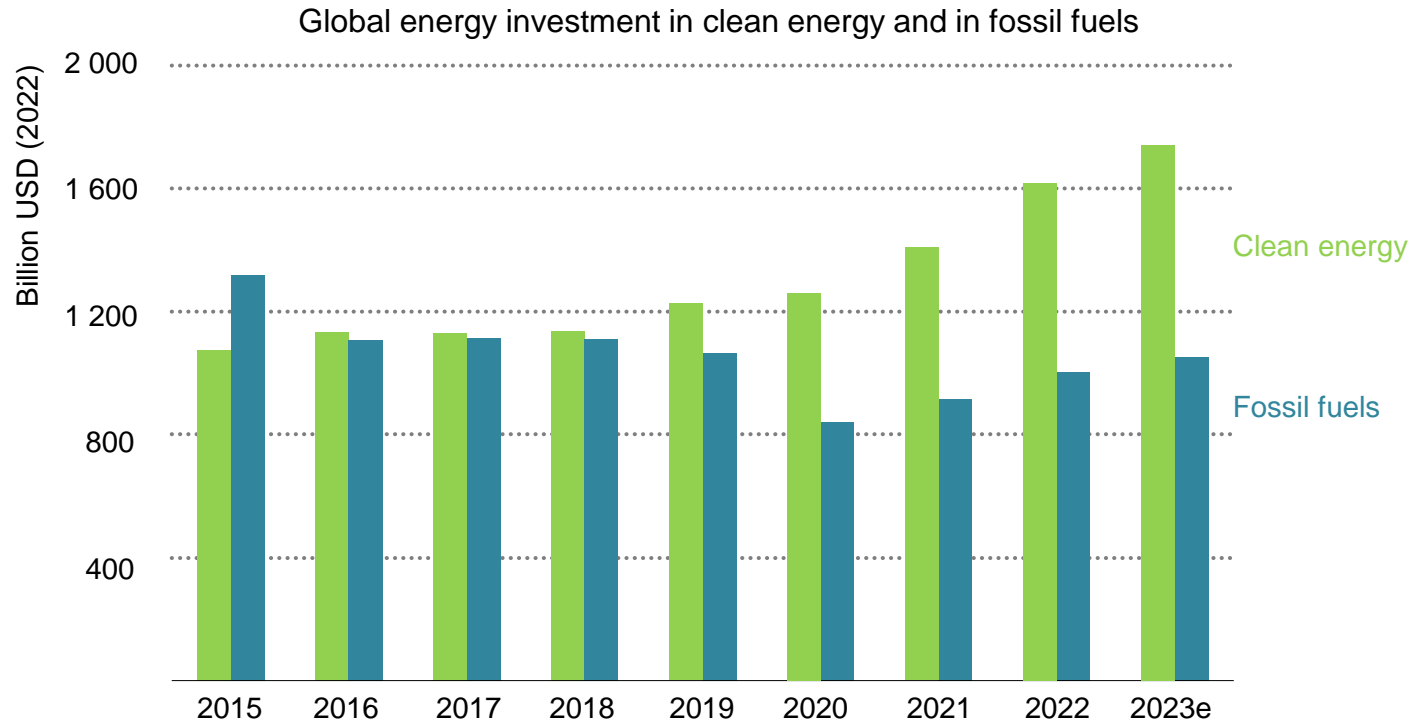
Net Zero Roadmap:

A Global Pathway to Keep the 1.5 °C Goal in Reach – 2023 Update

Uwe Remme, Head of Hydrogen and Alternative Fuels Unit

ETSAP Workshop, 17 November 2023

Clean energy investment is widening the gap over fossil fuels



For every dollar invested in fossil fuels, about 1.8 dollars are now going into clean energy. Five years ago, this ratio was one-to-one.

Cross-cutting

Energy system overview

- Energy efficiency
- Behavioural changes
- Electrification
- Renewables
- Bioenergy
- Hydrogen
- Carbon capture & storage
- Innovation
- Digitalisation
- International collaboration

Technology deep dives

- Direct air capture
- Bioenergy with carbon capture & storage
- CO₂ capture & utilisation
- Electrolysers

Infrastructure deep dives

- CO₂ transport & storage
- Data centres & transmission networks
- District heating

Electricity

Technology deep dives

- Coal-fired electricity
- Gas-fired electricity
- Solar PV
- Wind
- Hydro
- Nuclear
- Demand response
- Grid-scale storage
- Smart grids

Infrastructure deep dives

Oil & natural gas supply

Subsectors

- Methane emissions from oil and gas operations
- Flaring

Low-emission fuel supply

Subsectors

- Biofuels supply

Transport

Subsectors

- Cars and vans
- Trucks and buses
- Rail
- Aviation
- International shipping

Technology deep dive

- Electric vehicles

Industry

Subsectors

- Steel
- Chemicals
- Cement
- Aluminium
- Paper
- Light industry

Buildings

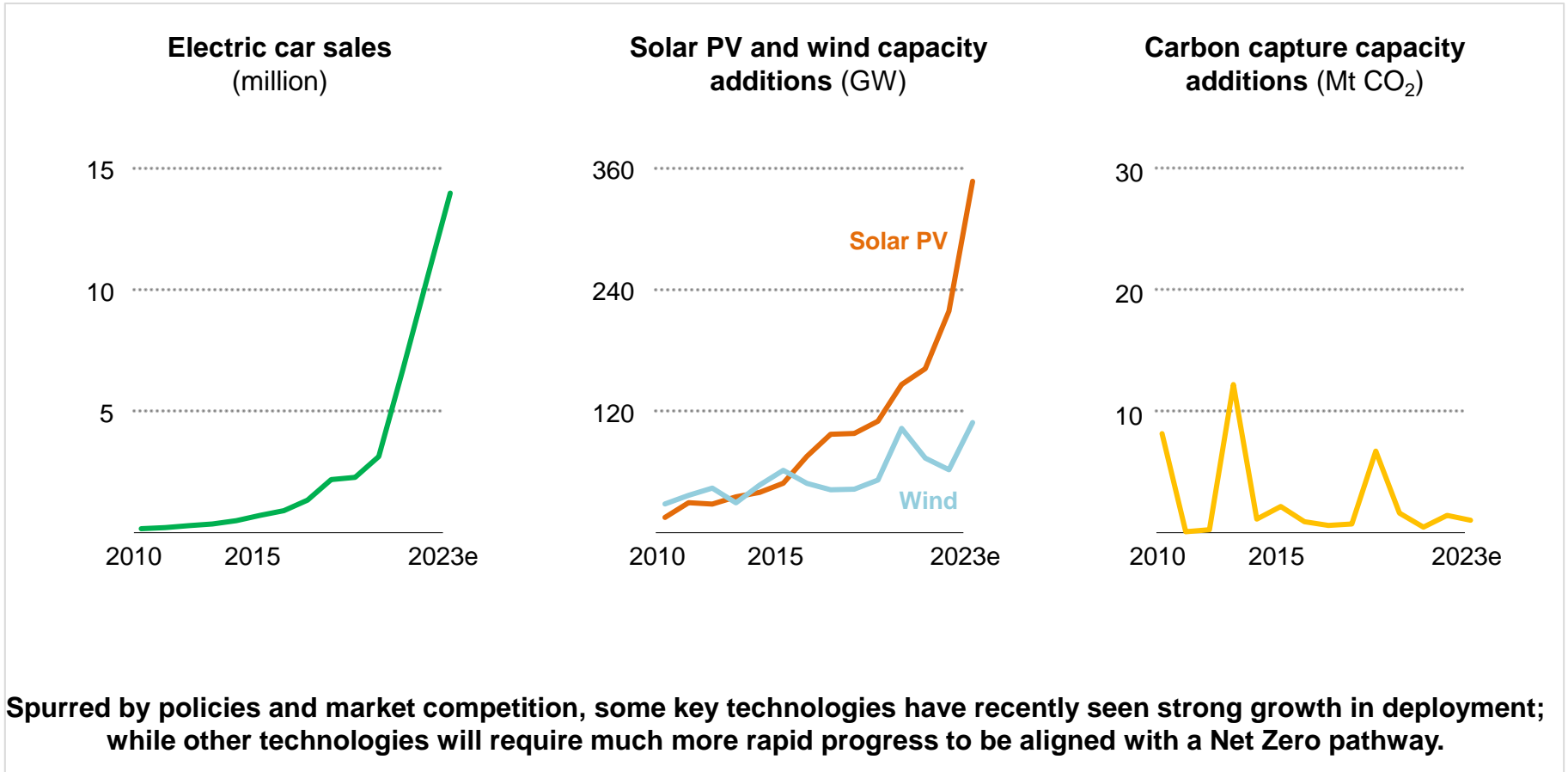
Subsectors

- Heating
- Space cooling
- Lighting
- Appliance & equipment

Technology deep dives

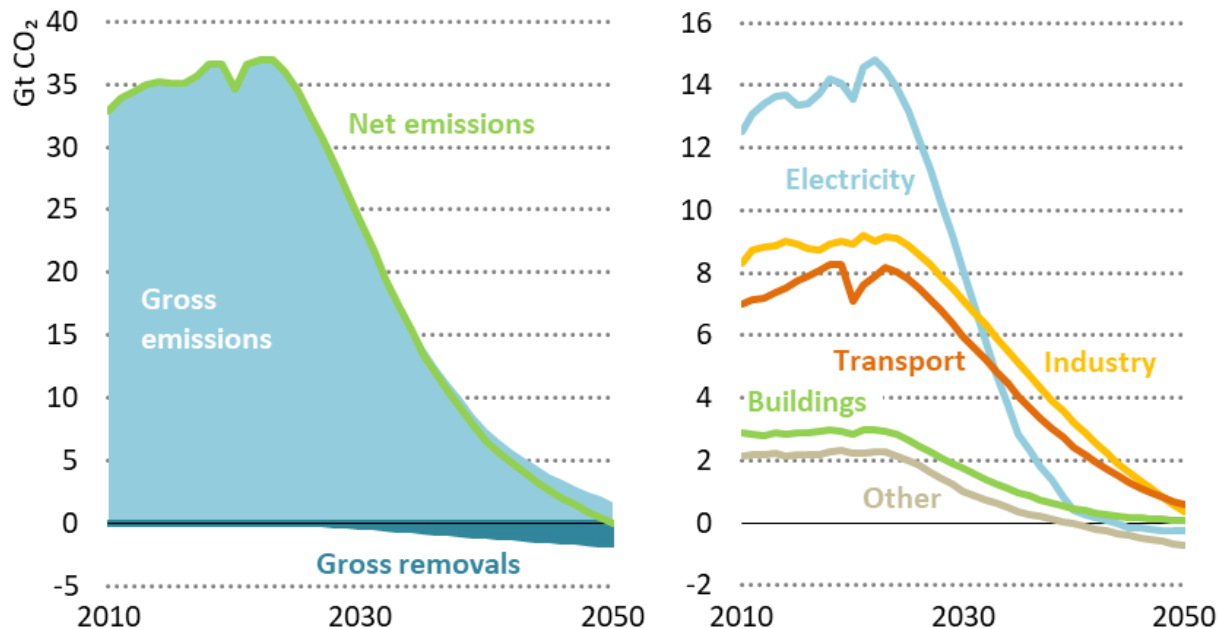
- Buildings envelope
- Heat pumps

Clean energy growth is keeping the door to 1.5 °C open



Rapid decarbonisation needed in all sectors to reach net zero

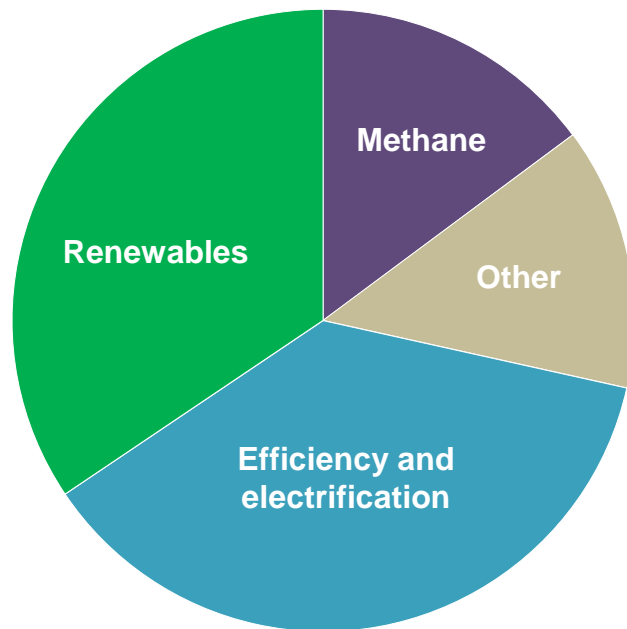
Energy sector gross emissions and removals, total net CO₂ emissions, and net emissions by sector in the NZE Scenario



Energy sector CO₂ emissions are reduced 65% by 2035 and reach net zero by 2050, with residual emissions of 1.7 Gt balanced by atmospheric removals of the same magnitude.

We have the tools to go much faster

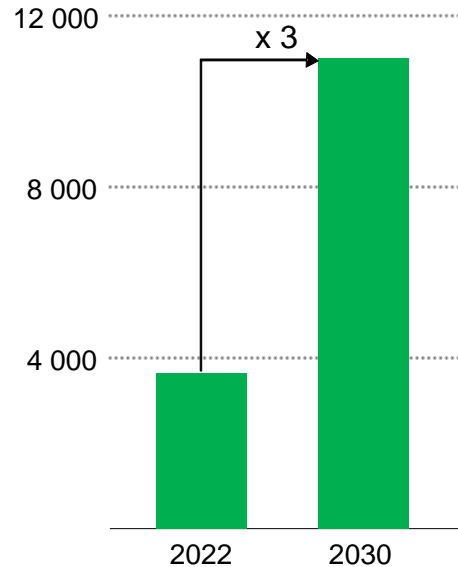
Emissions reductions by measure by 2030 in the NZE Scenario



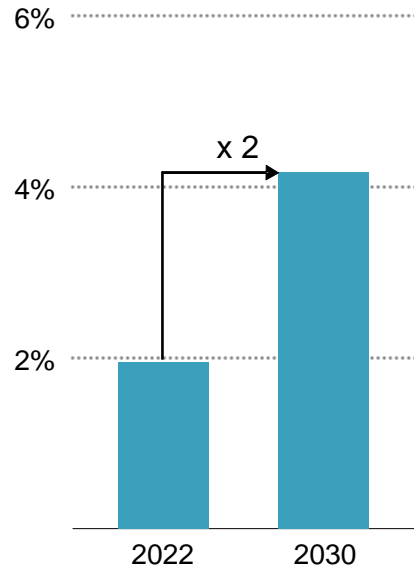
Energy-related greenhouse gas emissions peak by 2025 and decline by nearly 40% from today to 2030. Proven solutions available today deliver over 80% of what is needed this decade.

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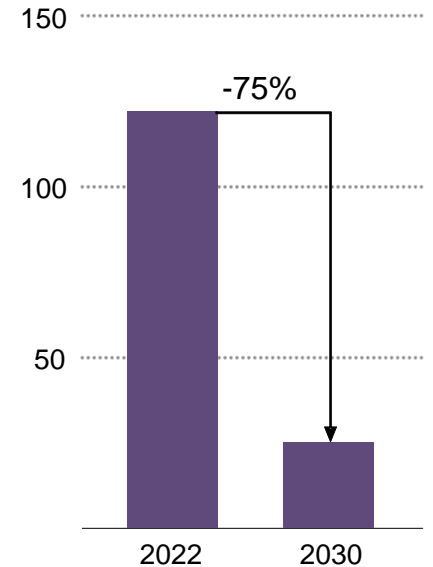
Renewables installed capacity (GW)



Annual energy intensity improvement



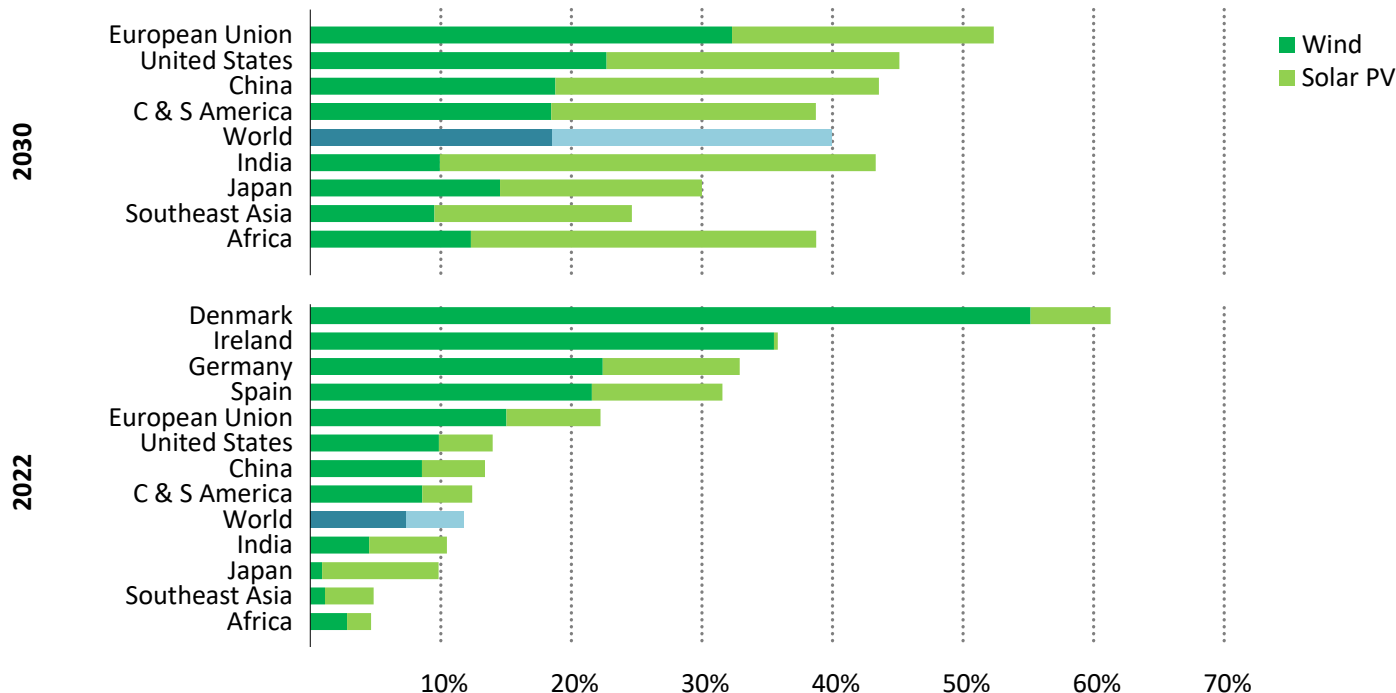
Methane emissions from fossil fuel operations (Mt)



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Integration of solar PV and wind is critical to the NZE Scenario...

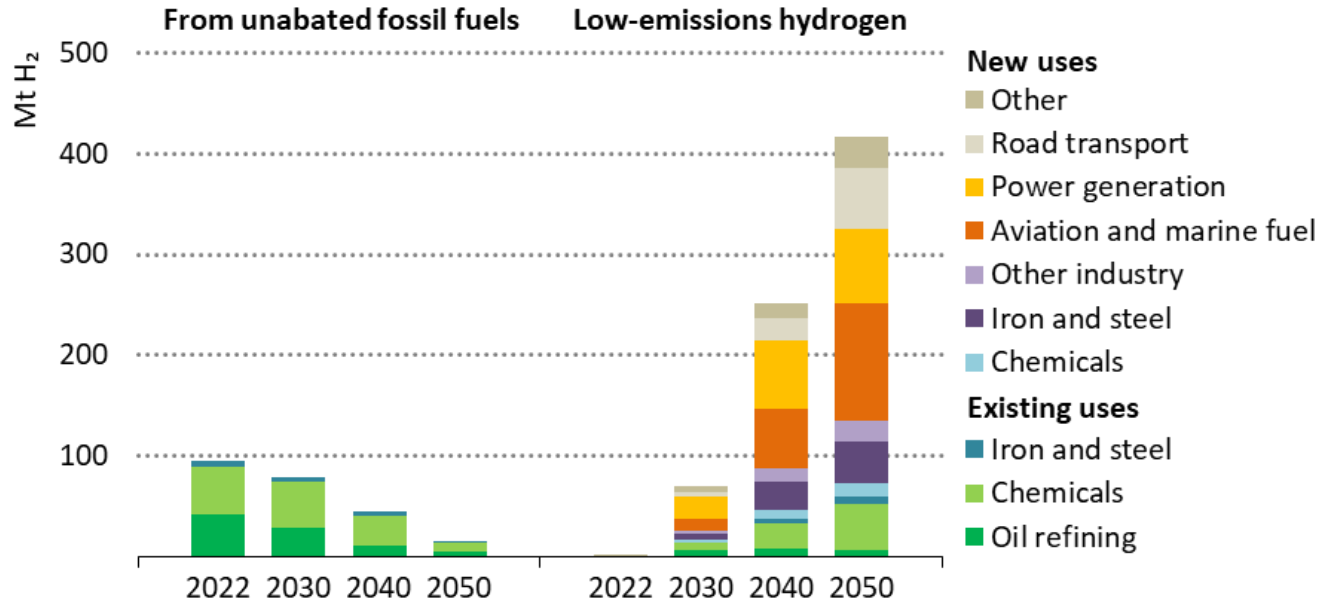
Share of total electricity generation from wind and solar PV by selected country/region in 2022 and in the NZE Scenario in 2030



...as their share in total generation in most regions reaches levels in 2030 seen only in a few countries today.

Almost half of global hydrogen supply is low-emission by 2030

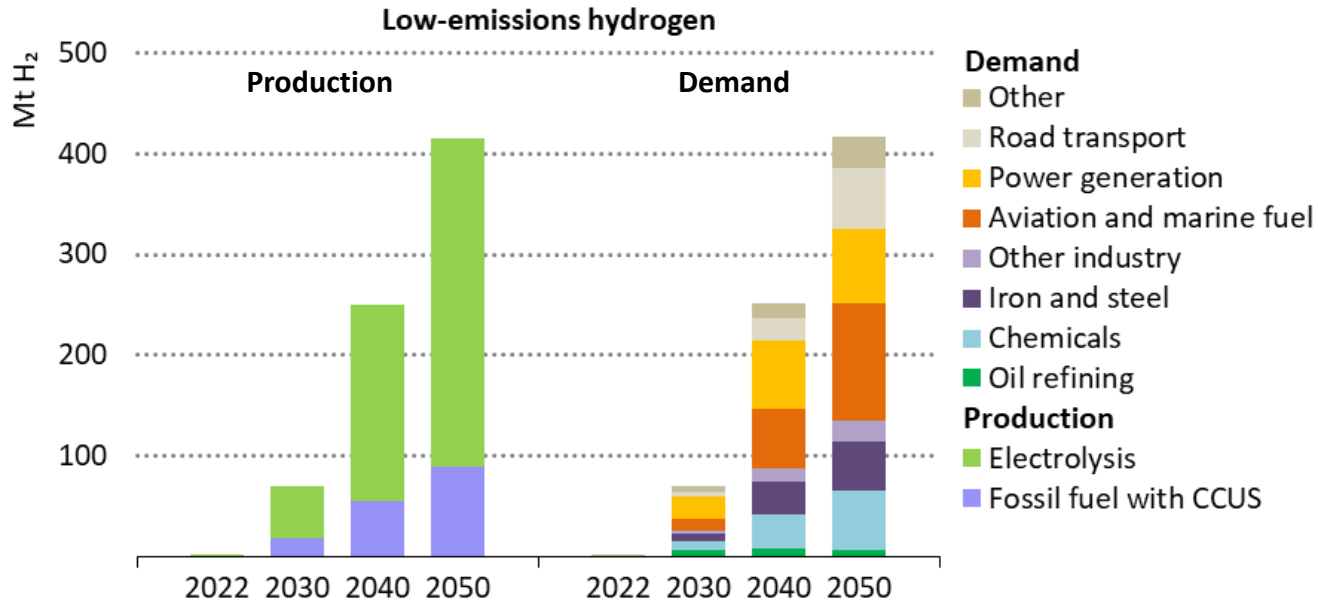
Global hydrogen demand in the NZE Scenario, 2022-2050



Use of low-emissions hydrogen rises significantly to 70 Mt by 2030 and extends to new applications such as in aviation and shipping.

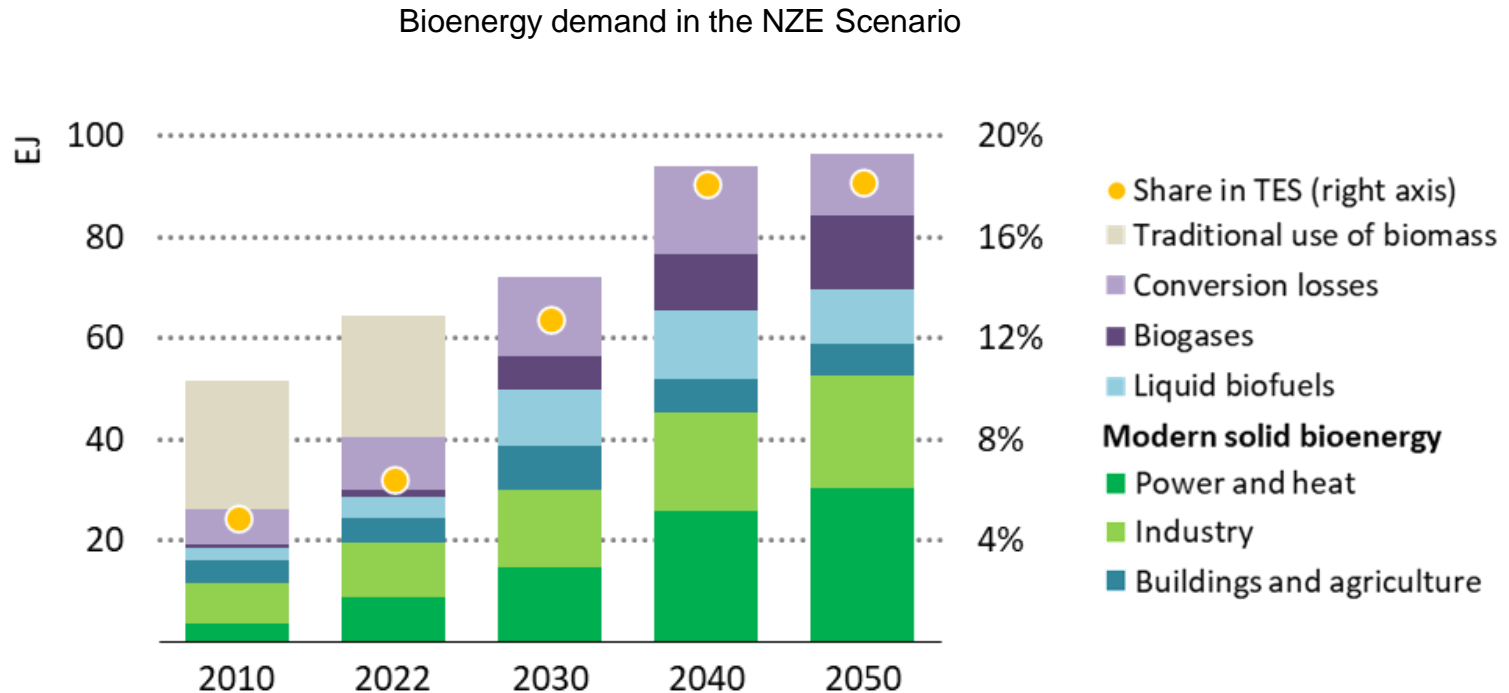
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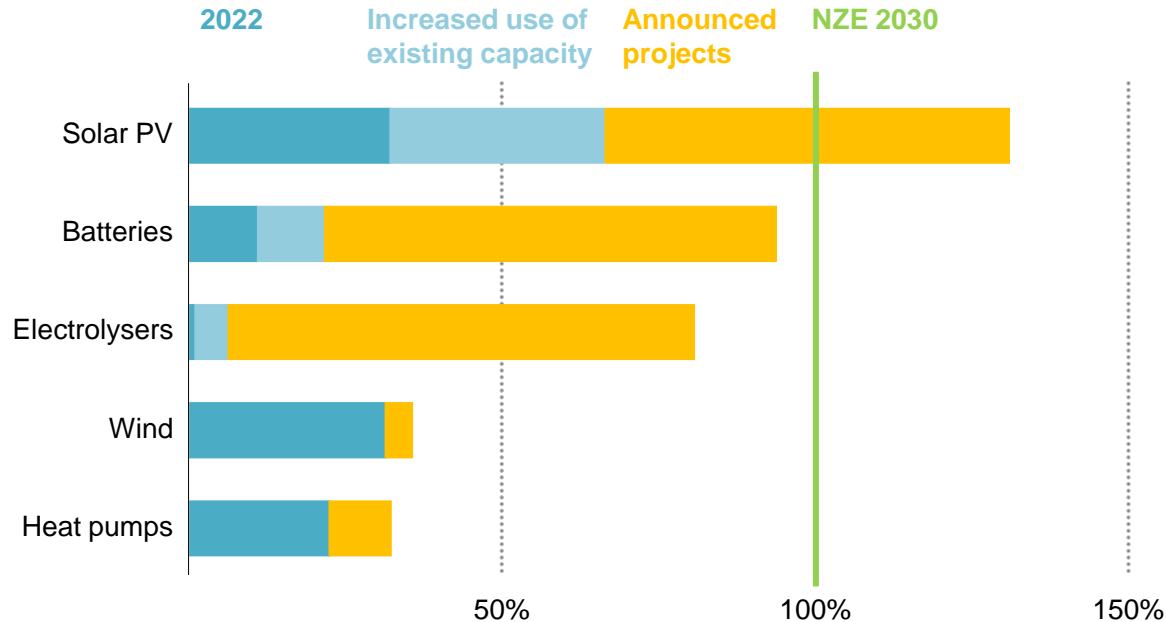
Modern bioenergy a key pillar of the clean energy transition



Share of modern bioenergy in total primary energy supply triples from 6% in 2022 to 18% by 2050.

Clean technology supply chains present an industrial opportunity

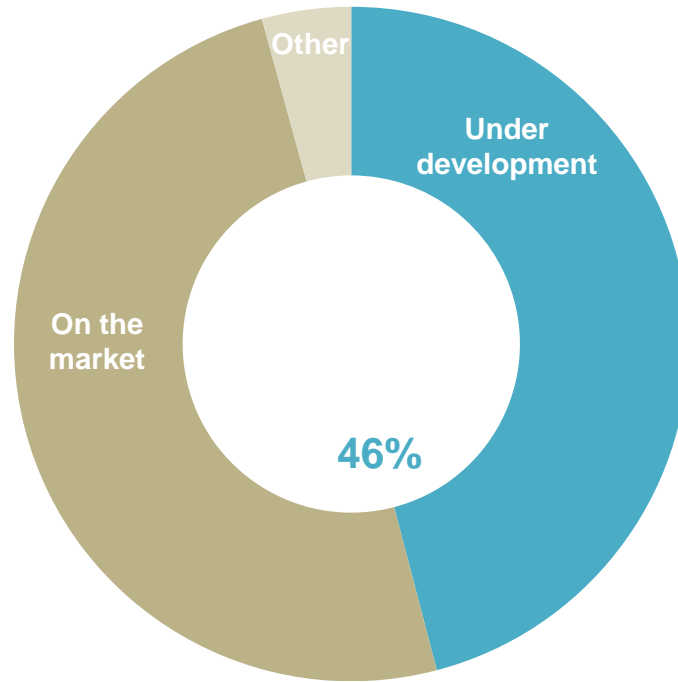
Announced manufacturing project throughput and deployment of key technologies in the NZE Scenario



If all announced projects proceed, solar PV manufacturing will exceed the 2030 level needed in the NZE Scenario, and batteries manufacturing will get very close; other technologies see larger gaps.

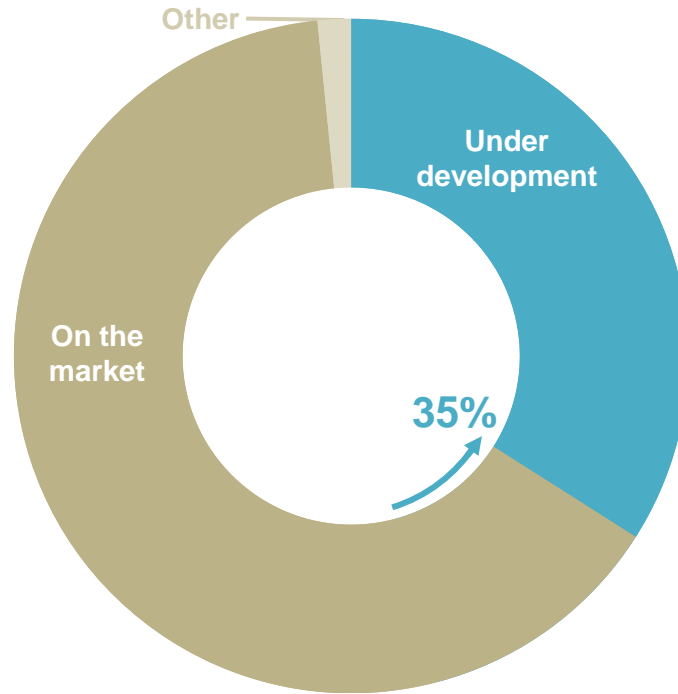
Innovation is already delivering new tools and lowering their costs

CO₂ emission reductions by technology maturity in 2050 in the NZE Scenario of **2021**



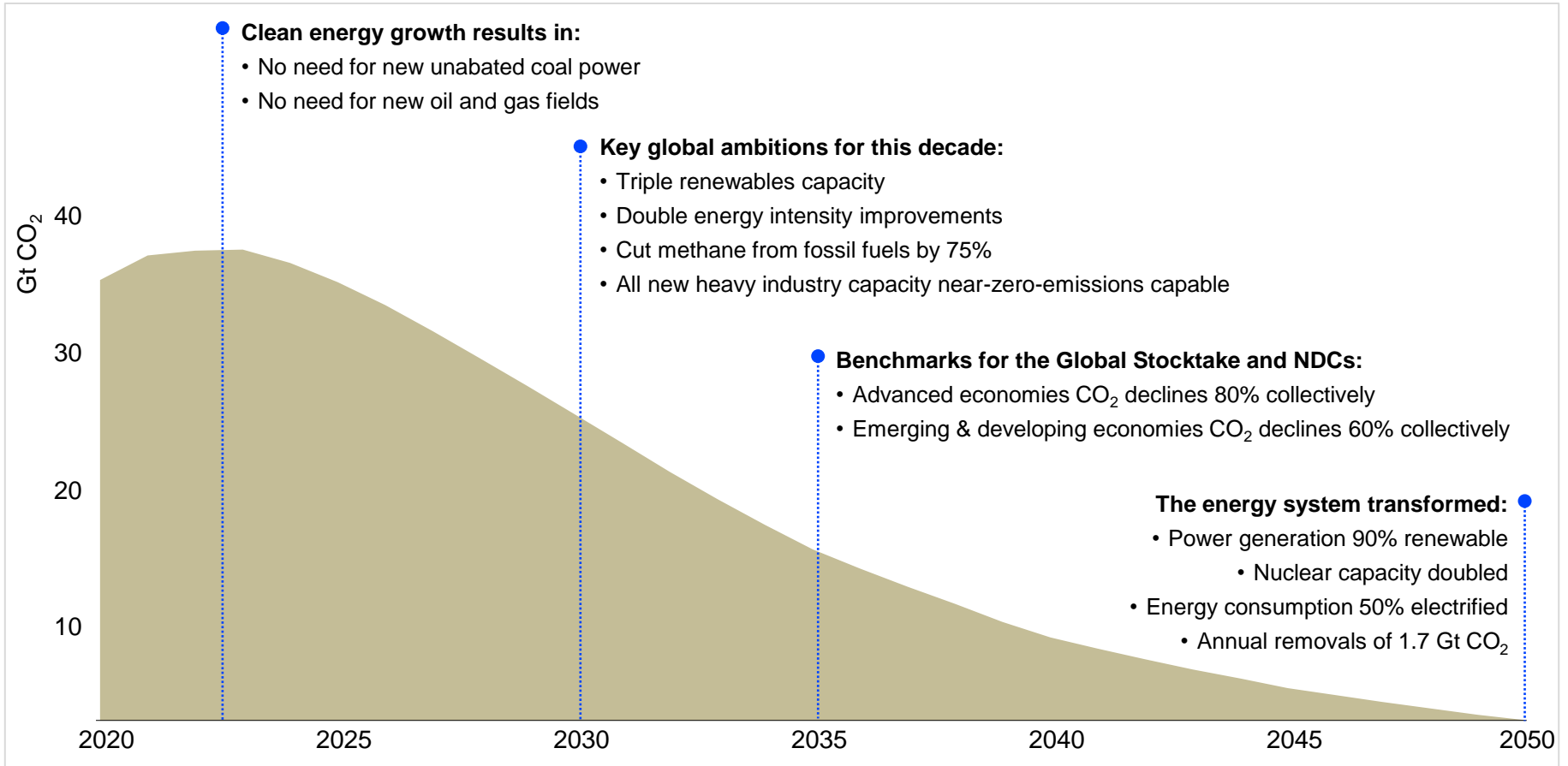
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CO₂ emission reductions by technology maturity in 2050 in the NZE Scenario of **2023**



Clean energy innovation has been accelerating in the last few years, yet more RD&D is needed to unlock the next generation of low-emissions technologies.

A roadmap to net zero by 2050



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