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Innovation Outlook
Renewable Ammonia

IRENA
International Renewable Energy Agency
in partnership with
AMMONIA ENERGY ASSOCIATION

Presenters:
- Gabriel Castellanos, Shipping Decarbonisation - IRENA
- Kevin Rouwenhorst, Technology Manager – Ammonia Energy Association (AEA)

TUESDAY, 05 JULY 2022 •

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SPEAKERS

Gabriel Castellanos
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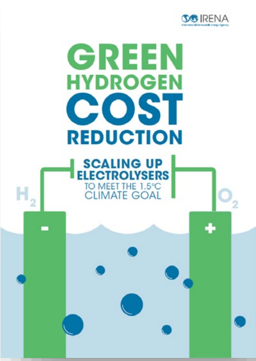
Gabriel Castellanos

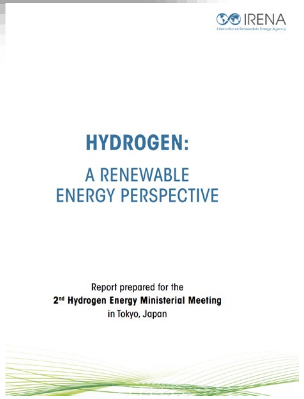
Shipping Decarbonisation - Innovation and Technology Centre, IRENA

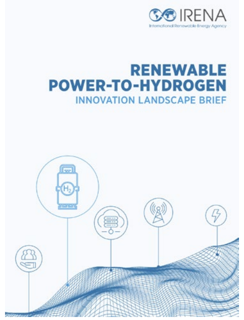
IRENA's comprehensive framework to scale up green hydrogen and its derivatives

Supply

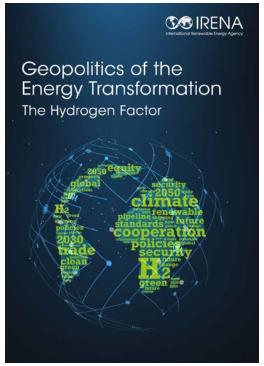


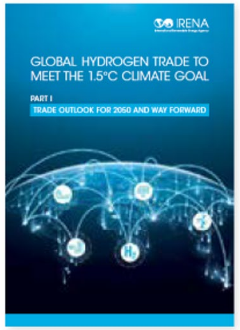
Sector coupling

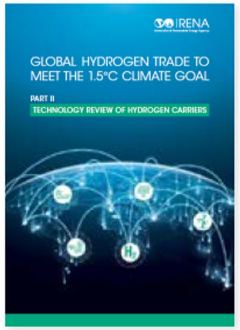


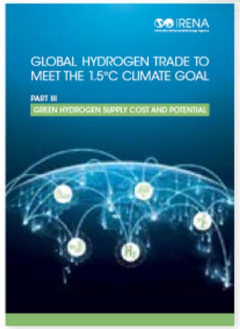


Trade

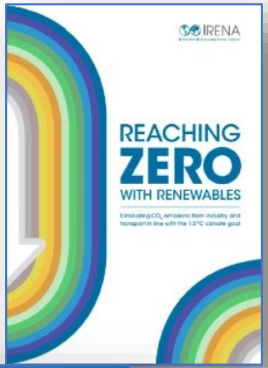


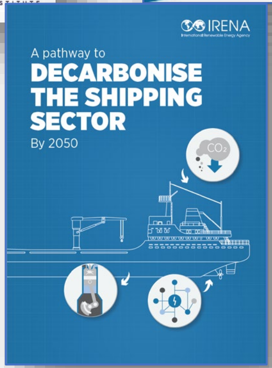




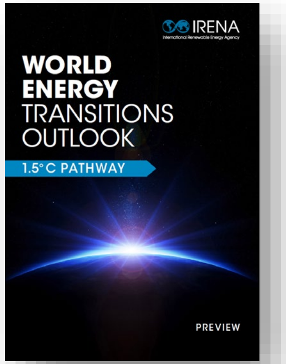


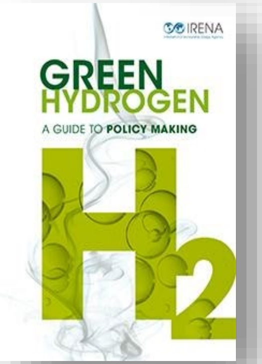
Demand





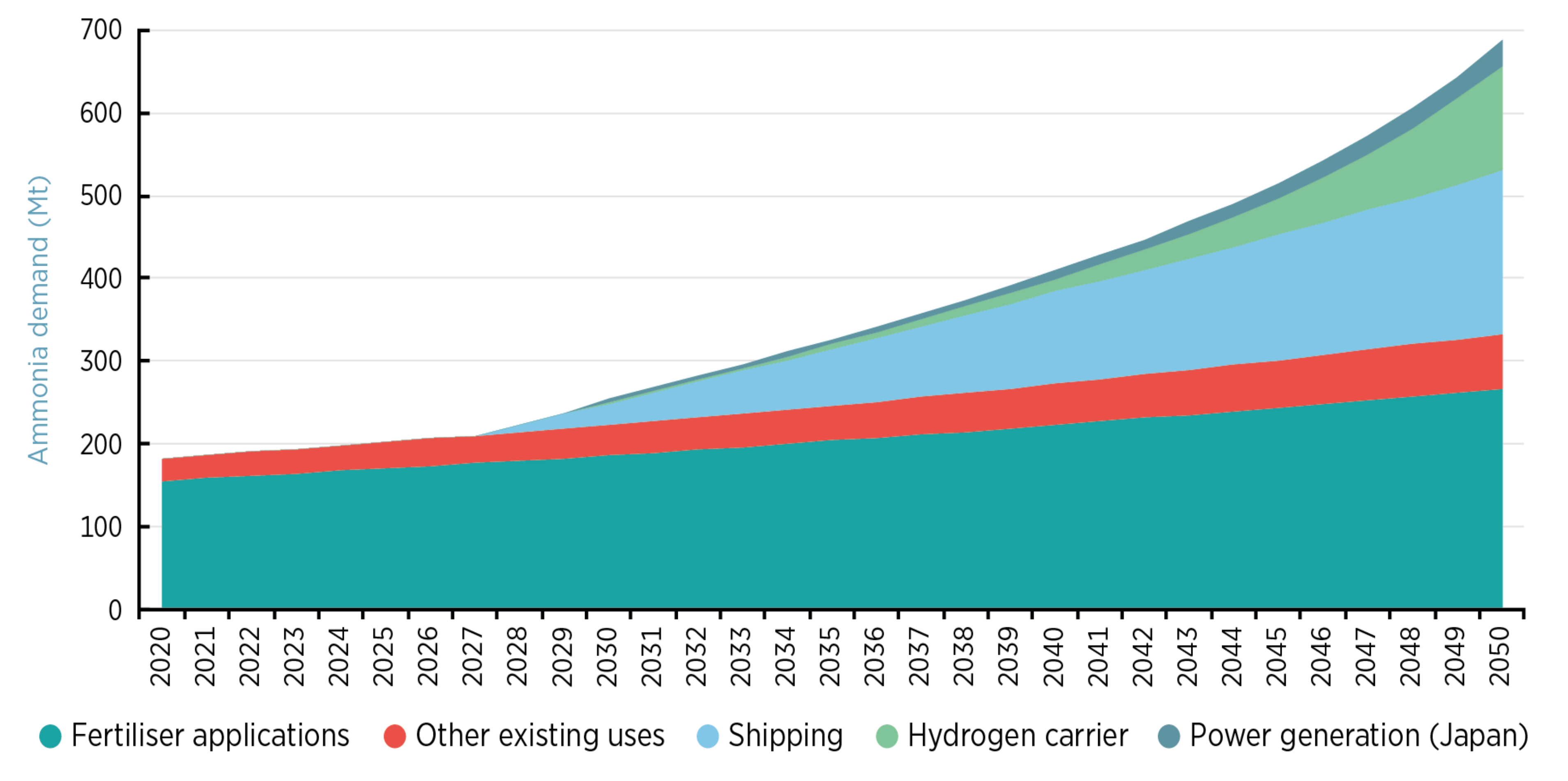
Cross cutting & Enabling Framework





Ammonia market status and prospects – demand side

Expected ammonia demand up to 2050 for the 1.5°C scenario



- Green ammonia to replace current ammonia demand
- Future possible green ammonia applications as shipping fuel, hydrogen carrier and power generation

For a Net-Zero future most ammonia must be renewable – supply side

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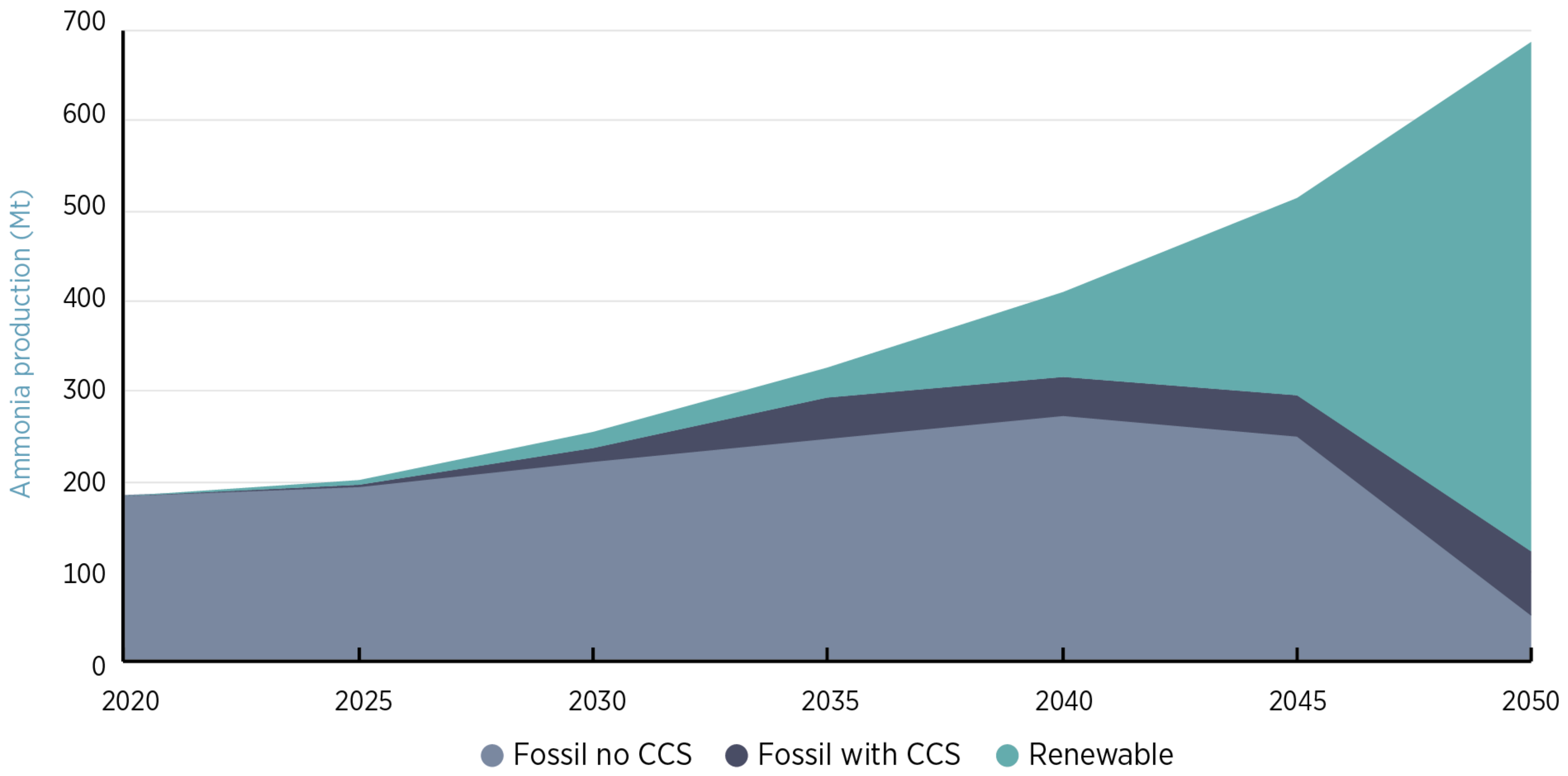
- Sector coupling requires attention
- Implications on additional renewable electricity generation capacity

Expected ammonia production capacity up to 2050 for the 1.5°C scenario.



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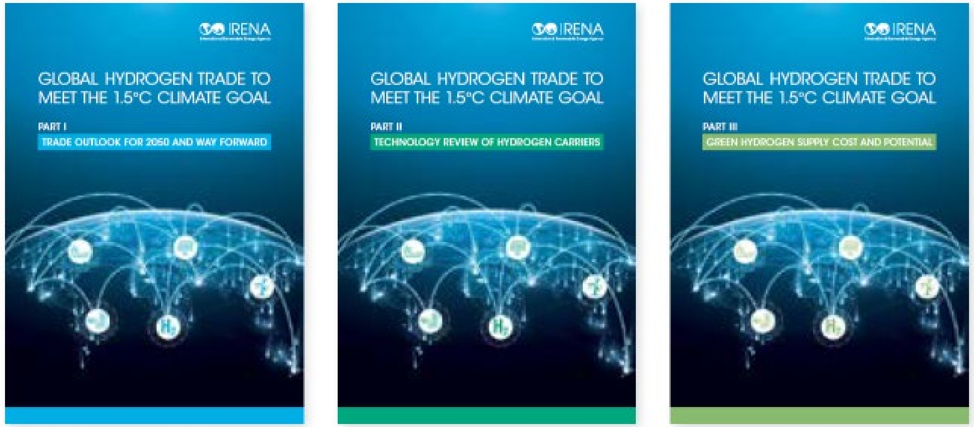
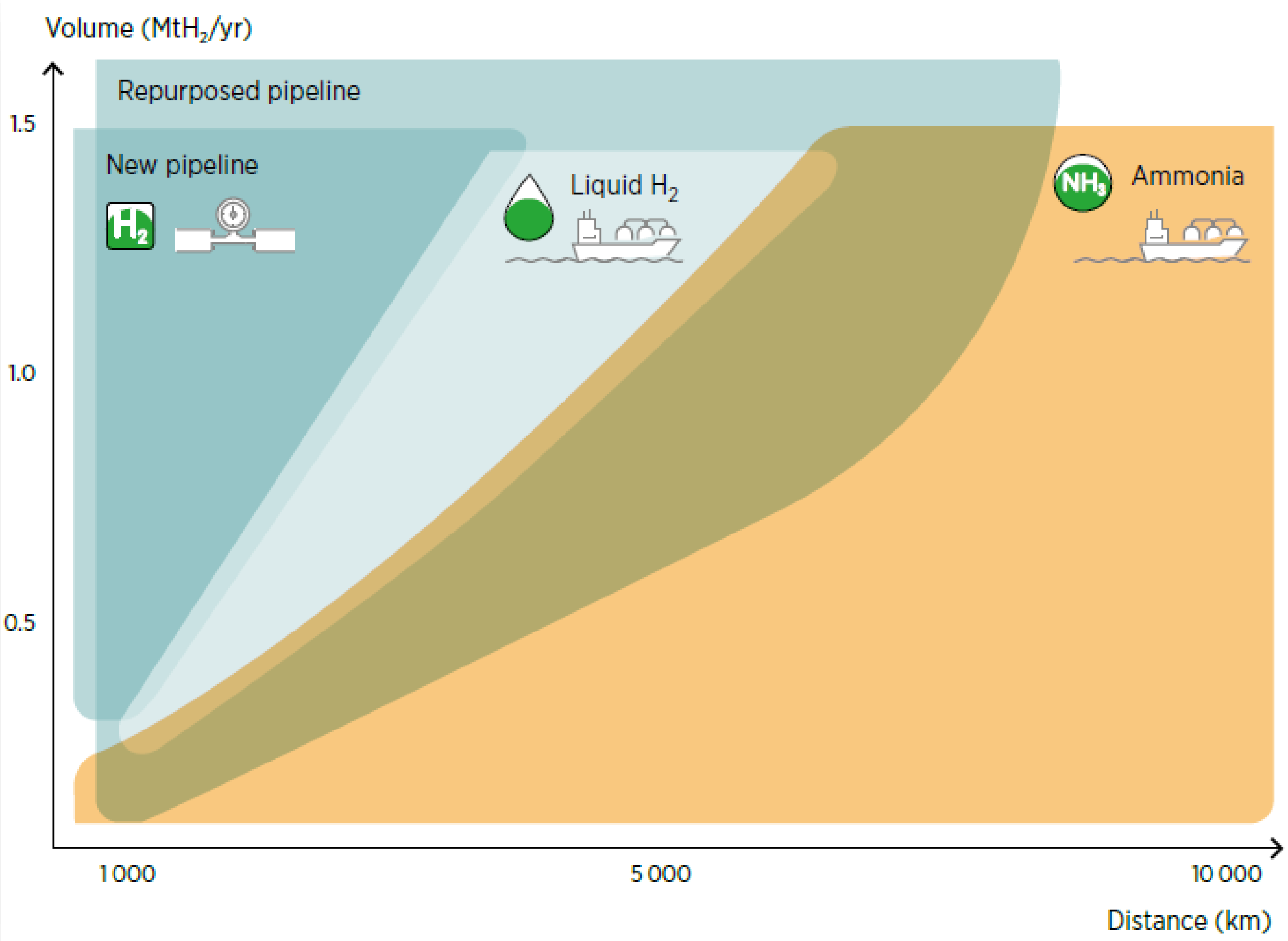
Ammonia is emerging a key part of a future global hydrogen trade flow

- Half of H_2 trade in the form of ammonia shipping

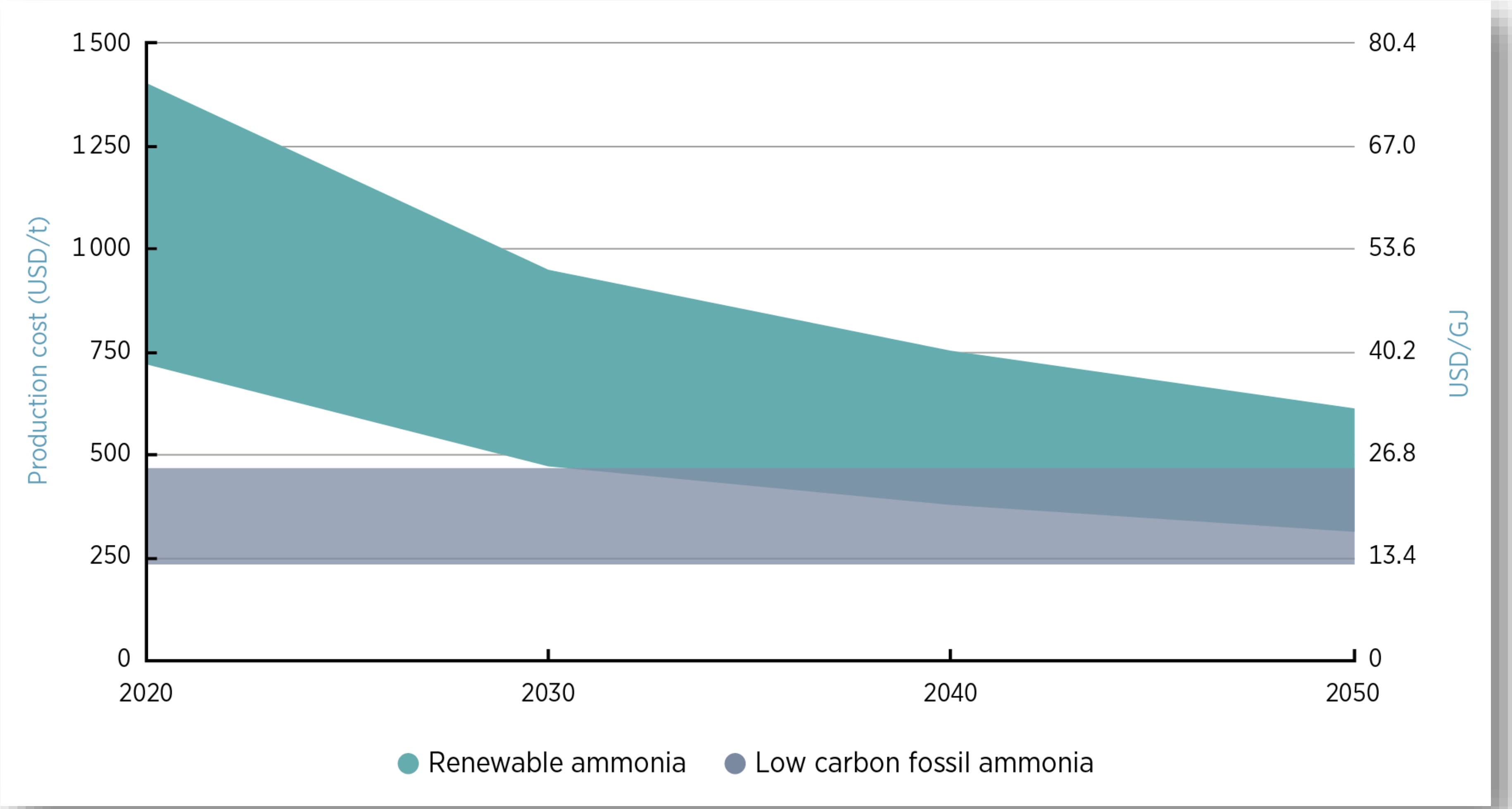


- Part I: Trade outlook for 2050 and way forward
- Part II: Technology review of hydrogen carriers
- Part III: Green hydrogen supply cost and potential



Production Costs - By 2050 costs expected to fall to USD 310-610/t

Current and future production costs of renewable ammonia



- Green ammonia already competitive in Europe versus Natural Gas ammonia

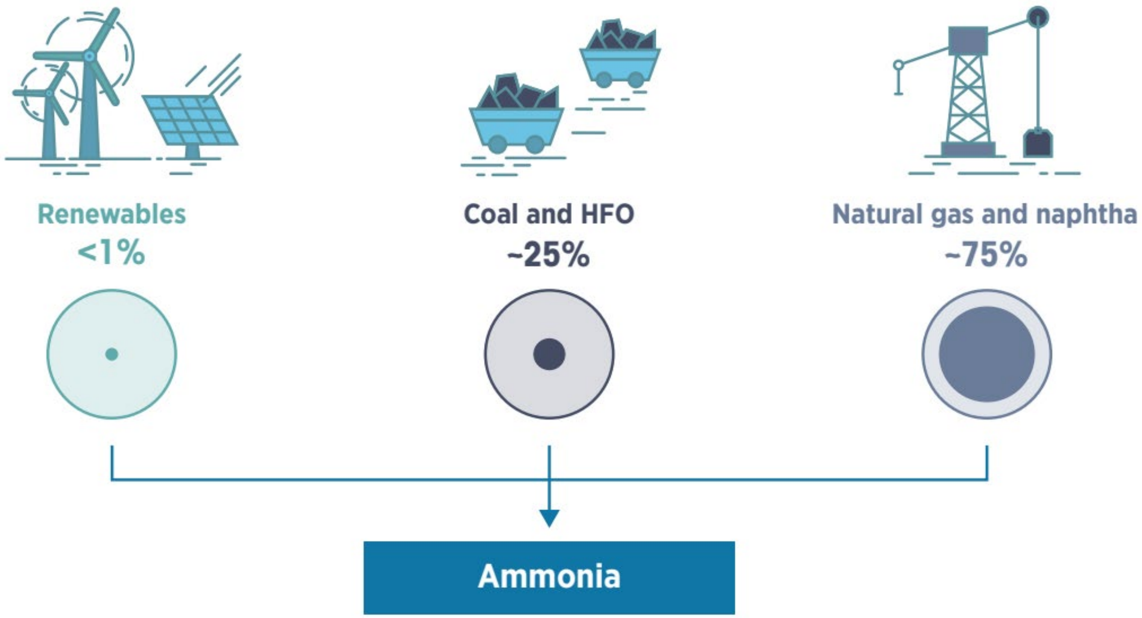
Note: Compared with production cost range for low-carbon fossil ammonia (USD 2-10/GJ)

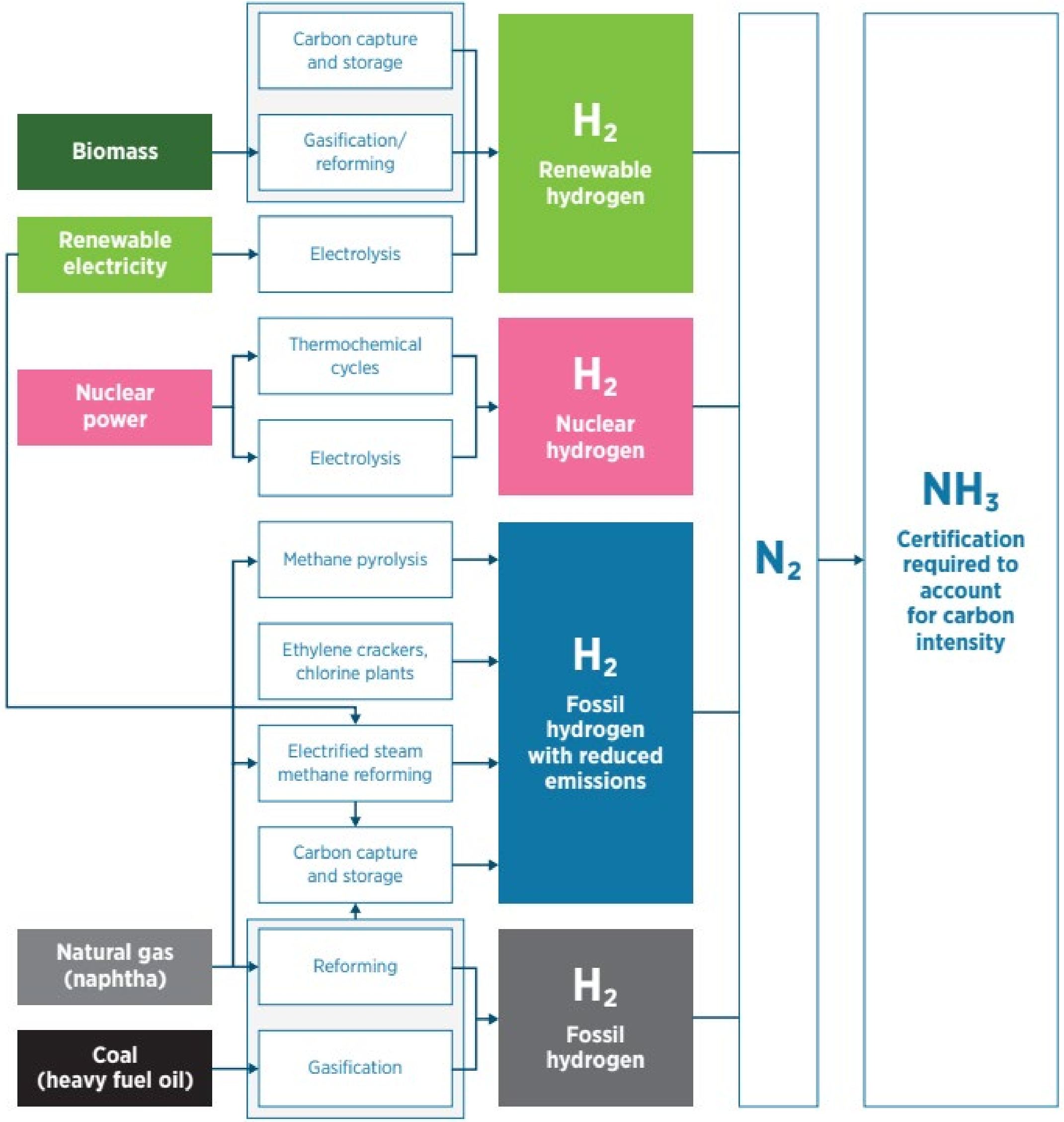
Kevin Rouwenhorst

Technology Manager – Ammonia Energy Association

Ammonia production pathways

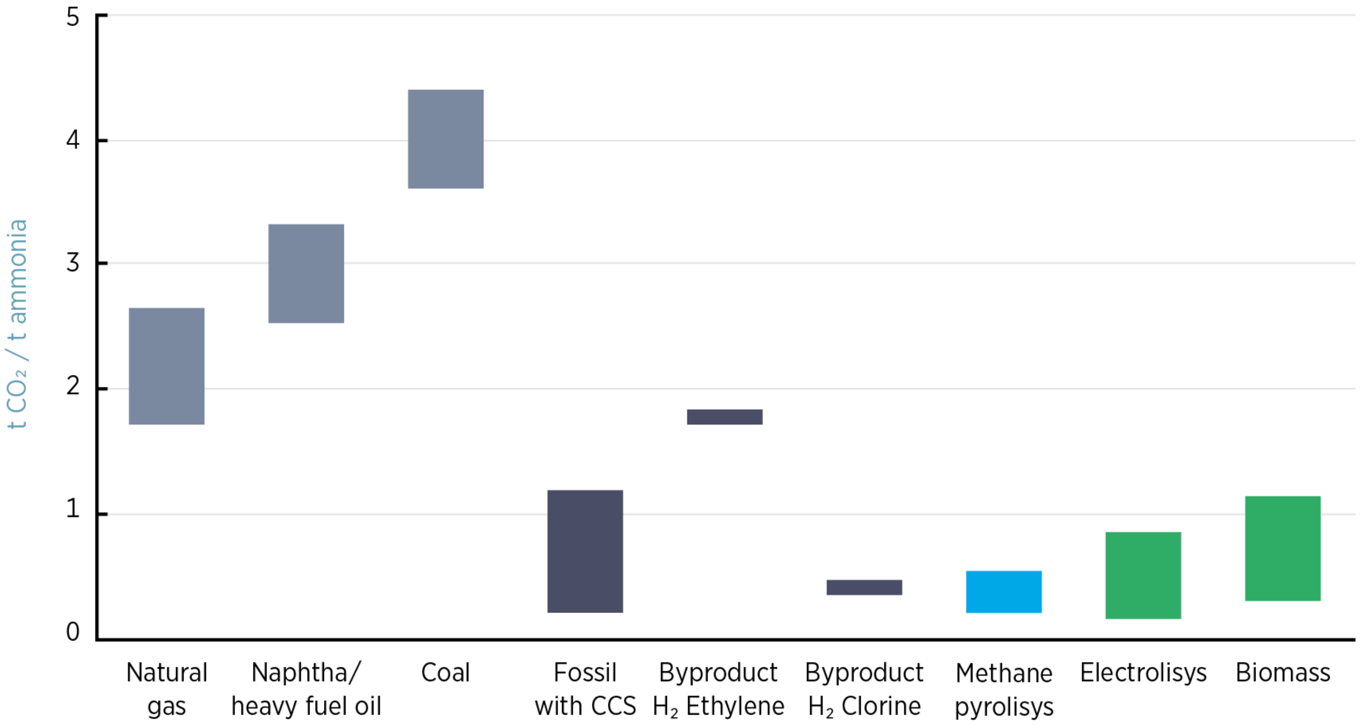
- Ammonia (NH_3) produced from hydrogen (H_2) and nitrogen (N_2) in Haber-Bosch process
- Hydrogen production typically accounts for >90% of total energy consumption of ammonia production, currently mainly fossil-based
- Ammonia production currently generates about 0.5 Gt CO_2 equivalent annually (around 1% of global GHG emissions)





Performance and sustainability - Guarantees of origin are needed for defining ammonia based on its carbon intensity

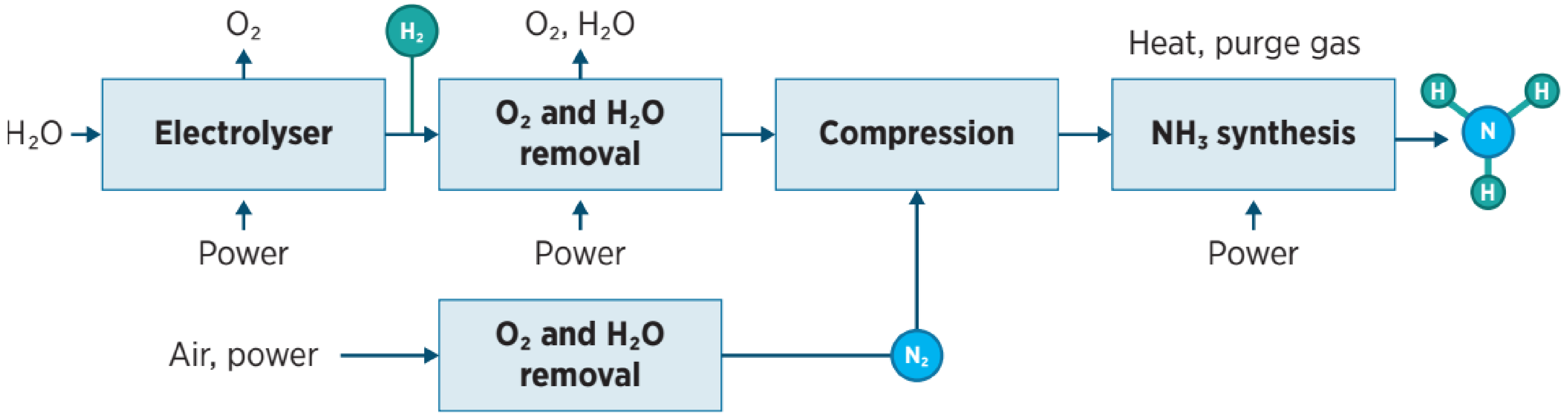
- CO_2 emissions from fossil-based ammonia production vary depending on the feedstock, i.e. **1.6 – 4 t CO2 per ton ammonia.**
- Additional GHG emissions occur upstream, with embedded emissions and fugitive methane, and downstream, during storage, transport, and distribution.
- Beyond GHG emissions, other sustainability criteria should be considered, including availability of water and land, scarcity of certain metals, and impacts on the global nitrogen cycle.



GHG emissions of ammonia production from various feedstocks

Renewable ammonia production: electrolysis

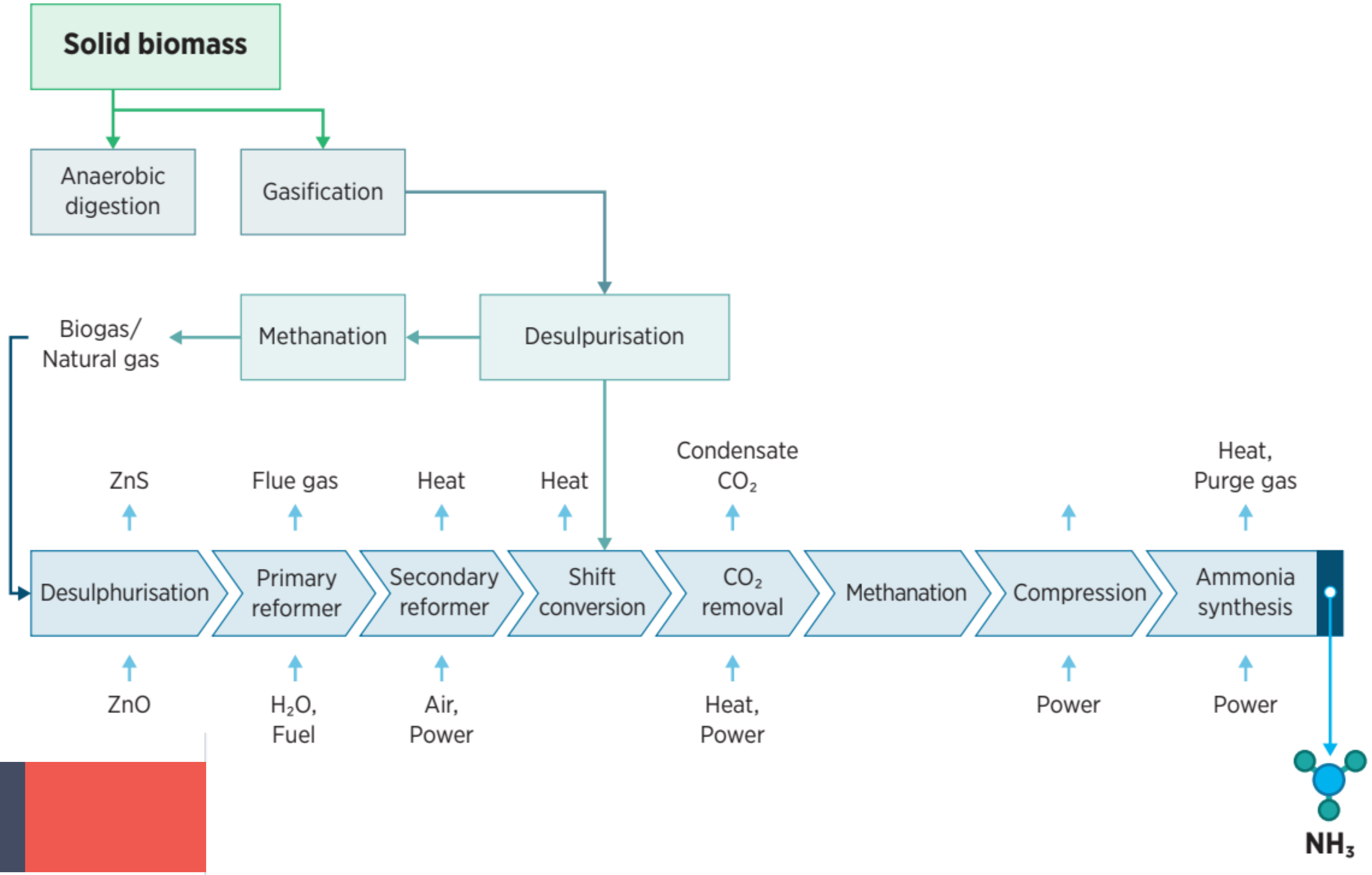
- Ammonia can also be produced from electrolysis-based hydrogen with zero-carbon electricity
  - Renewables (solar PV, wind, hydropower), nuclear power
  - 1920s: renewable ammonia commercial based on alkaline electrolysis and hydropower (replaced by natural gas reforming due to cost)
  - Nowadays shift to solar PV and wind (low electricity cost <20 USD/MWh in best locations)

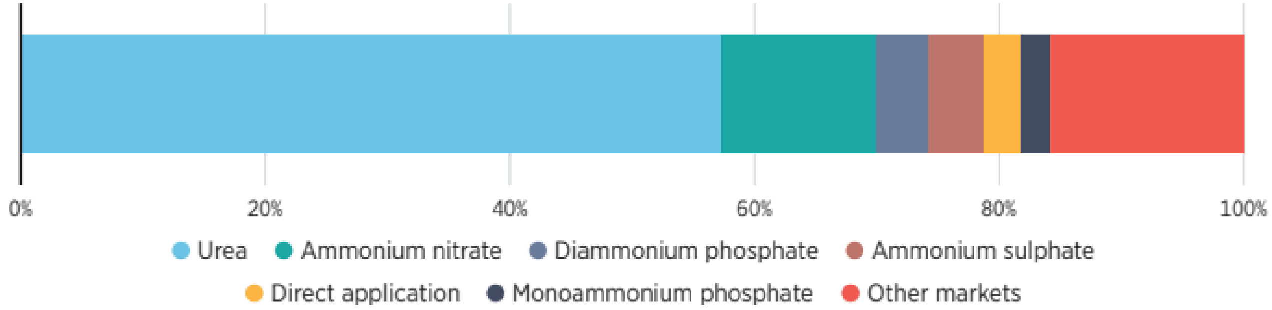


Hydroelectric ammonia plant in Cusco, Peru

Renewable ammonia production: biomass

- Biomass & biogas can replace natural gas and coal feedstock in existing facilities
  - Cost premium on biomass
  - Mainly of interest for urea production (carbon containing molecule, currently the biggest market for NH_3)





Gabriel Castellanos

Shipping Decarbonisation - Innovation and Technology Centre, IRENA

Policy recommendations to close the cost gap

Establish a realistic carbon levy - 60-90 USD/t CO2 for fossil-based ammonia with CCS and up to 150 USD/t CO2 to bridge the gap between fossil-based and RE ammonia.

Translate political will into policies - strong, stable, and sustained regulatory measures for fuel standards and RE quotas or mandates.

Fund value chains rather than lone technologies - support deployment by connecting the value chain across production, distribution, and utilization.

Develop trade strategies and supply chains by encouraging international co-operation - i.e. between project developers, ammonia production companies, and ammonia users, to create jobs and foster competitive new industries for renewable ammonia. **Carbon Border Adjustment Mechanism (CBAM).**

De-risk investment capital via financial instruments – e.g., enable grants, investments, loans, or loan guarantees, intermediate secured buyer of auctioned projects, etc.

Final remarks

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A transition to renewable ammonia is essential to limit the global temperature rise to 1.5C and bringing CO2 emissions closer to net-zero by the mid-century.

The decarbonization of various sector depends on renewable NH3 i.e. chemical, agricultural, energy, and transport sectors.

Under a 1.5°C aligned scenario, this transition would require to increase production by nearly four times. With growth driven by new energy uses that exceed current uses.

Cheap H2 is the driver to achieve costs competitiveness.

RE ammonia is coming. We need to be ready to seize the opportunities.

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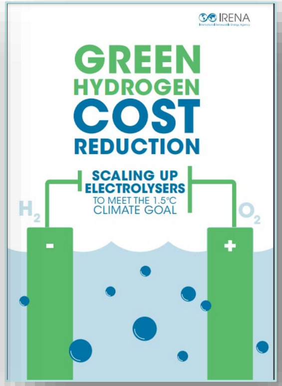

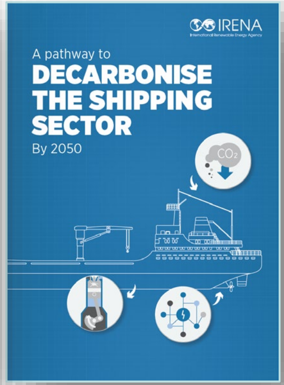

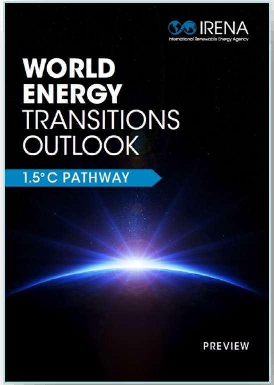

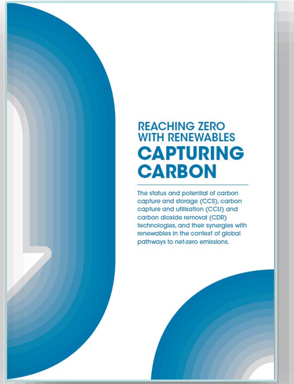

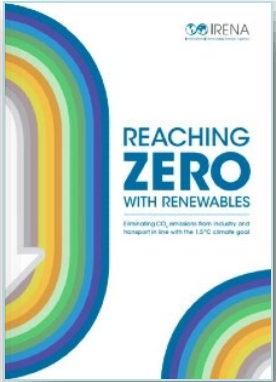

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Q & A

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