



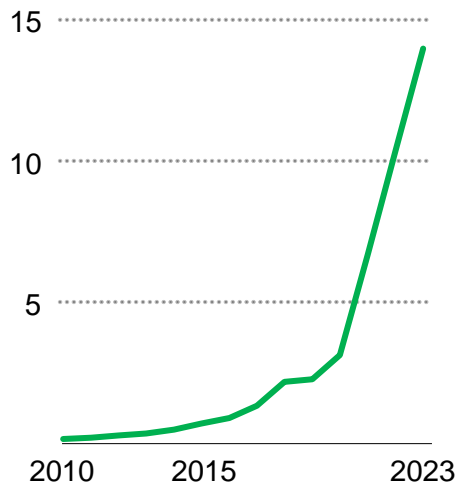
# Low-emission fuels for shipping and aviation

Elizabeth Connelly, PhD

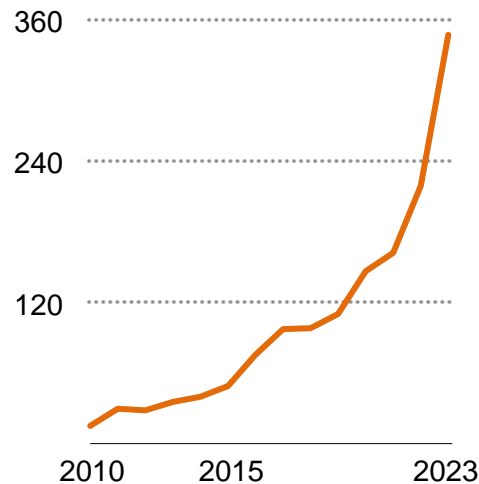
4 October 2023

# The path to 1.5 °C has narrowed, but clean energy growth is keeping it open

**Electric car sales**  
(million)



**Solar PV capacity additions**  
(GW)



**Global CO<sub>2</sub> emissions reached a record high in 2022, but the speed of the roll-out of key clean energy technologies means that coal, oil and natural gas will all peak this decade even without any new climate policies.**

## 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
- CO<sub>2</sub> capture & utilisation
- Electrolysers

### Infrastructure deep dives

- CO<sub>2</sub> 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

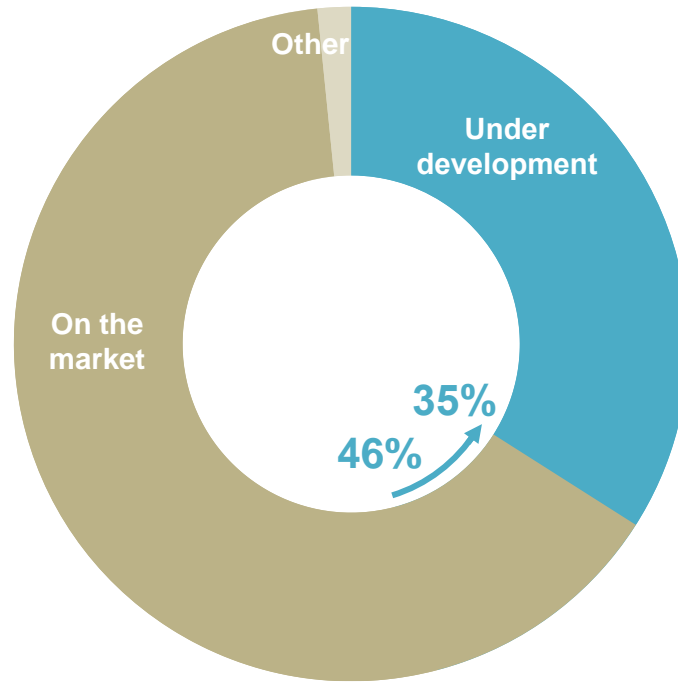
- Heating
- Space cooling
- Lighting
- Appliance & equipment

### Technology deep dives

- Buildings envelope
- Heat pumps

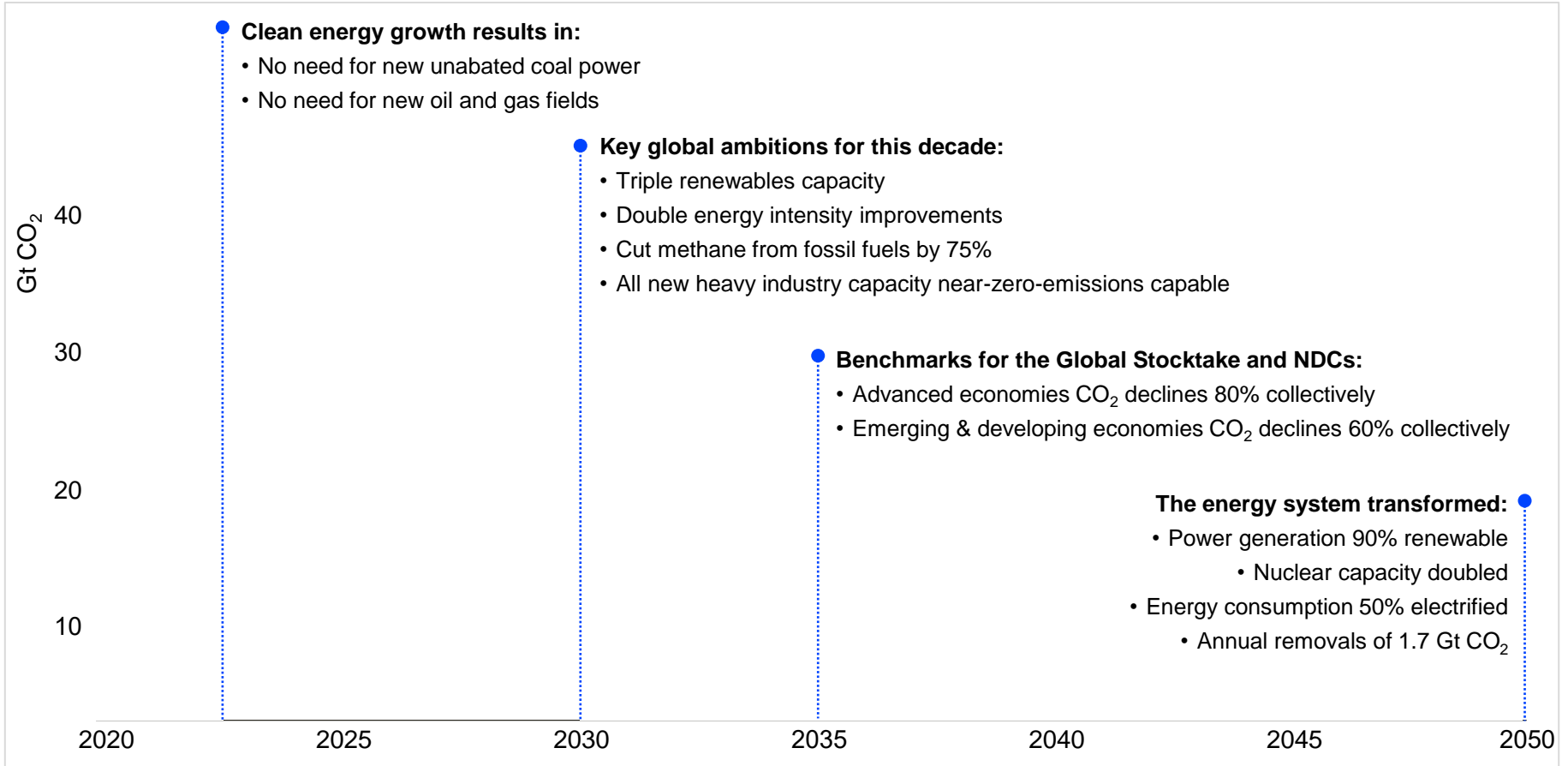
# Innovation is already delivering new tools and lowering their costs

CO<sub>2</sub> emission reductions by technology maturity in 2050 in the NZE Scenario of 2023



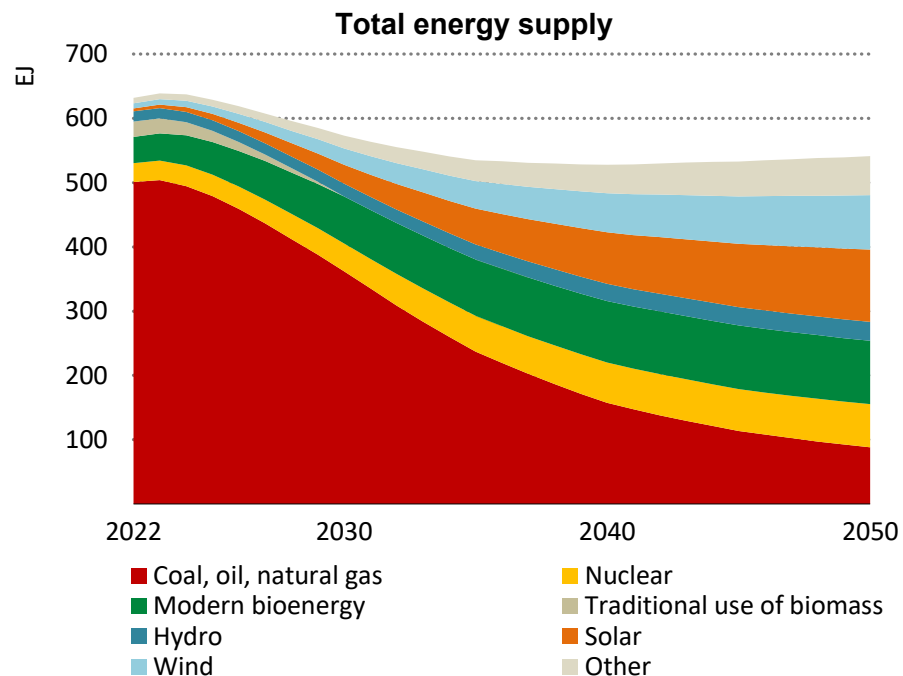
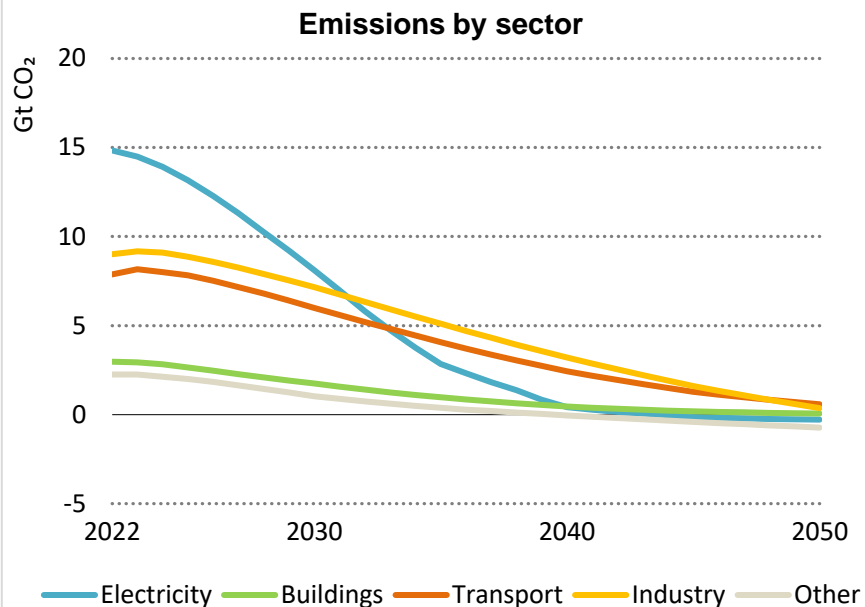
**Clean energy innovation has been accelerating in the last few years, yet more RD&D is needed to unlock the next generation of low-emissions technologies.**

# A roadmap to net zero by 2050



# To reach net zero emissions, the energy sector must diversify

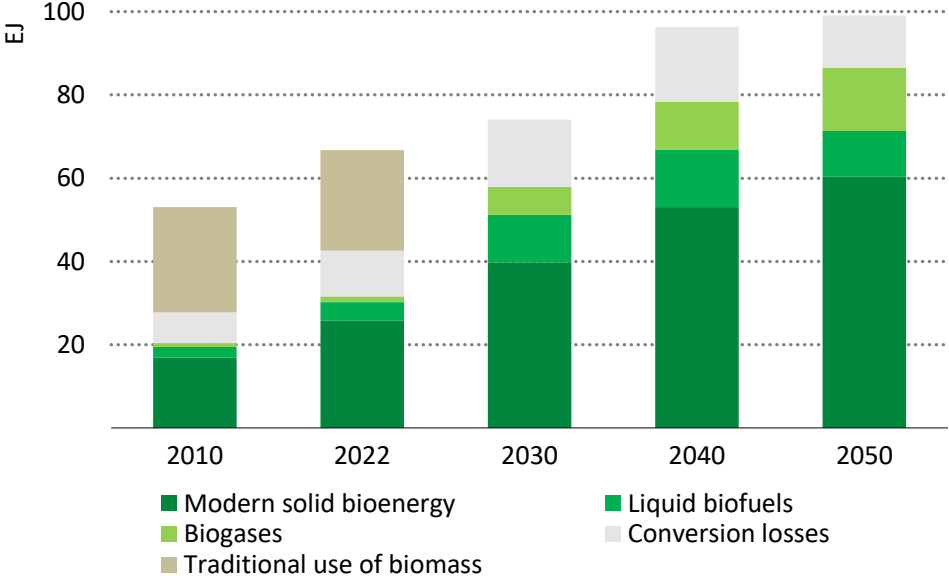
## Global net CO<sub>2</sub> emissions by sector, and total energy supply in the NZE



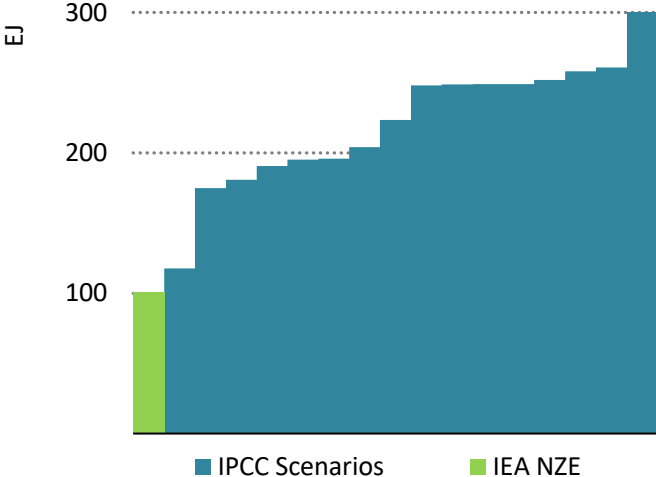
**Total demand for fossil fuels falls by more than one-quarter by 2030.**

# Bioenergy supply in the NZE is limited to 100 EJ

Bioenergy supply by source in the NZE Scenario, 2010-2050



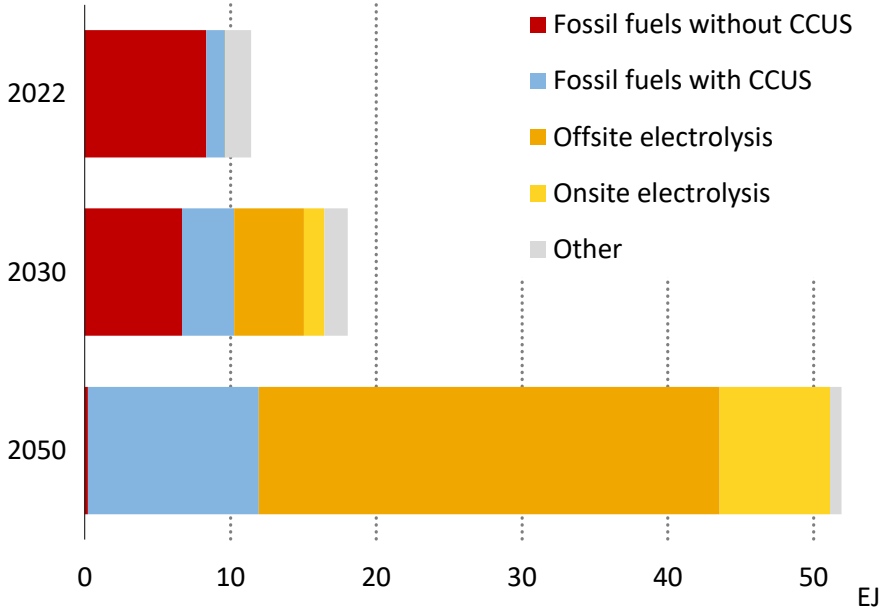
Comparison of bioenergy supply in selected IPCC scenarios and the IEA NZE Scenario in 2050



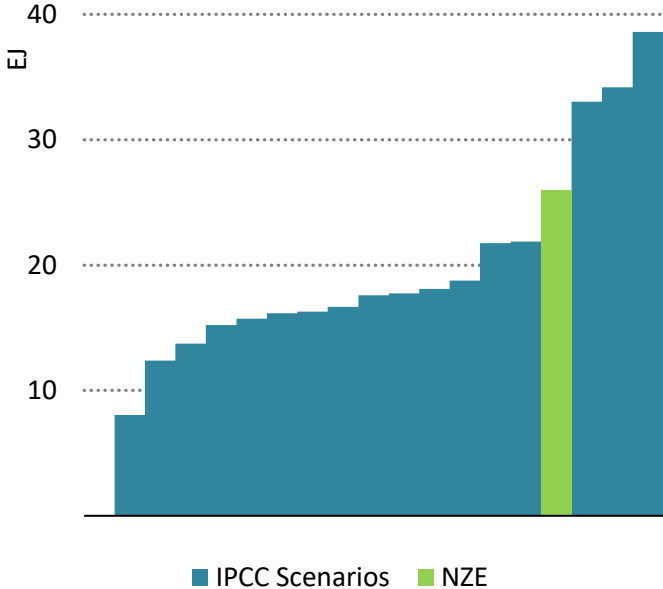
**The median IPCC scenario reaching net zero emissions by 2050 sees around 235 EJ of bioenergy demand, over twice the level in the NZE.**

# Low-emission hydrogen supply increases

Hydrogen supply by source in the NZE Scenario, 2022-2050



Comparison of hydrogen TFC in selected IPCC scenarios and the IEA NZE Scenario in 2050

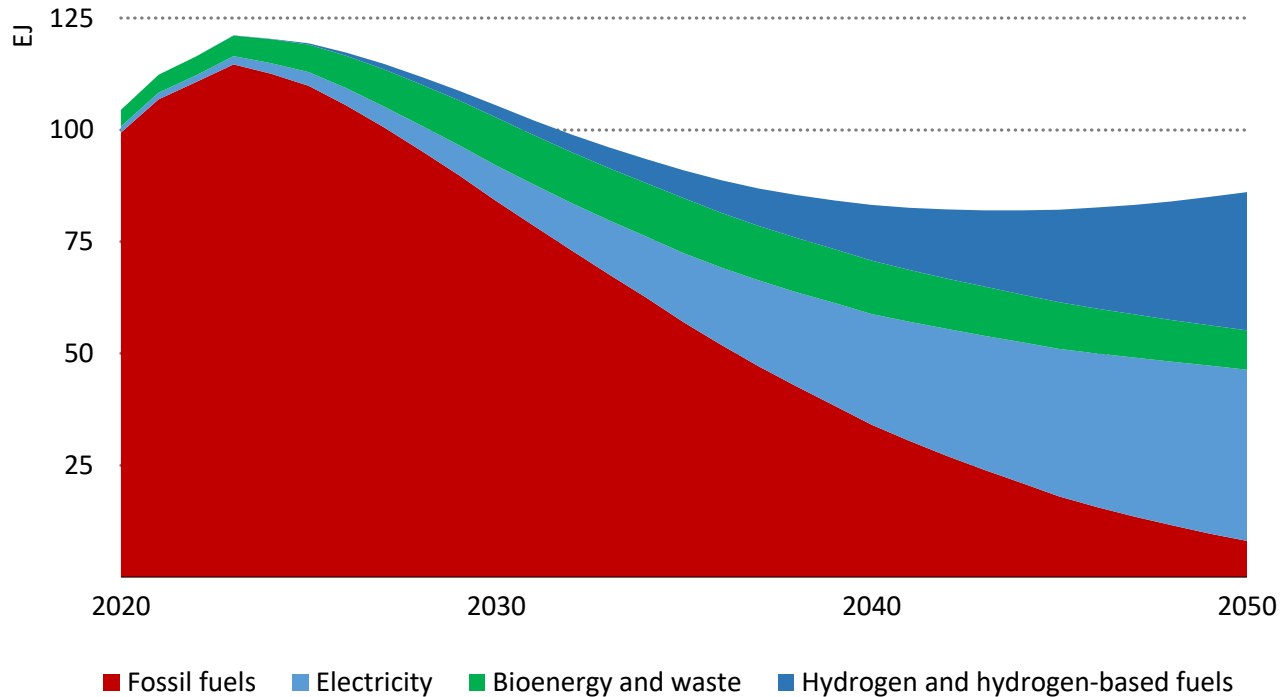


**The NZE Scenario sees total final consumption of 25 EJ of hydrogen and hydrogen-based fuels compared to 18 EJ in the median IPCC scenario.**



# Less than 10% of transport energy will come from fossil fuels in 2050

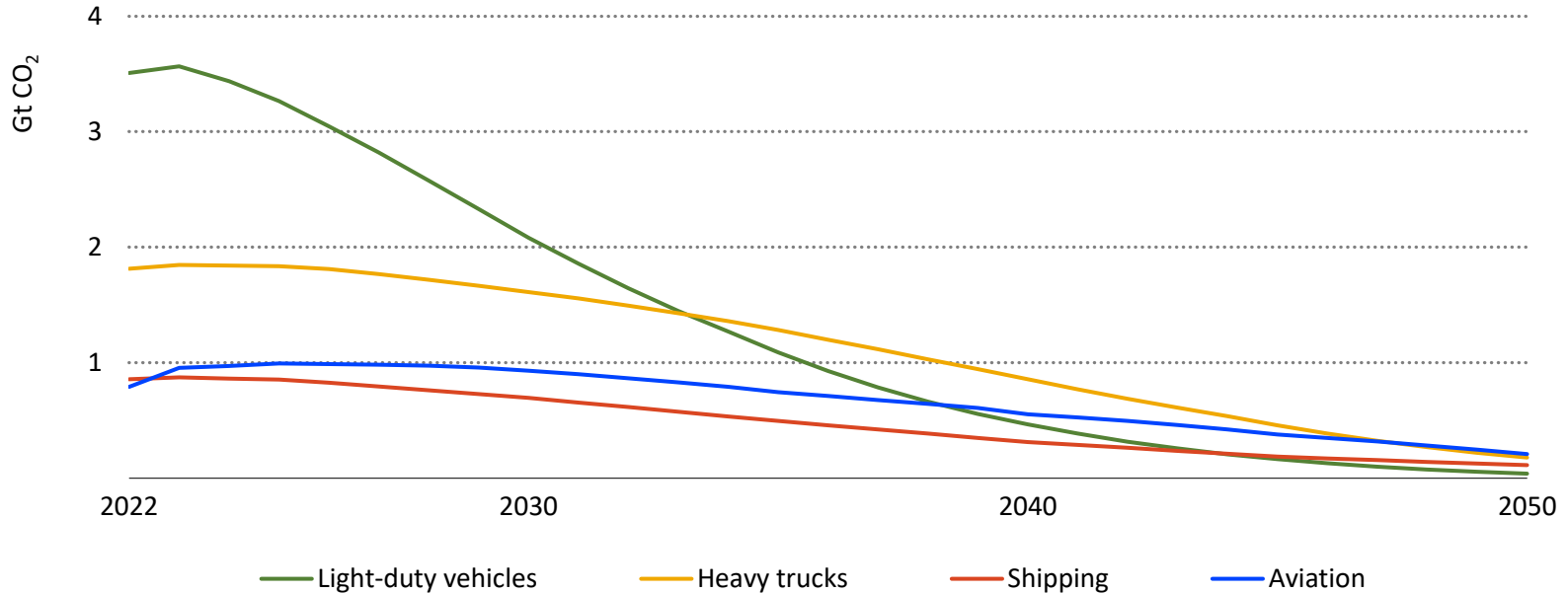
Global transport final consumption by fuel type in the NZE, 2020-50



**Biofuels and hydrogen-based fuels account for almost 50% of transport energy demand by 2050.**

# Transport modes do not decarbonise at the same rate

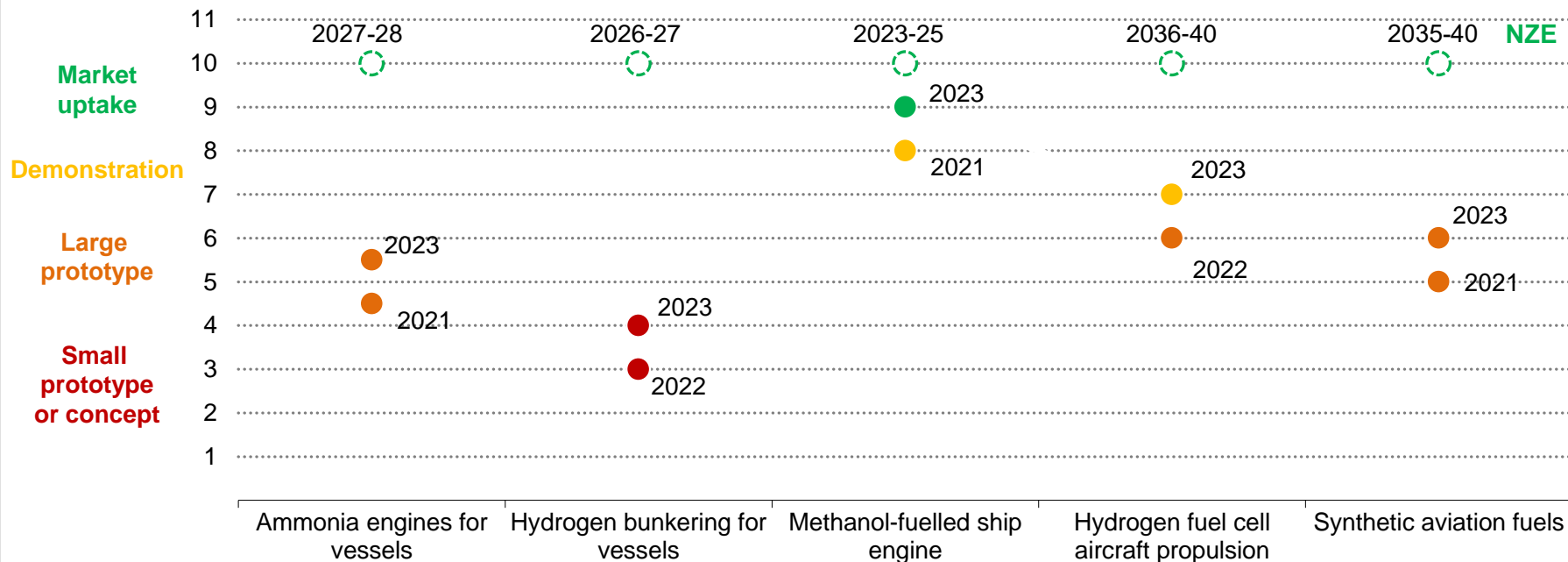
Global CO<sub>2</sub> transport emissions in the NZE, 2000-2050



**Passenger cars can make use of low-emissions technologies on the market, but major advances are needed for heavy trucks, shipping and aviation to reduce their emissions.**

# Technology innovation is critical for the Net Zero pathway

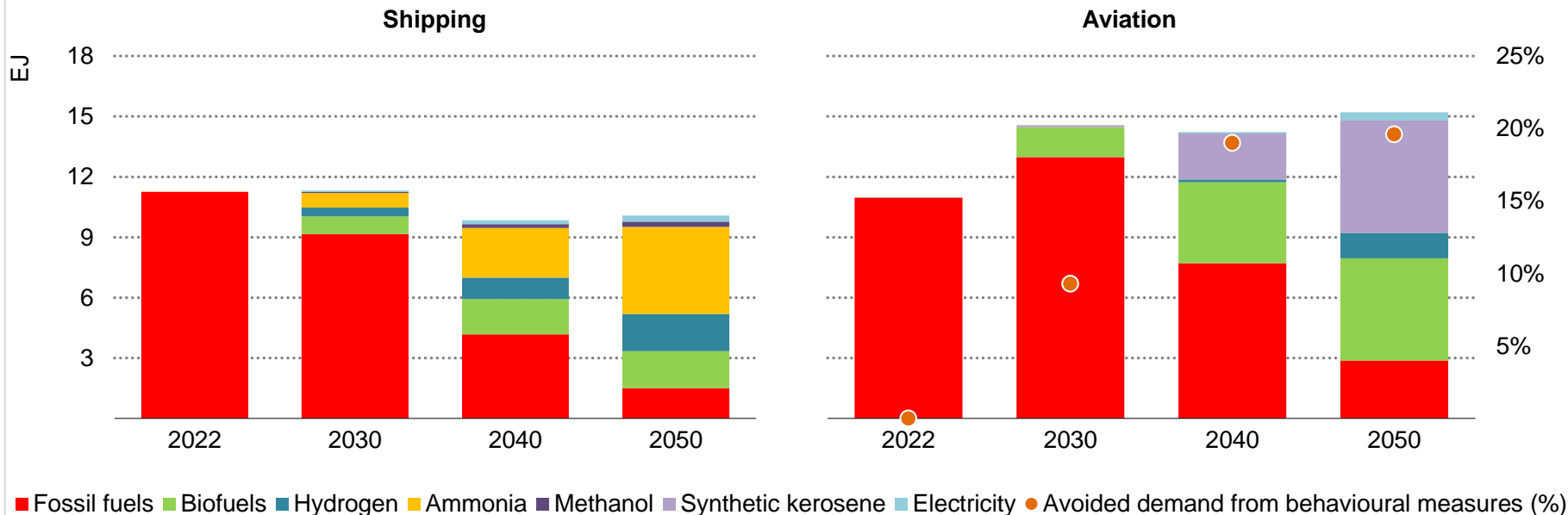
Technology readiness of key technologies for shipping and aviation



**Key technologies for shipping must be commercialised this decade to be in line with the NZE Scenario, while hydrogen-based fuels for aviation need to commercialise by 2040.**

# Hard-to-abate transport modes will require low-emission fuels

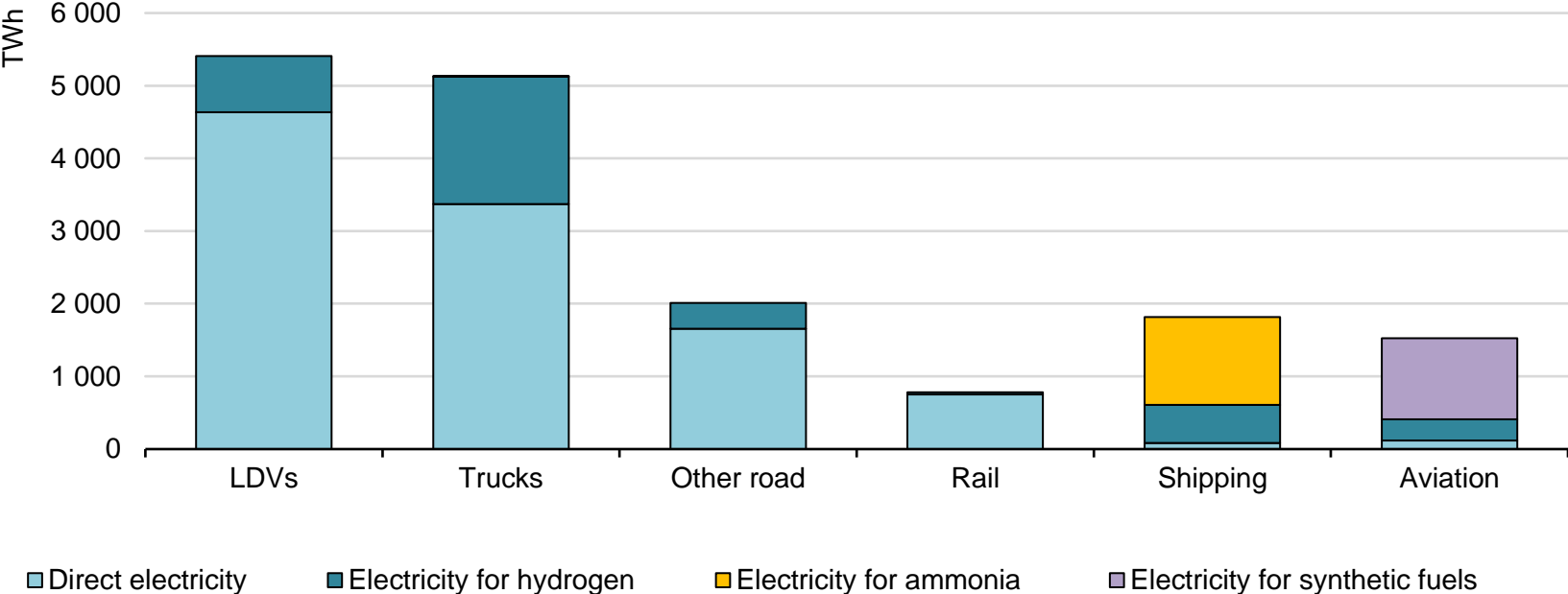
Energy consumption in shipping and aviation in the Net Zero by 2050 Scenario, 2022-2050



**Low-emission fuels ramp up from less than 1% of energy consumed today in shipping and aviation to almost 15% in 2030 and 80% in 2050 in the NZE Scenario.**

# Electricity will be needed for low-emission fuel production

Direct and indirect electricity demand by transport mode in the NZE, 2050



**Electricity demand for hydrogen-based fuels production increases total transport electricity demand by 6 000 TWh to reach a total of almost 17 000 TWh.**

**Session 1**

**Low-emission fuel supply and infrastructure**

**Session 2**

**Demand for low-emission fuels in long distance transport**

**Session 3**

**Policies to creating a market for low-emission fuels**

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