



# The Role of Low-Carbon Fuels in Clean Energy Transitions of the Power Sector

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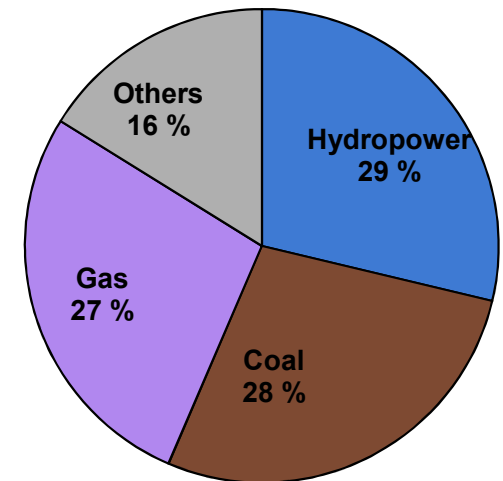
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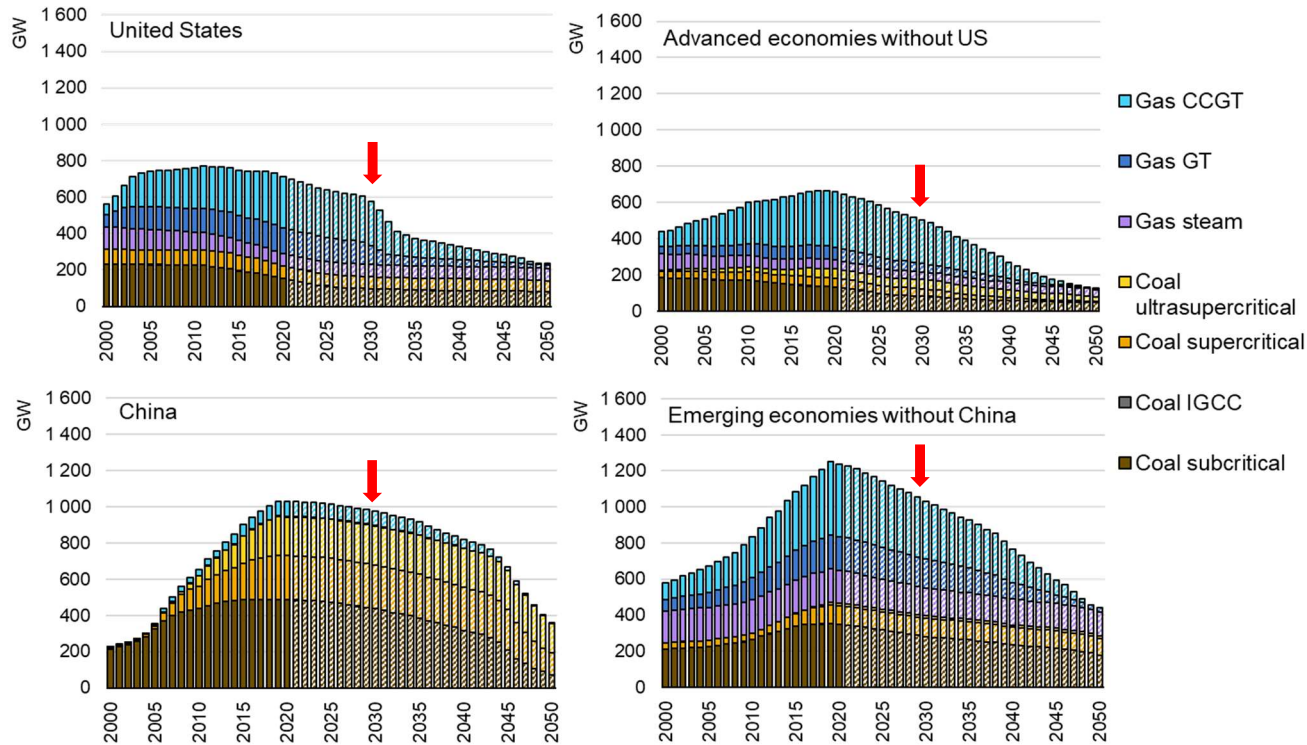
- Governments around the world are faced with the challenge of ensuring electricity security and meeting growing electricity uses while simultaneously cutting emissions.
- Massive deployment of solar PV and wind requires a significant expansion of all flexible resources, including low-carbon dispatchable power plants, energy storage, demand response & grids.
- Thermal generation from fossil fuels currently provides key flexibility services that contribute to security of electricity supply.
- Using low-carbon hydrogen and ammonia in fossil fuel power plants is an additional tool for decarbonising the power sector, while simultaneously maintaining flexibility services of existing fleets.

Global dispatchable capacity by fuel, 2019



# Fossil fleets have technical lifetimes that extend well into the future

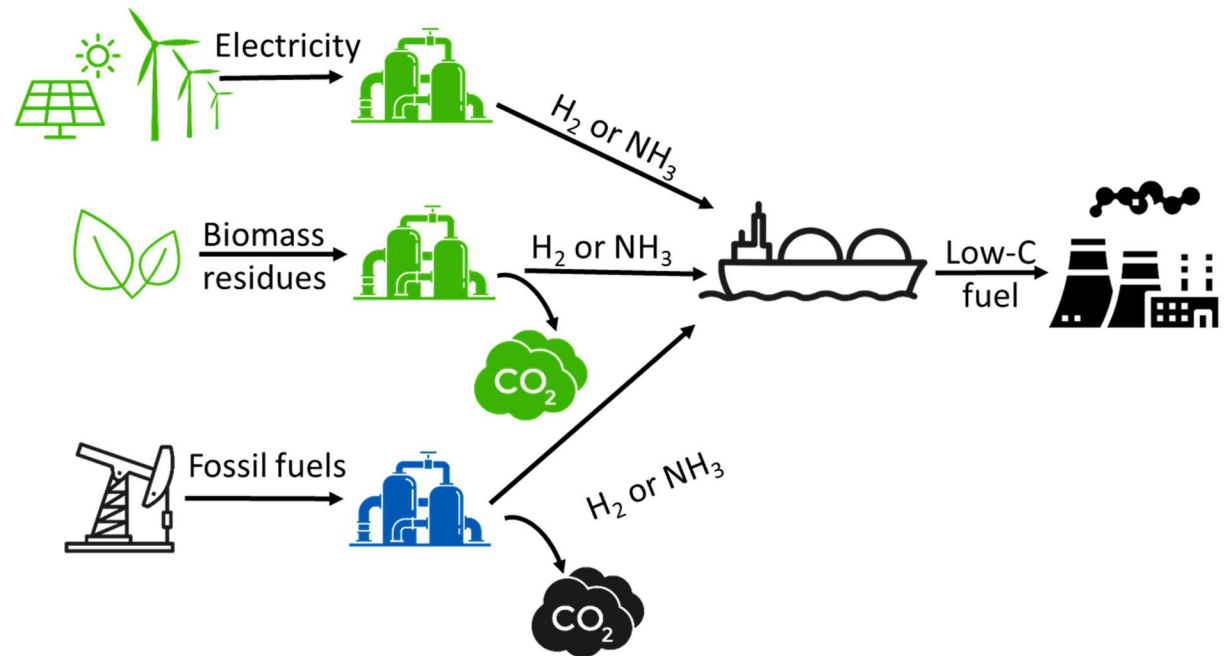
Cumulative capacity by 2019 and expected retirement of the existing fleet by 2050 based on technical lifetime (GW)



**Fossil fuel based generation was responsible for 13.7 Gt of CO<sub>2</sub> emissions in 2019 globally.  
This generation must be decarbonized to be on track to achieve long-term climate targets**

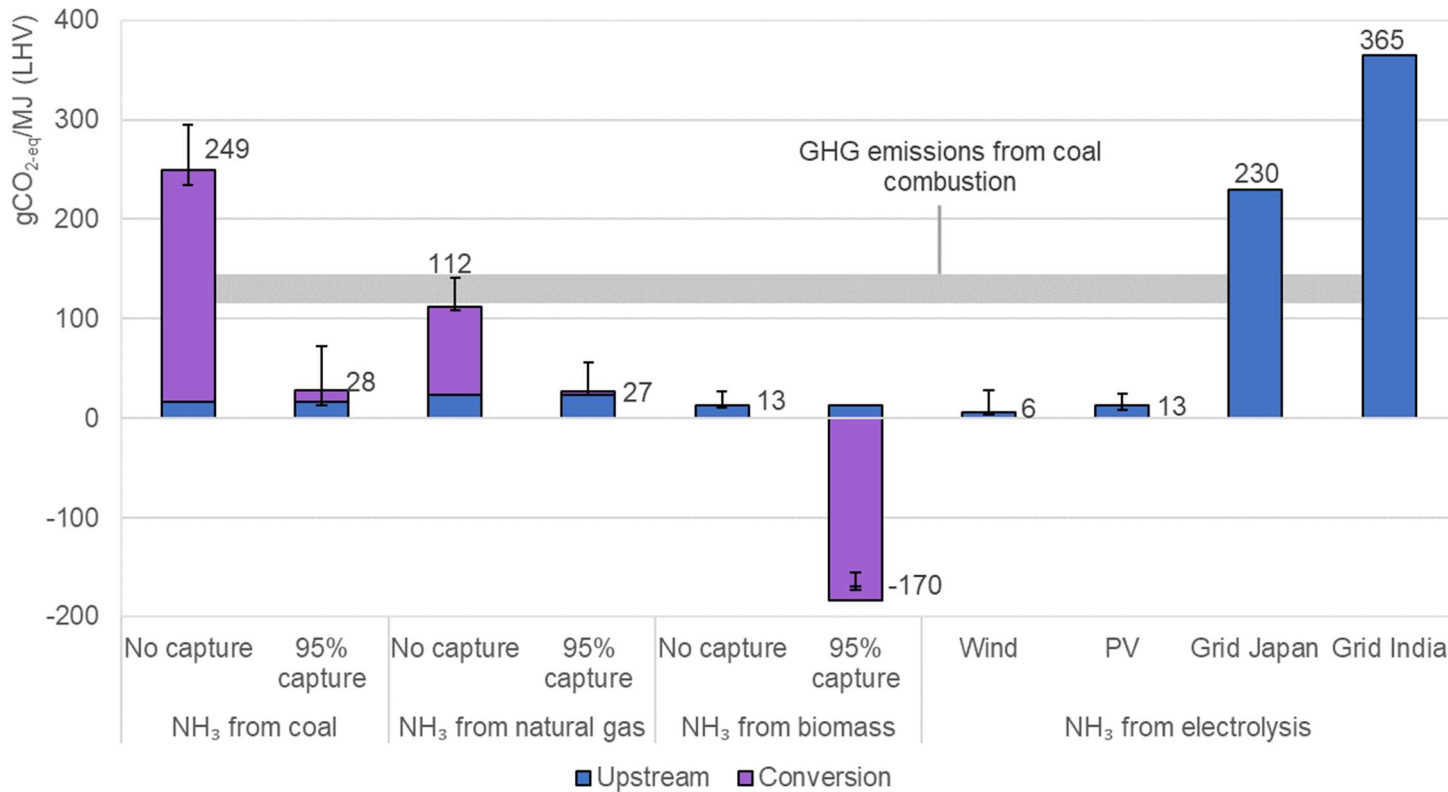
# Low-C fuels can decarbonise existing fossil generation

- Three major options for decarbonising fossil fuel electricity generation
  - Early retirement / reduced operation
  - CCUS retrofit to power plants
  - **Co-firing with low-carbon fuels**
- Technology is progressing rapidly
  - Small gas turbines already operating at >90% share of hydrogen
  - 20% co-firing with coal tested with ammonia at pilot scale
  - Large-scale projects with higher co-firing rates are under development



# Using low-C fuels can lead to significant reduction in GHG emissions

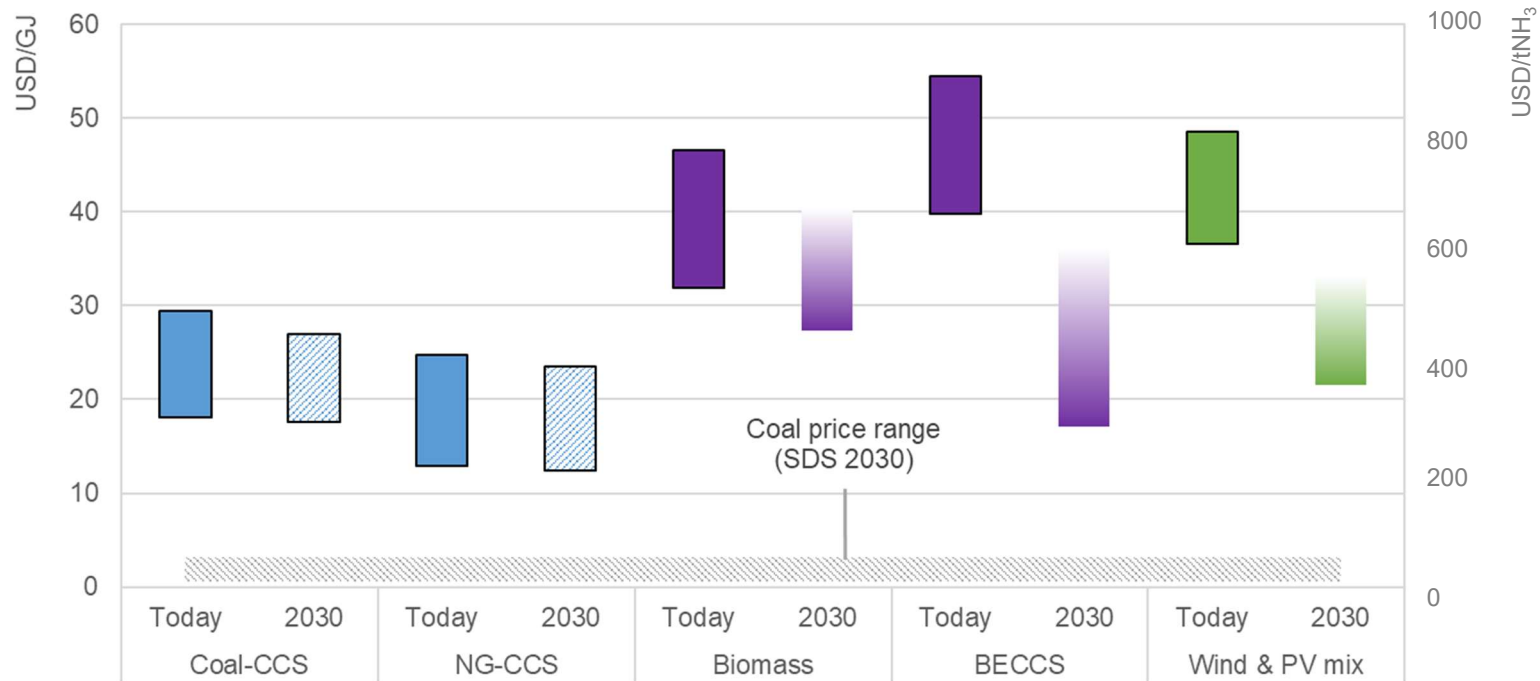
Indicative life-cycle GHG emissions of coal and ammonia for different production routes



**International standards are required to ensure that use of low carbon fuels lead to global emission cuts.**

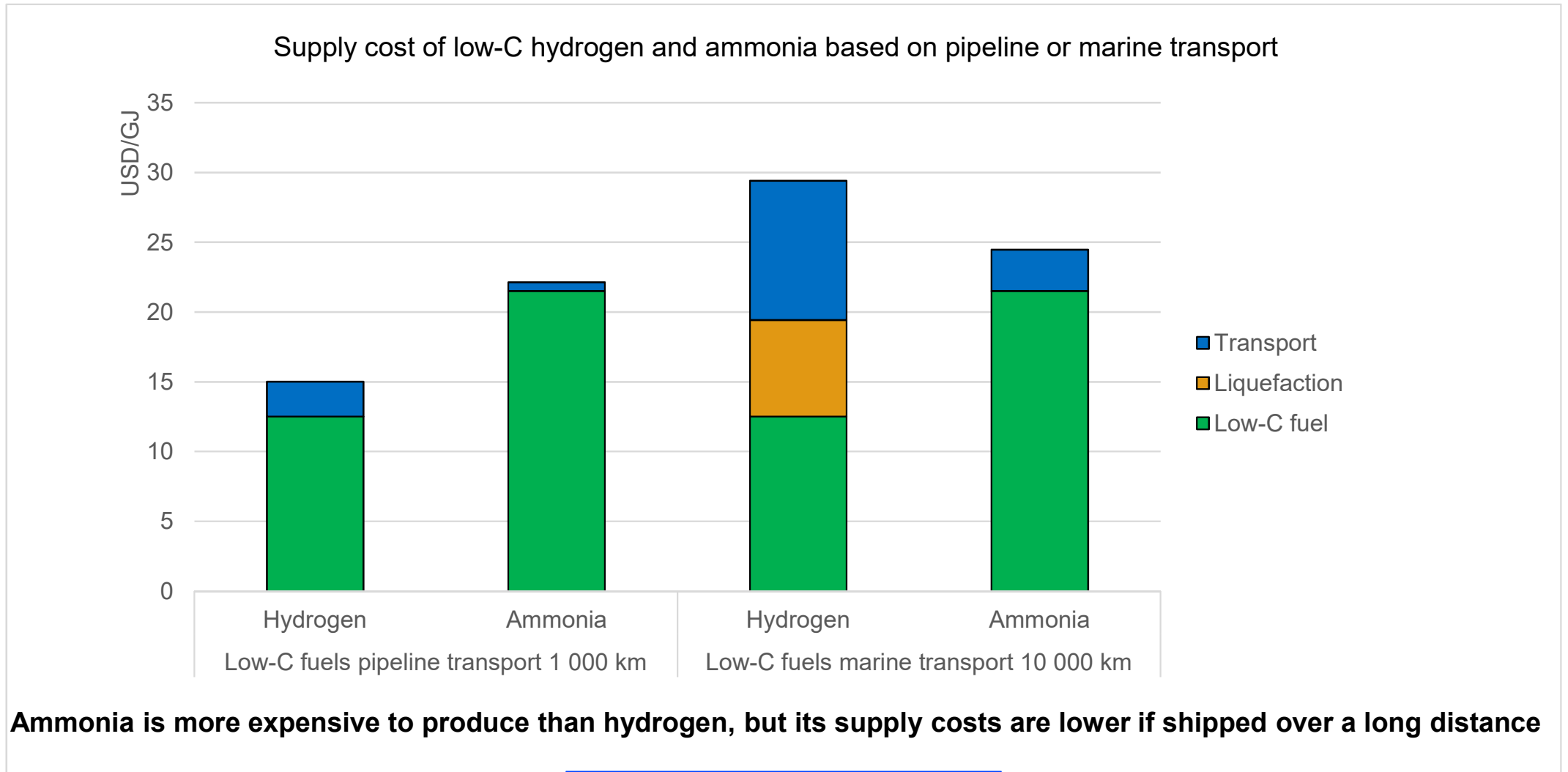
# Production costs of low-carbon fuels must decrease further

Indicative production costs for low-carbon ammonia for today and 2030



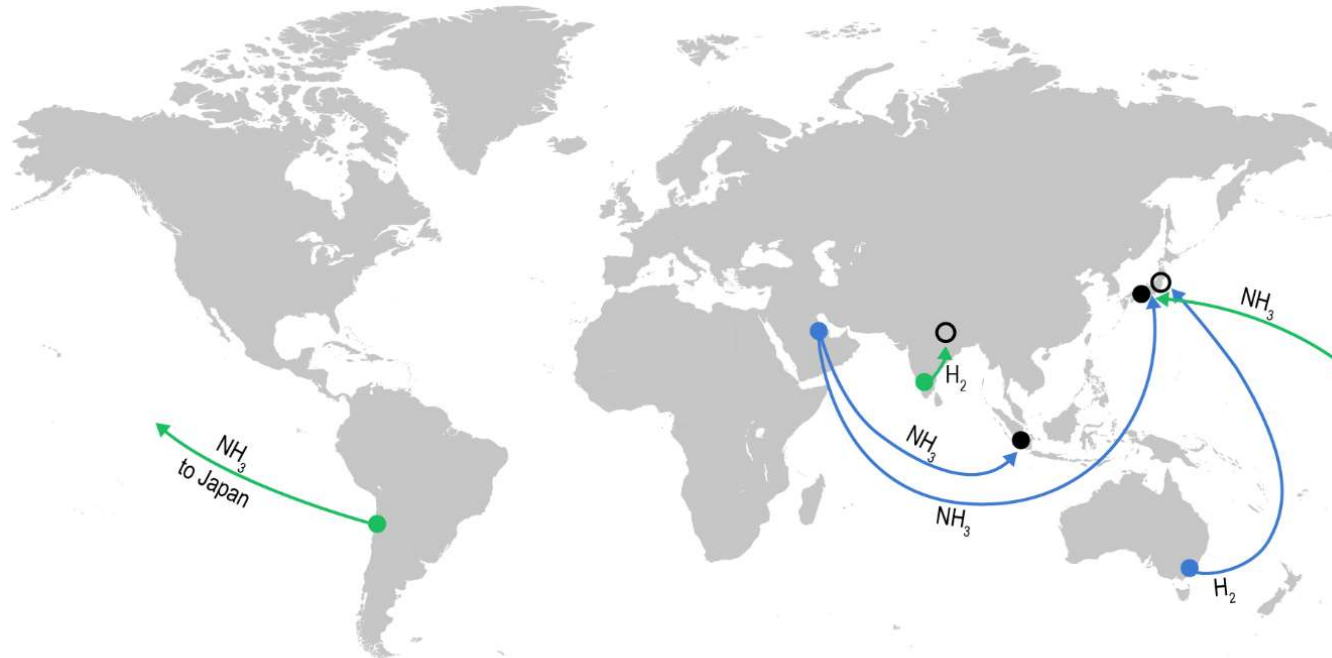
**Low-carbon fuel ammonia is expected to be significantly more expensive than coal in 2030 in the SDS. Production costs in 2030 are within commodity price ranges (USD 160-700/t) in recent years**

# Transport is a key component of total supply cost of low-carbon fuels



# Detailed analysis of selected low-carbon fuel supply chains

Analysed supply chains for the production and use of low-C fuels in thermal power plants



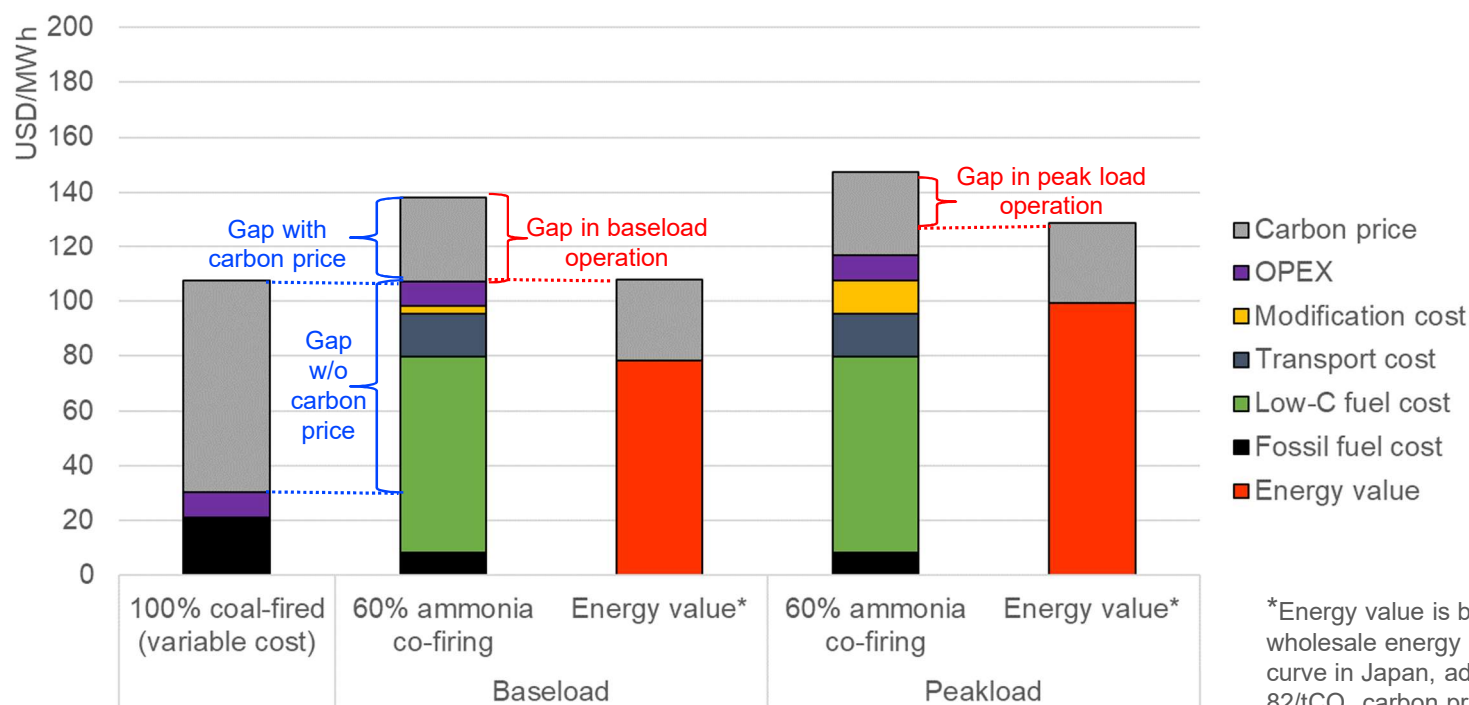
Production sites	Use sites	Examined value chains
● Wind/PV mix	● Coal power plant	→
● Fossil with CCUS	○ NGCC power plant	

**Examined cases: Importing low-carbon fuels to an advanced economy (Japan);  
Importing low-carbon ammonia to an emerging economy (Indonesia);  
Using domestically produced low-carbon hydrogen in an emerging economy (India).**



# Japan: Cost increase is moderated by carbon price and energy market

Energy market value and LCOE of low-carbon ammonia co-firing for Japan in the SDS 2030

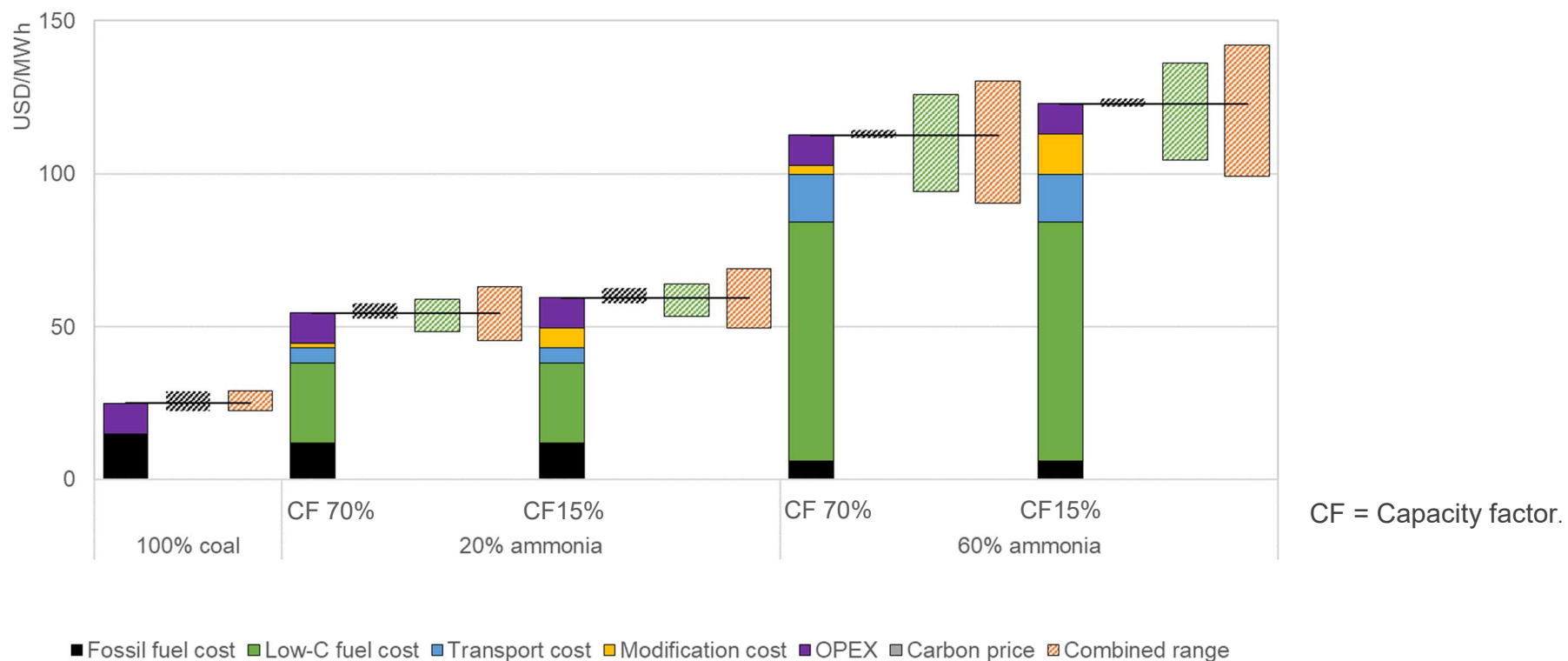


\*Energy value is based on 2019 wholesale energy price duration curve in Japan, adjusted with USD 82/tCO<sub>2</sub> carbon price for advanced economies in the SDS in 2030.

**In an efficient wholesale electricity market, co-firing of low-carbon ammonia can have a better business case for peak load than baseload operation. The capacity market can offer an additional source of revenue**

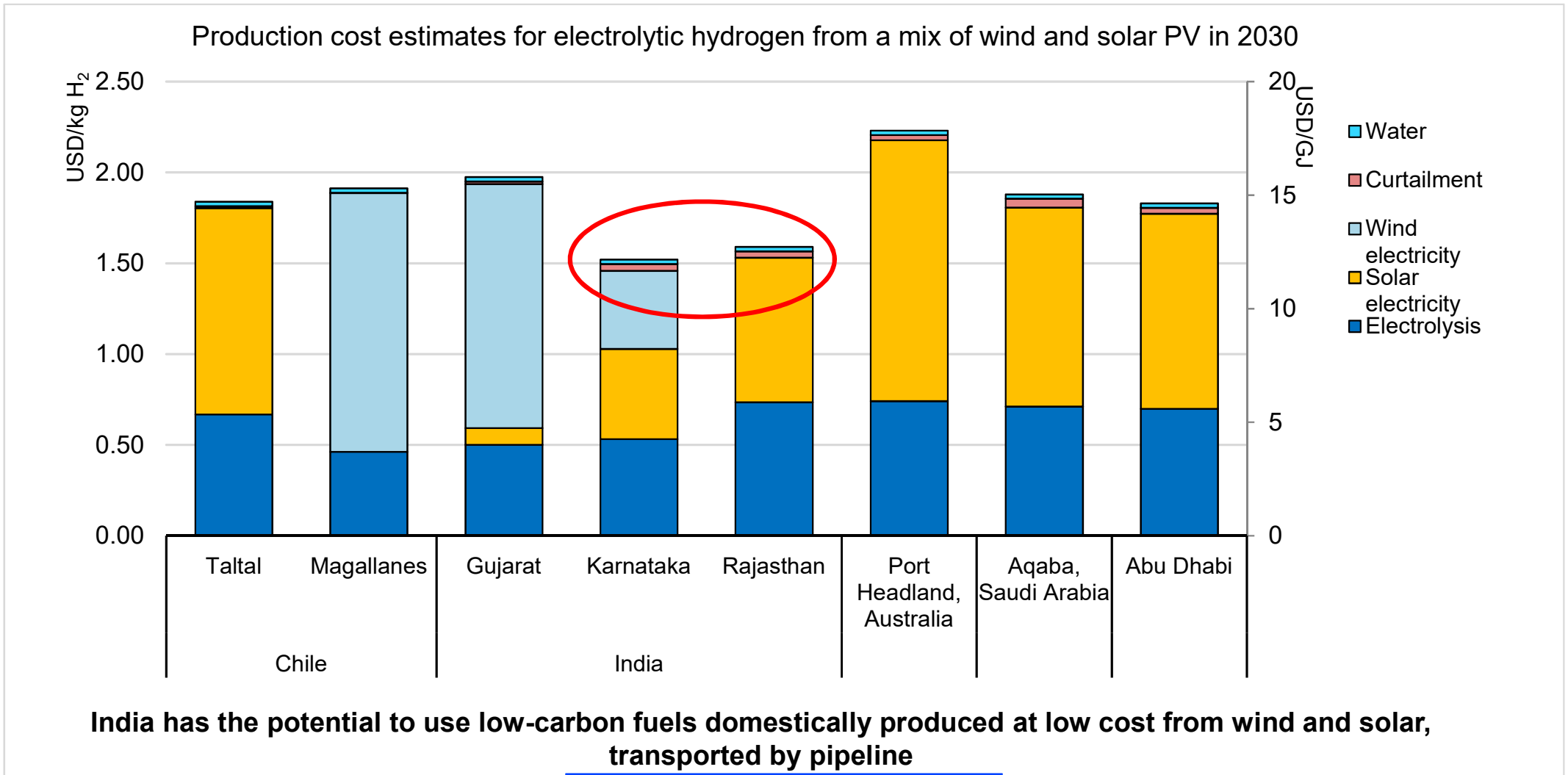
# Indonesia: Co-firing of low-carbon fuels remains an expensive option in 2030

LCOEs in 2030 for an existing coal power plant in Indonesia  
co-firing imported low-carbon ammonia from Saudi Arabia under different shares and operating regimes



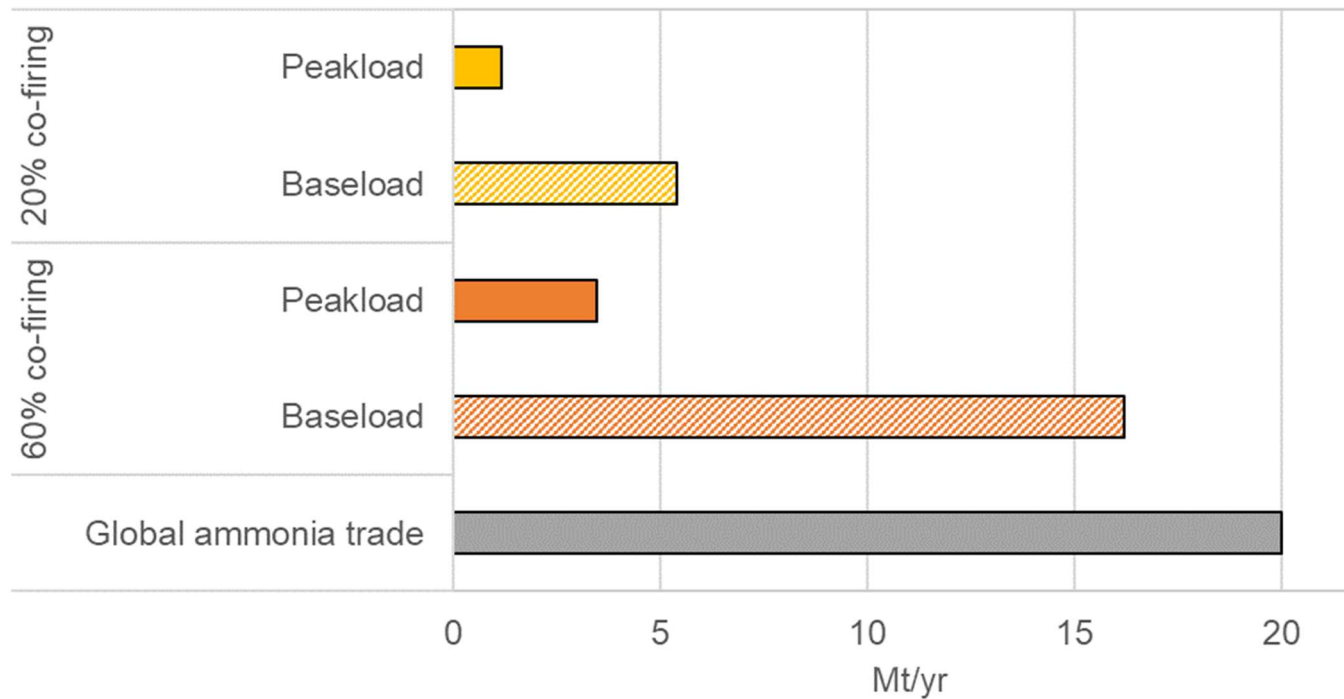
**Co-firing with low-carbon fuels is a possible long-term option for emerging economies in Southeast Asia, after having mobilised other flexibility resources like grids and interconnections, storage and demand response**

# India has excellent renewable resources to produce low-carbon fuels



# Major expansion of supply infrastructure is needed

Demand for low-carbon ammonia for different co-firing modes in a 10 GW<sub>e</sub> coal fleet.



**Co-firing 60% of ammonia in a coal fleet of just 10 GW<sub>e</sub> would also require massive expansion of the current electrolyser and CO<sub>2</sub> storage capacities.**

# Conclusions

- Using low-carbon hydrogen and ammonia in fossil fuel power plants can play an important role to help ensure electricity security in clean energy transitions. Their value depends on system contexts and regional conditions
- Low-carbon fuels have an especially important potential in countries or regions where the thermal fleet is young, or when the availability of other low-carbon dispatchable resources is constrained, such as in East and Southeast Asia
- Diverse supply routes for low-carbon fuels can enhance security of supply and cost predictability
- International rules and standards are necessary to achieve measurable life-cycle emission reductions
- A portfolio of policies is required to reduce production costs and improve system value of low carbon fuels in the power sector
- Developing markets for low-carbon fuels and their supply chains by 2030 will establish significant opportunities in many countries and sectors of the economy