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Navigating the way to a renewable future: Solutions to decarbonise shipping

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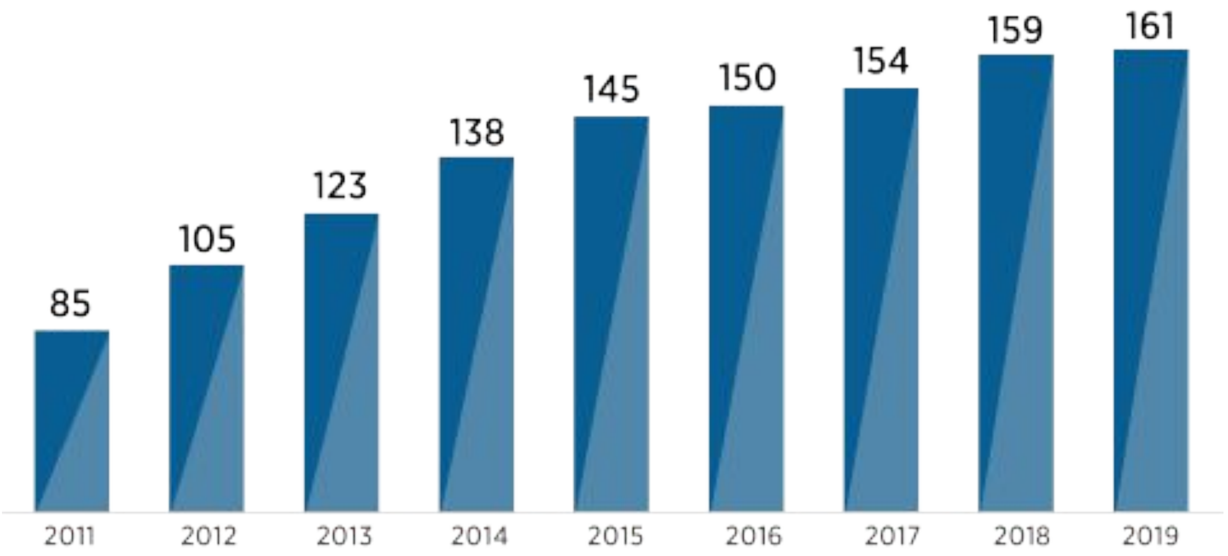
IRENA at a glance

- Intergovernmental Organization (IGO)
- Established in 2011
- HQ in Abu Dhabi, UAE
- IRENA Innovation and Technology Centre – Bonn, Germany
- Permanent Observer to the United Nations
- Director-General – Francesco la Camera



Membership

161 members + 22 in accession

Important considerations in the context of shipping

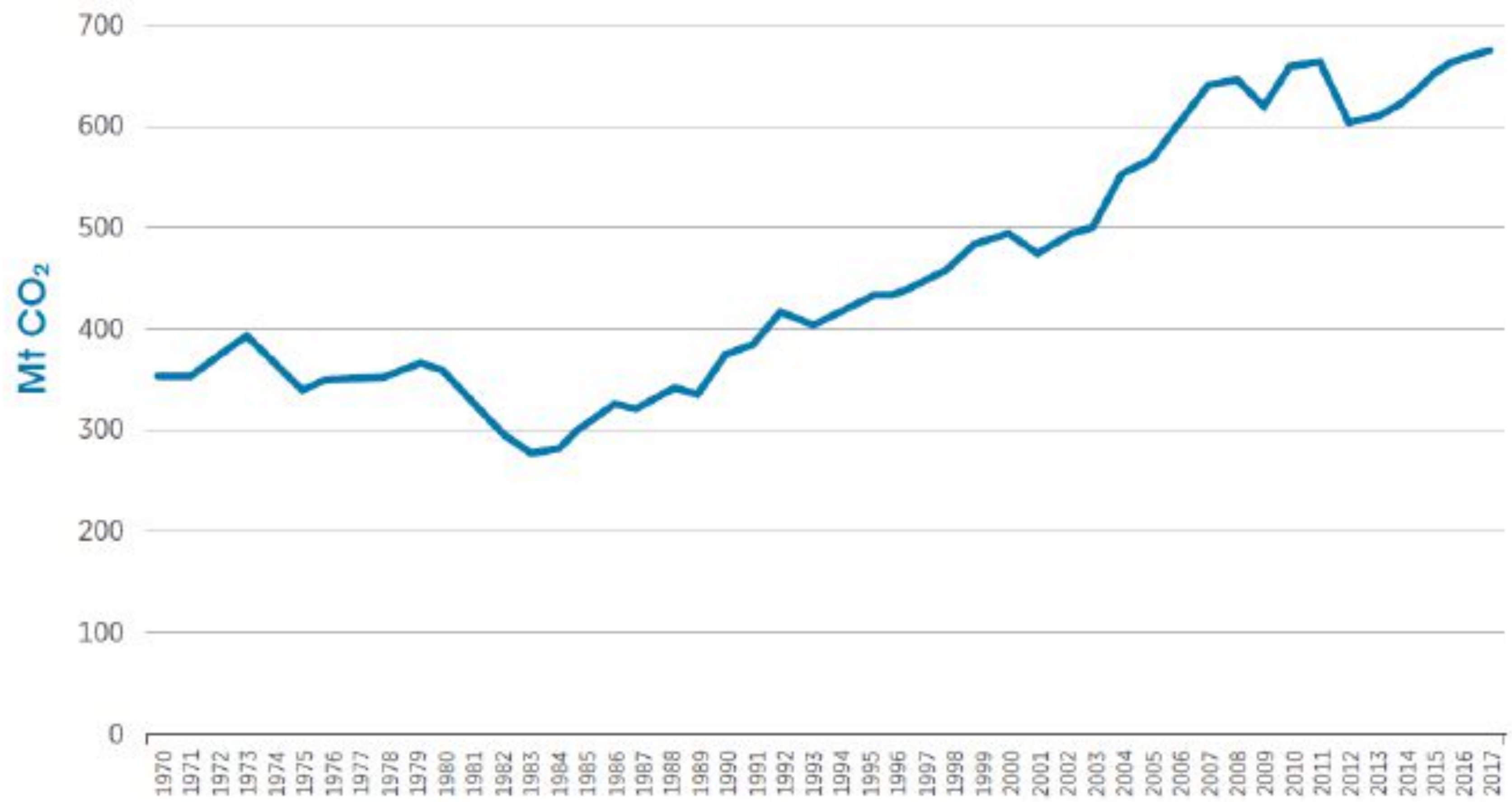
- **Similarities with power sector**
  - Long-lived assets, high upfront capital costs
  - Could likely benefit from technology-specific support mechanisms to reduce costs

- **Differences with power sector**
  - Shipping sector competes internationally
  - Shipping is outside national climate policy regimes
  - Different techno-economic challenges
    - RE: capital costs, variability
    - Shipping: fuel costs and availability

Let’s start with the problem

On average, the shipping sector is responsible for 3% of annual global green-house gas emissions on a CO2-equivalent basis.

Annual CO2 emissions associated with international shipping



Source: JRC-EDGAR (2018)

What are the options?

- Alternative marine fuels / propulsion
  - Biofuels
    - Diesel substitutes
    - Bio-alcohols
    - Gaseous biofuels
  - E-fuels
    - Hydrogen
    - Ammonia
    - Methanol
    - Methane
    - Other liquid fuels (gasoline, diesel)
- Electric engines / Batteries
- Efficiency improvements
  - Incl. solar and wind applications
- Other technologies (carbon capture)

Not all fuels are made the same

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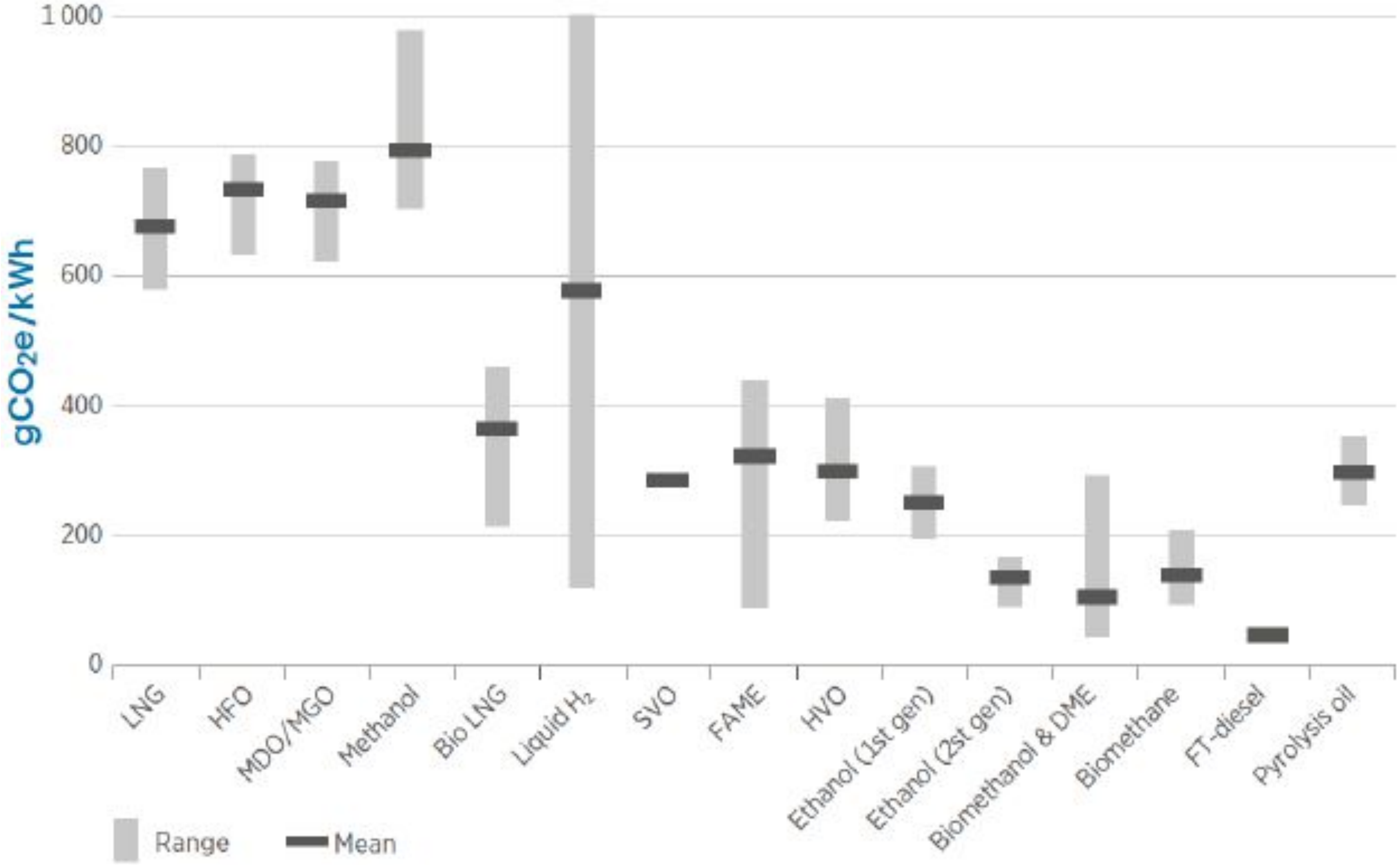
Total life cycle GHG emissions per kWh of engine output for different fuels



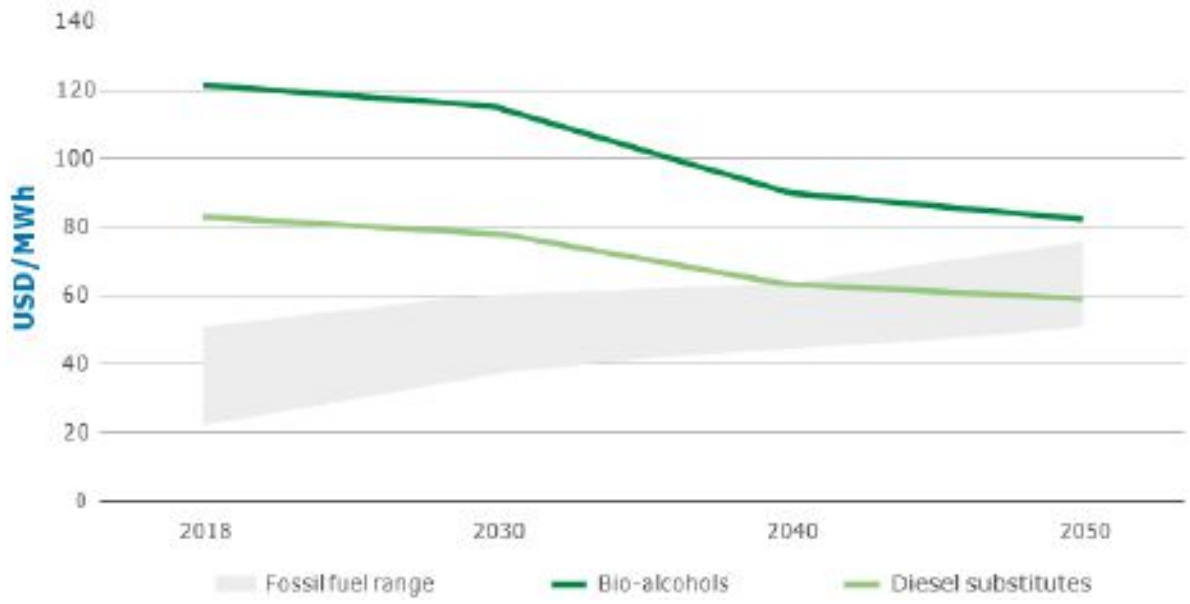
Source: Balcombe et al. (2019)

Biofuels

+ GHG, NOx and SOx emission reductions
+ Some are compatible as drop-in fuels
+ Safer in case of spills due to biodegradability
+ Low storage, bunkering, infrastructure and logistics costs (diesel substitutes)

- Can reduce engine lifespan (carbon build-ups, SVO; water contamination, FAME)
- Sustainability concerns
- Availability concerns
- High production costs (mainly due to feedstock)
- High adaptation costs (bio-alcohols and gaseous biofuels)

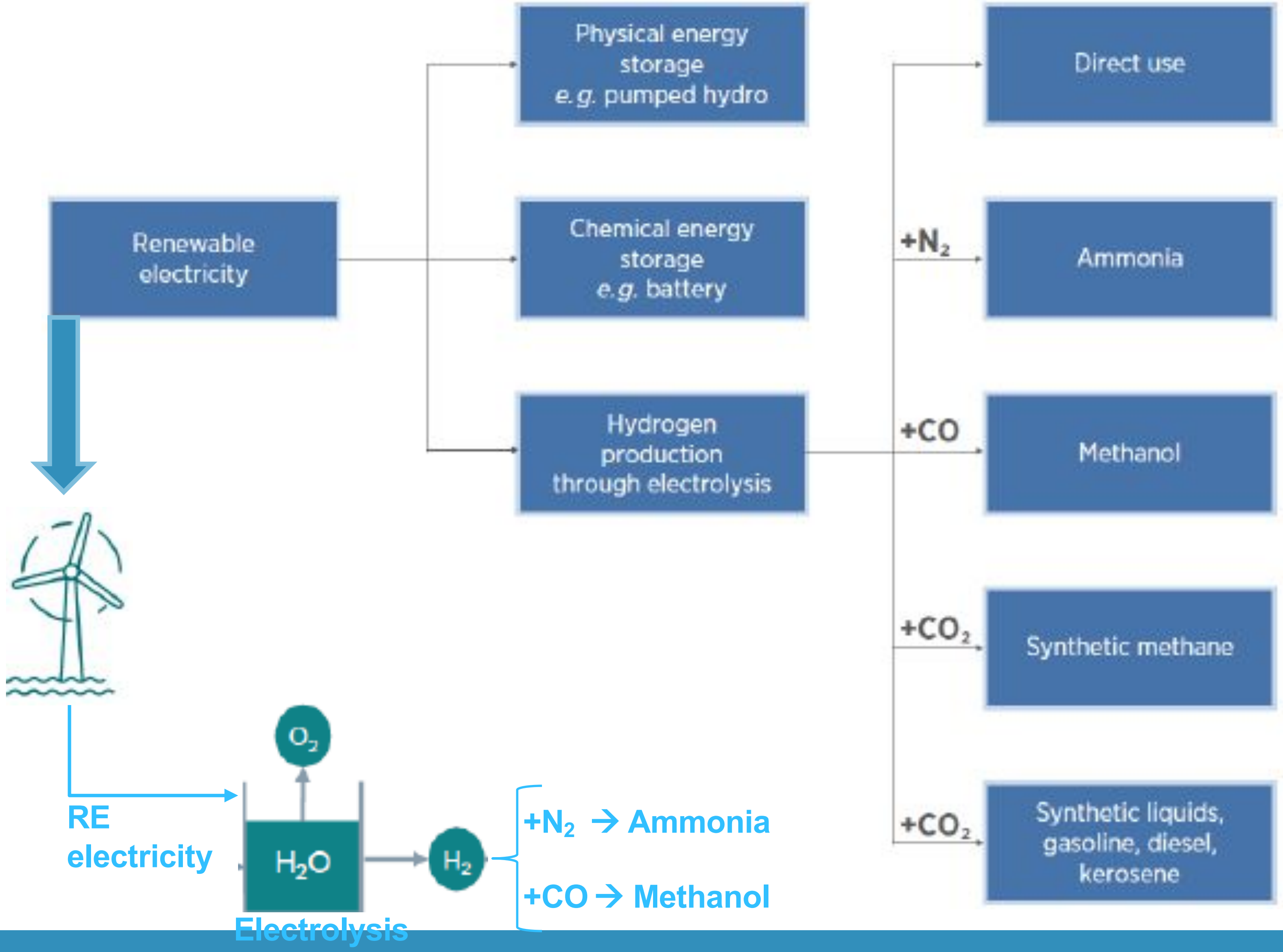
Biofuel cost projections



Source: Biofuel cost projections (IRENA, 2016); fossil fuel cost range (Lloyd's Register, 2019; Ship & Bunker, 2019)

The backbone towards a decarbonised shipping sector will depend on the supply of green hydrogen. Offshore wind has a clear role in the production of green hydrogen.

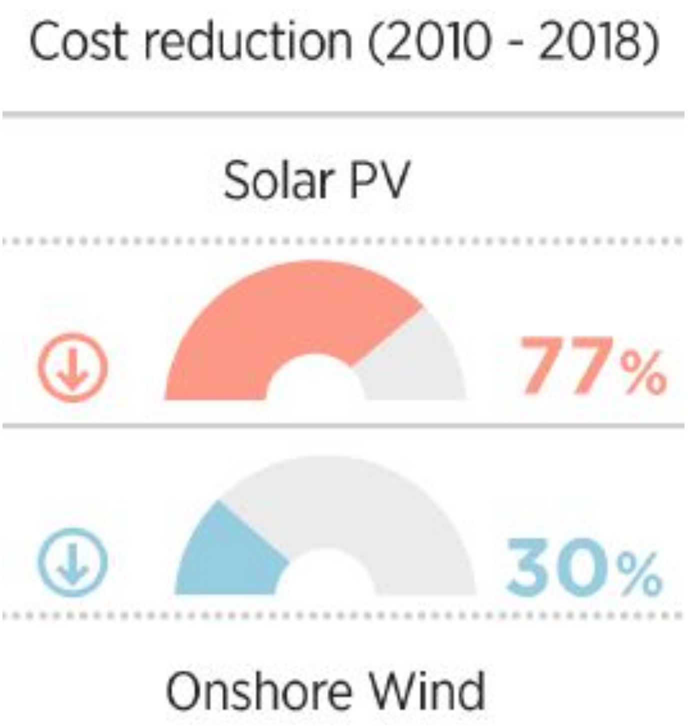
Schematic representation of power-to-X routes

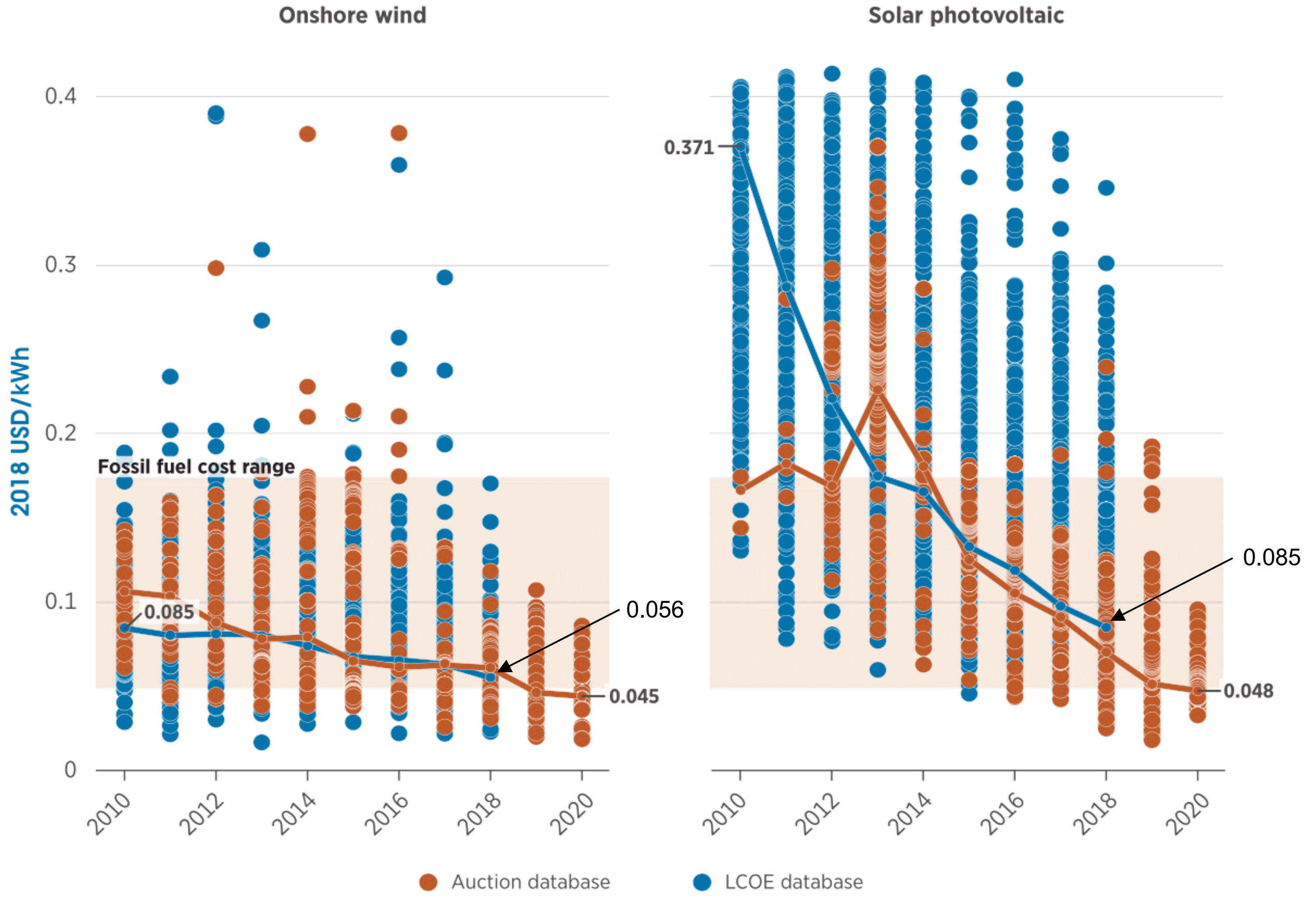


- Green hydrogen-derived fuels or so called **Powerfuels**, **particularly ammonia and e-methanol** will be the **primary RE fuels for decarbonising the shipping sector by 2030 and beyond.**

- In the long-term powerfuels need to be:
  - ✓ **Sustainable → H_2 produced from REs**
  - ✓ **Scalable**
  - ✓ **Affordable**
  - ✓ **Commercially available**
  - ✓ **Safe for users**

Renewables are getting cheaper



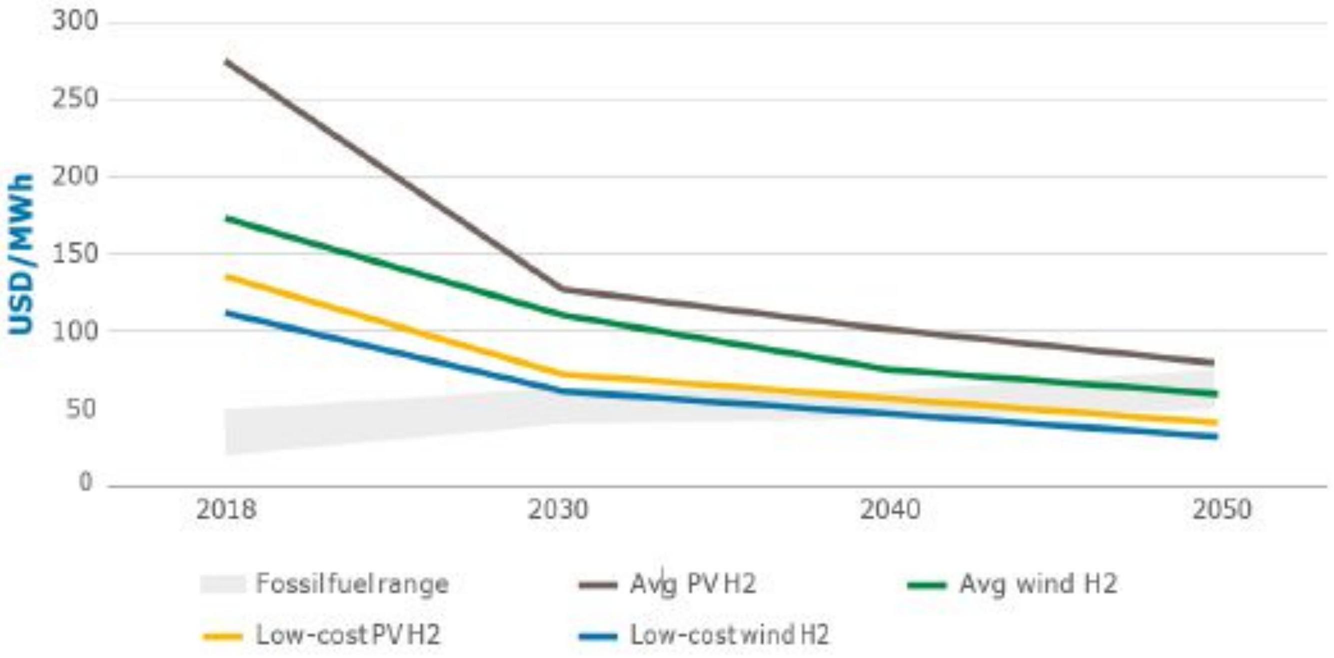


Hydrogen

+ Zero carbon if produced from RES
+ No SOx and negligible NOx emissions

- Not at commercial scale
- Very low volumetric energy density
- Difficult to store, requires cryogenic temperatures or very high pressure
- Considerable changes to infrastructure and logistics
- High costs
- High flammability

Hydrogen cost projections



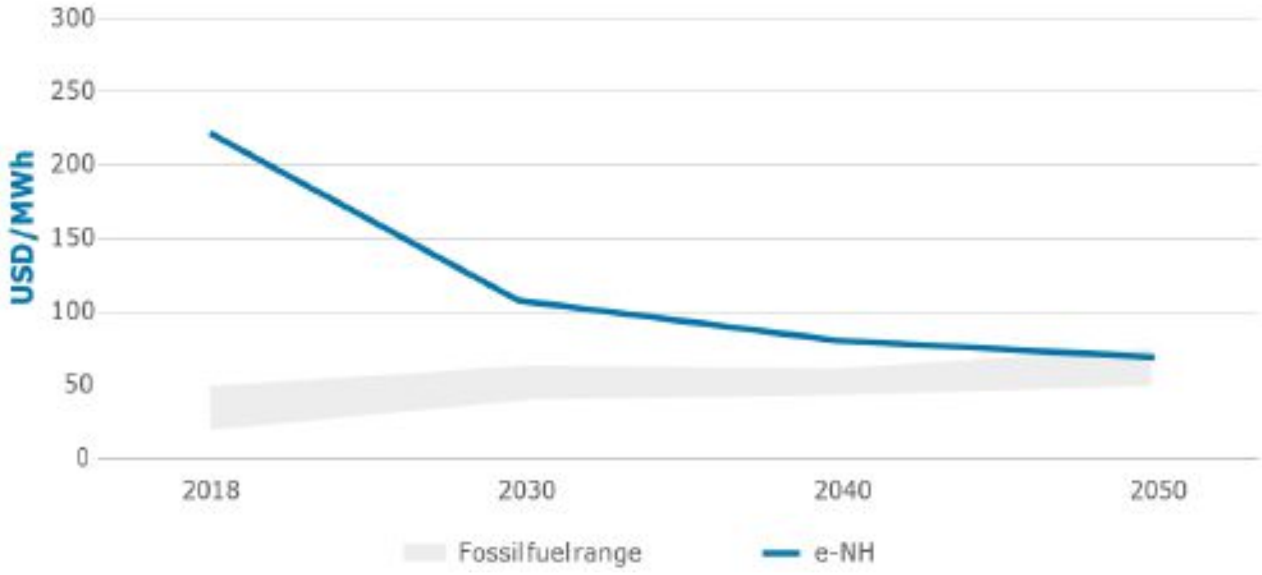
Source: Hydrogen cost projections (IRENA, 2019); fuel cost projections (Lloyd's Register, 2019; Ship & Bunker, 2019)

Ammonia

+ Zero carbon, SOx, and negligible NOx if used in fuel cells (can produce NOx if combusted, might need SCR)
+ Higher volumetric energy density than H_2
+ Easier to store than H_2
+ Widely used commodity

- No active commercial applications
- Bunkering and storage need modification due to refrigeration needs
- High costs
- Toxic

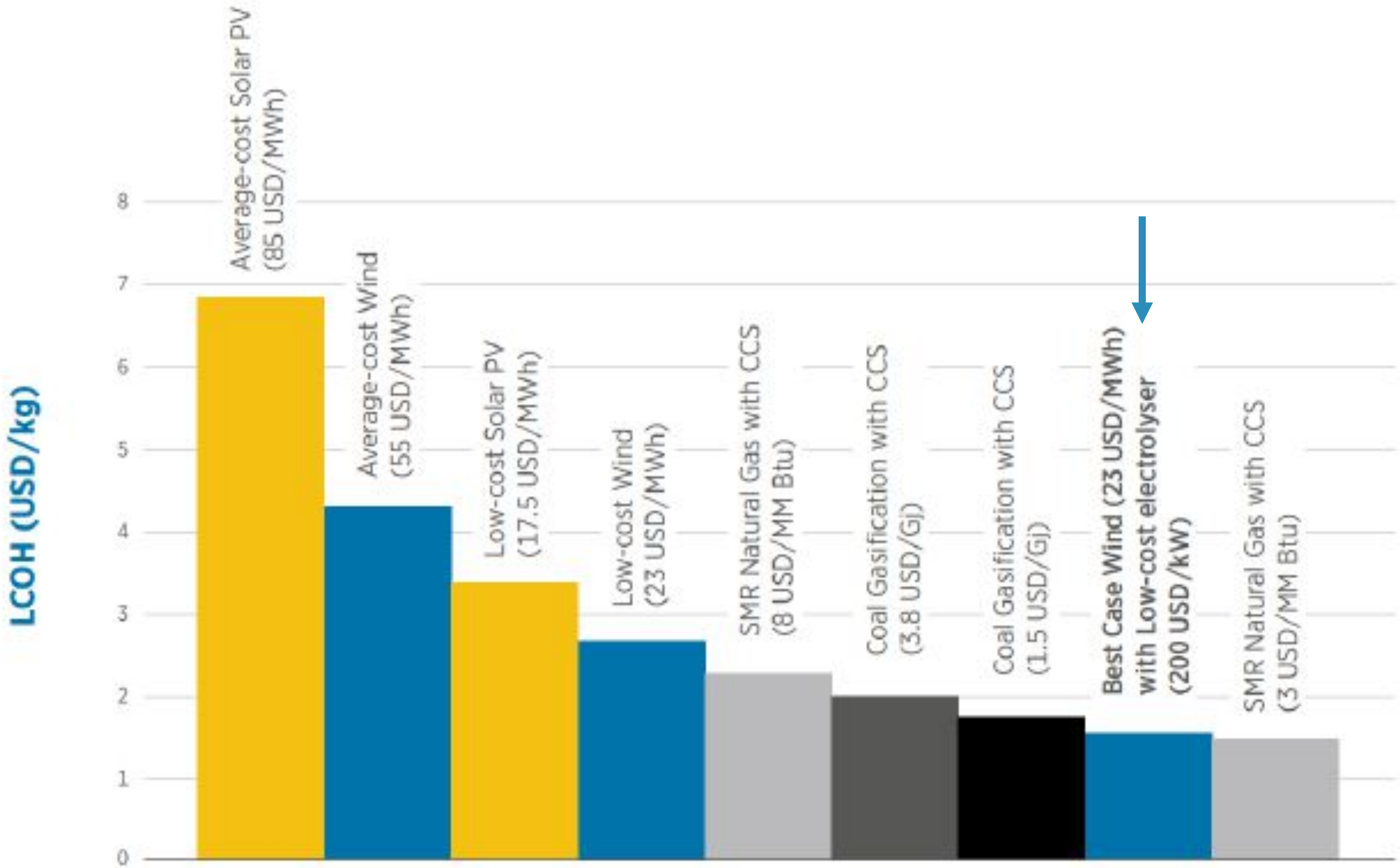
E-Ammonia cost projections



Source: Hydrogen cost projections (IRENA, 2019); fuel cost projections (Lloyd's Register, 2019; Ship & Bunker, 2019)

The lowest-cost RE projects e.g. offshore wind can provide hydrogen at a cost comparable to that of hydrogen produced from fossil fuels.

Costs of producing hydrogen from renewables and fossil fuels today



Notes: Electrolyser capex: USD 840/kW; Efficiency: 65%; Electrolyser load factor equals to either solar or wind reference capacity factors. For sake of simplicity, all reference capacity factors are set at 48% for wind farms and 26% for solar PV systems.

Source: IRENA analysis

- **The best-case renewable hydrogen supply can be economic today,** but typical conditions need further cost reductions.
- **Low-cost RE power of USD 23/MWh is seen today in some wind projects**, in combination with low costs electrolysers; could result in a **Green Hydrogen costs of around USD 2 per Kg-H_2**.

Overview and Outlook

- To achieve the 2050 carbon reduction targets, the shipping sector will need to shift to carbon-free propulsion alternatives such as advanced biofuels, electric propulsion, renewable hydrogen and other hydrogen-based fuels such as ammonia.

- Given that bunker costs can account for 24 - 41% of total vessel operation costs, fuel prices and its availability will play a critical role in selecting one or another clean fuel option.

- Other key, decisive factors will include the infrastructural adaptation costs of ships and ports, technological maturity and sustainability issues (e.g. food security in the case of biofuels).

- As the adoption of clean technologies grows across sectors, technology improves, renewable fuel costs fall and regulation becomes more favourable, carbon-neutral options are expected to become more competitive in the medium to long-term.

- Decarbonising the shipping sector will require a global effort where the close cooperation between private and public stakeholders will be highly important.

IRENA‘s work on Hydrogen and Shipping

https://www.irena.org/publications/2019/Sep/Hydrogen-A-renewable-energy-perspective

https://www.irena.org/publications/2019/Sep/Navigating-the-way-to-a-renewable-future

- **Key Findings - Hydrogen**
  - Important synergies with RE – Storage and flexibility
  - Electrolysers are scaling up from MW to GW
  - Electrolyser costs to halve by 2050 (850 USD/kW today)
- **Key Findings - Shipping**
  - Need for global effort and cooperation of public and private sectors
  - Fuel price and availability will be decisive
  - Cost reductions in technology and RE will make alternative fuels competitive in the medium to long term
  - Life cycle emissions will have to be considered

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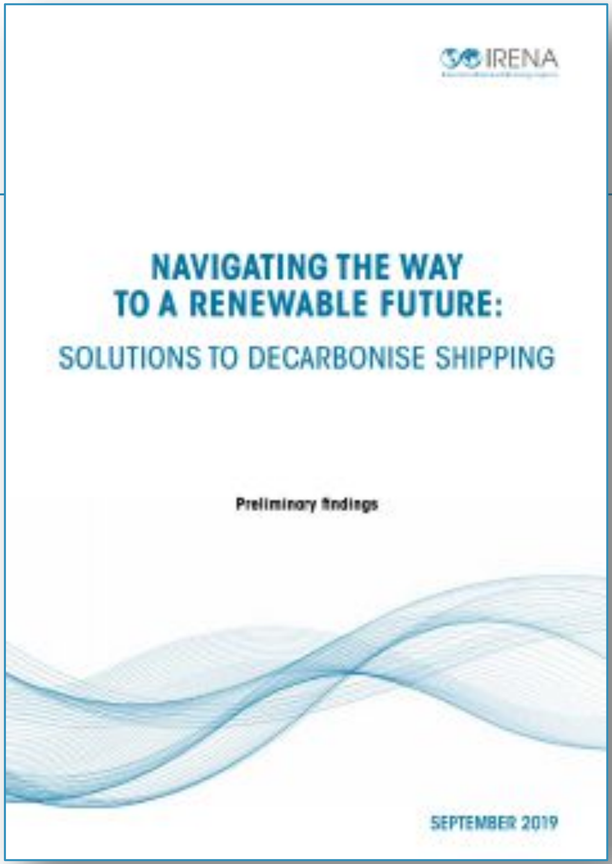
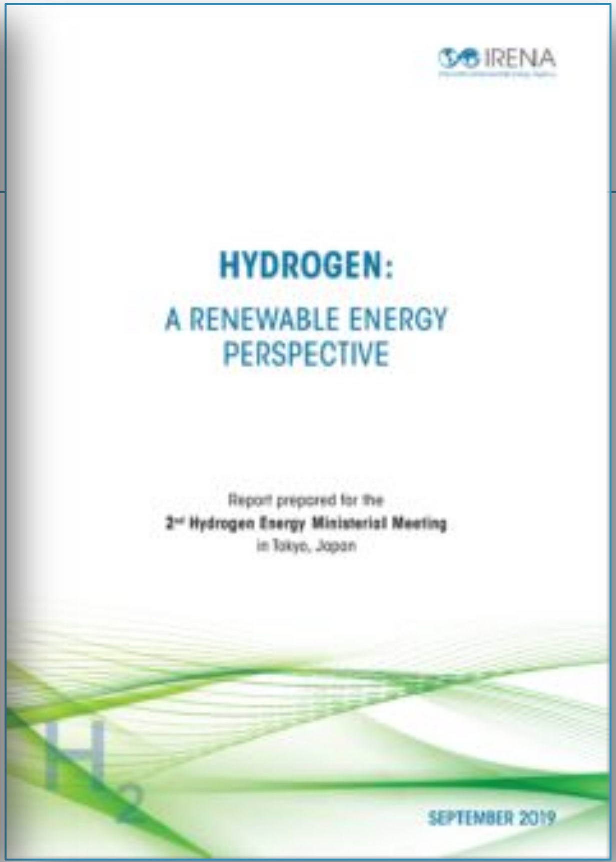
Thank you!





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Hydrogen production costs - Currently accelerating investments in electrolysers worldwide

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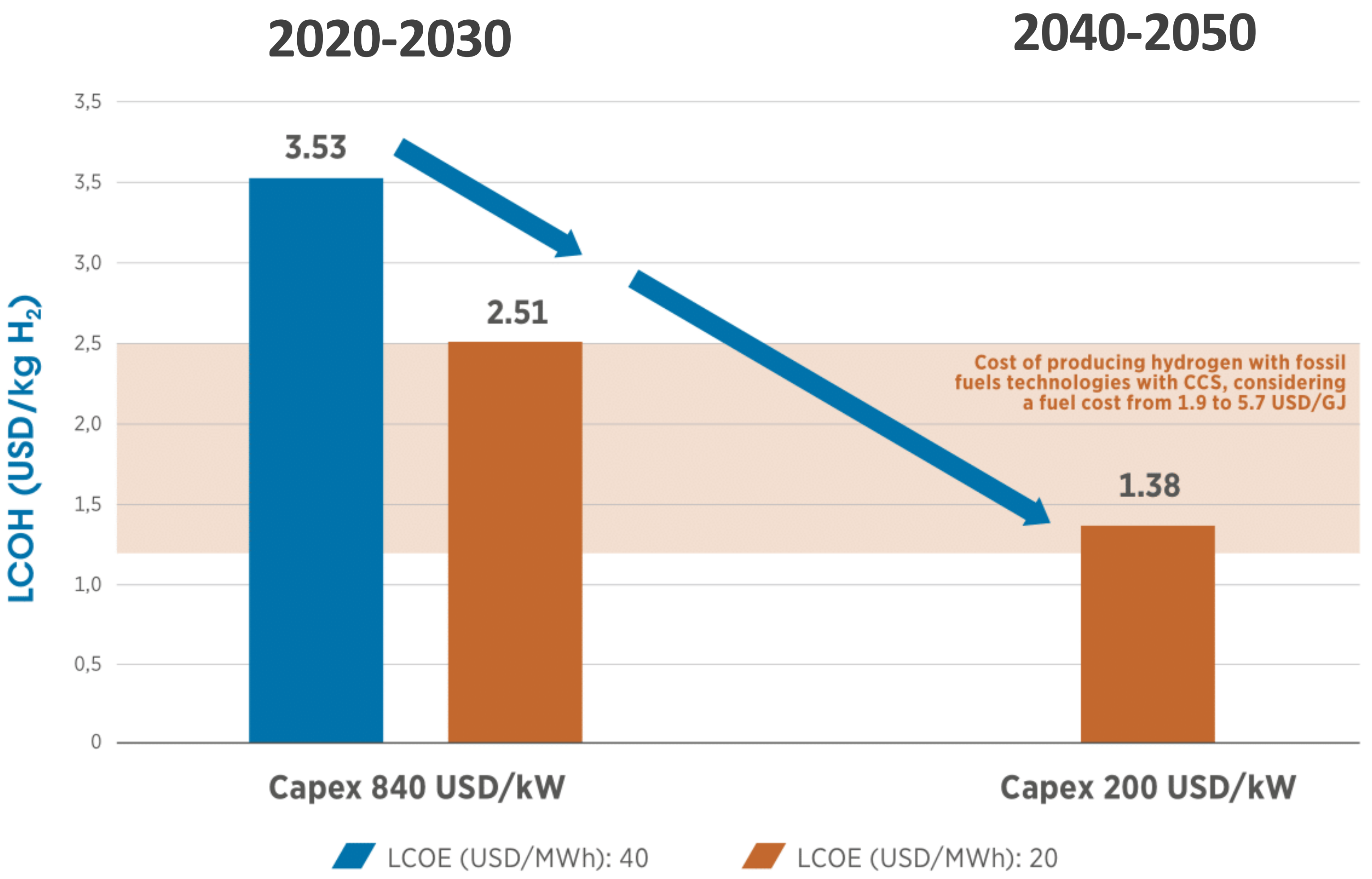
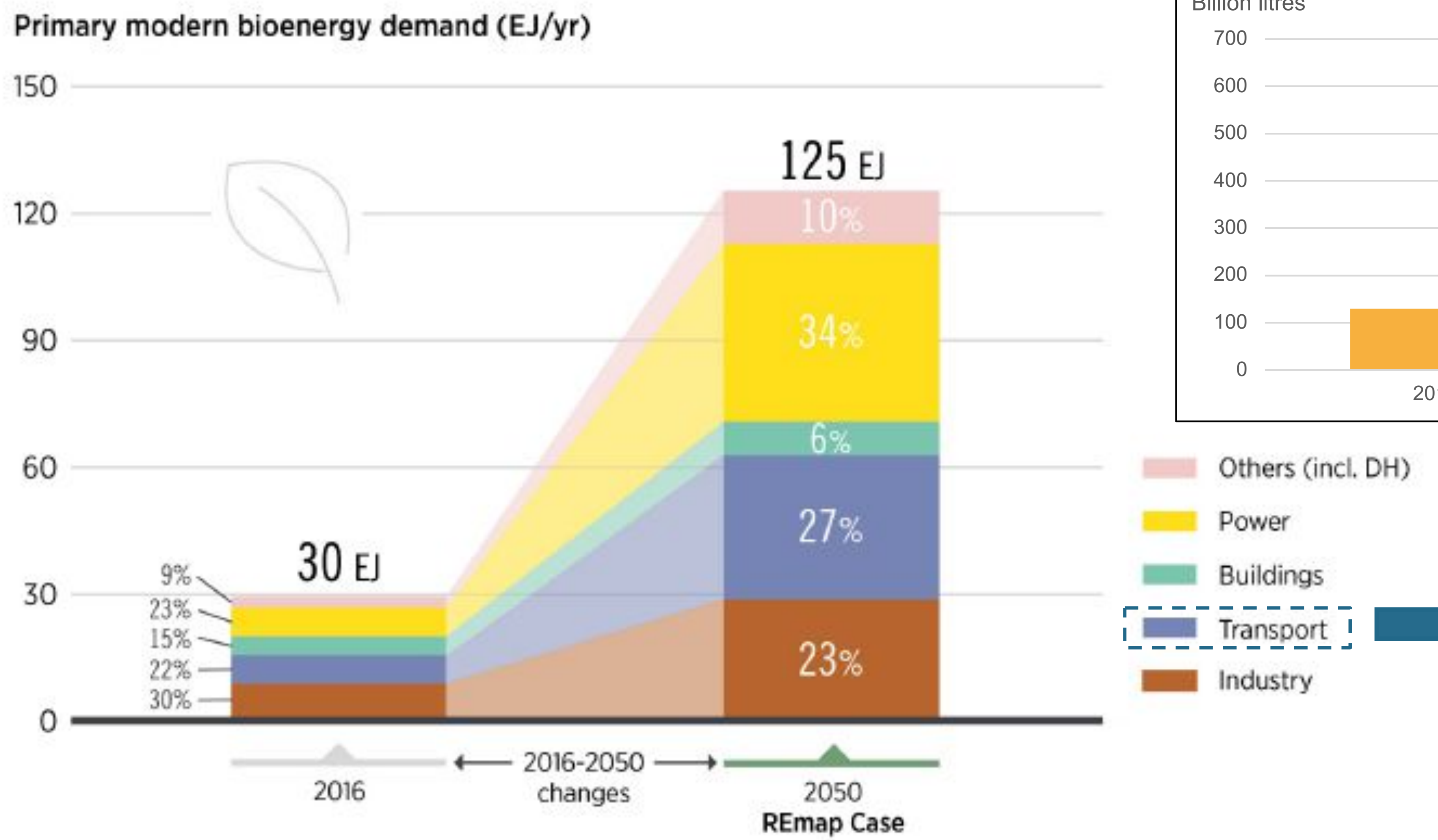


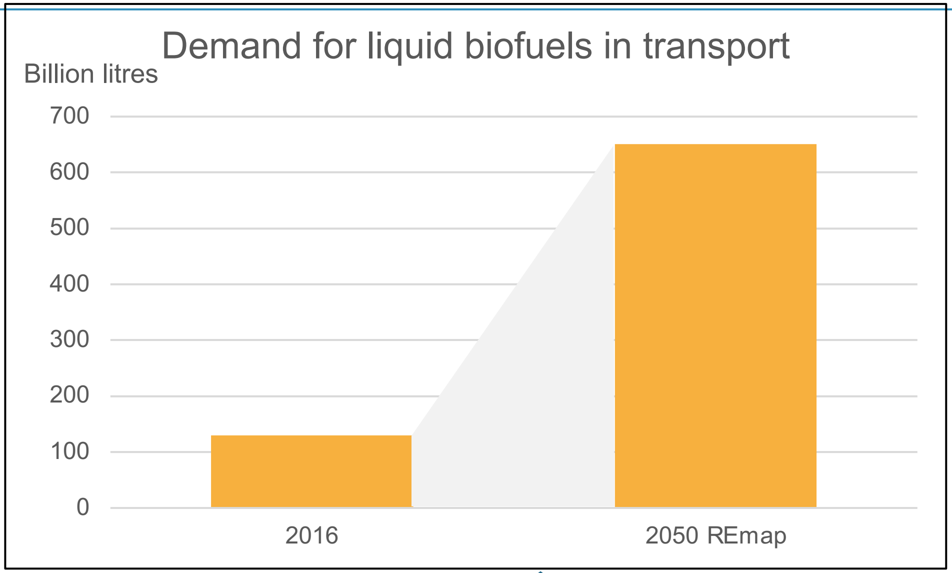
- Energy content 8 kg hydrogen = 1 GJ natural gas. Natural gas wholesale price today USD 2/GJ (US) – USD 8/GJ
- Replacing gas with hydrogen - saving 0.056 t CO2/GJ – translates into 100-200 USD/t CO2
- This would apply to ammonia, synthetic methanol from H2/CO2

Hydrogen from renewables is close to competitiveness at best solar and wind sites

Key assumptions - Electrolyser load factor: 4200 hours (48%), conversion efficiency 75%

Modern bioenergy deployment should be over four times larger than the current level





Data based on the Global Energy Transformation: A Roadmap to 2050 (IRENA 2019)

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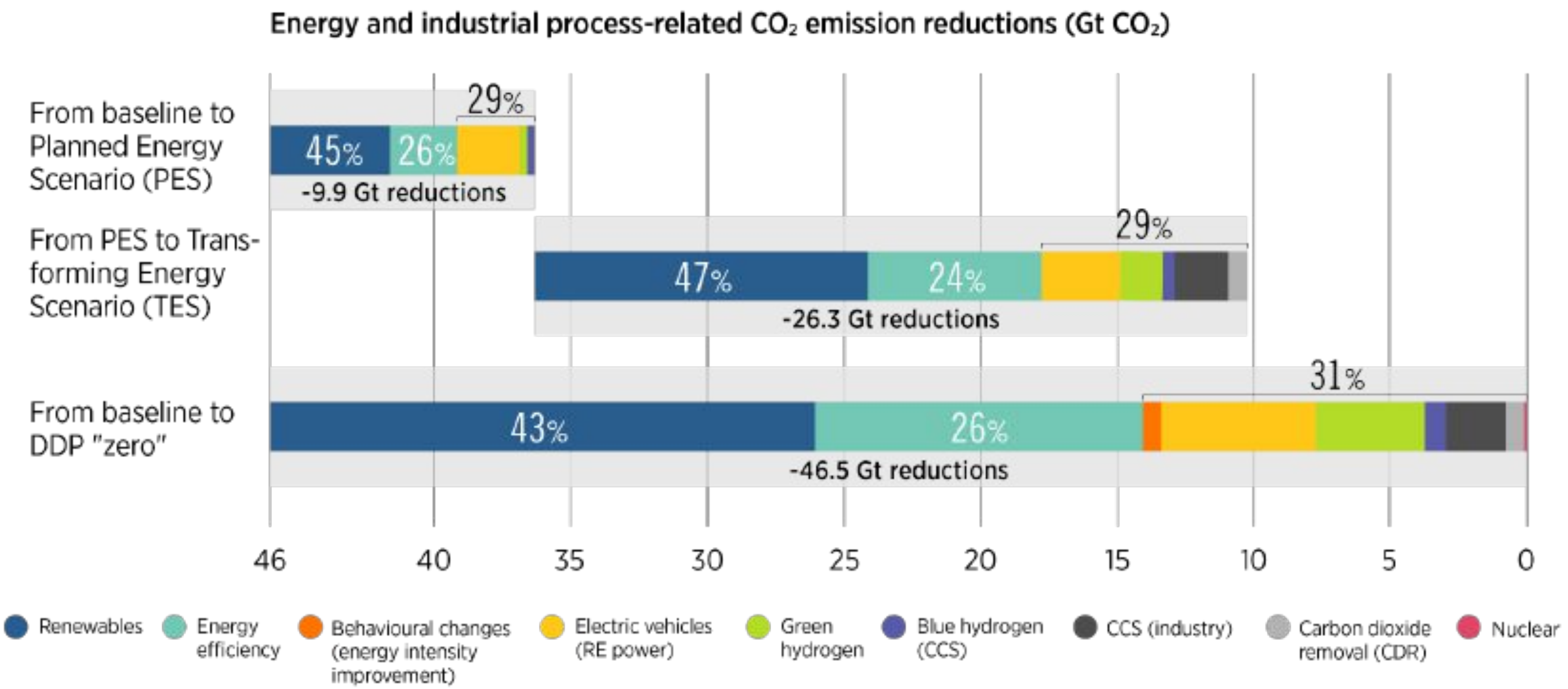
THE POST-COVID RECOVERY

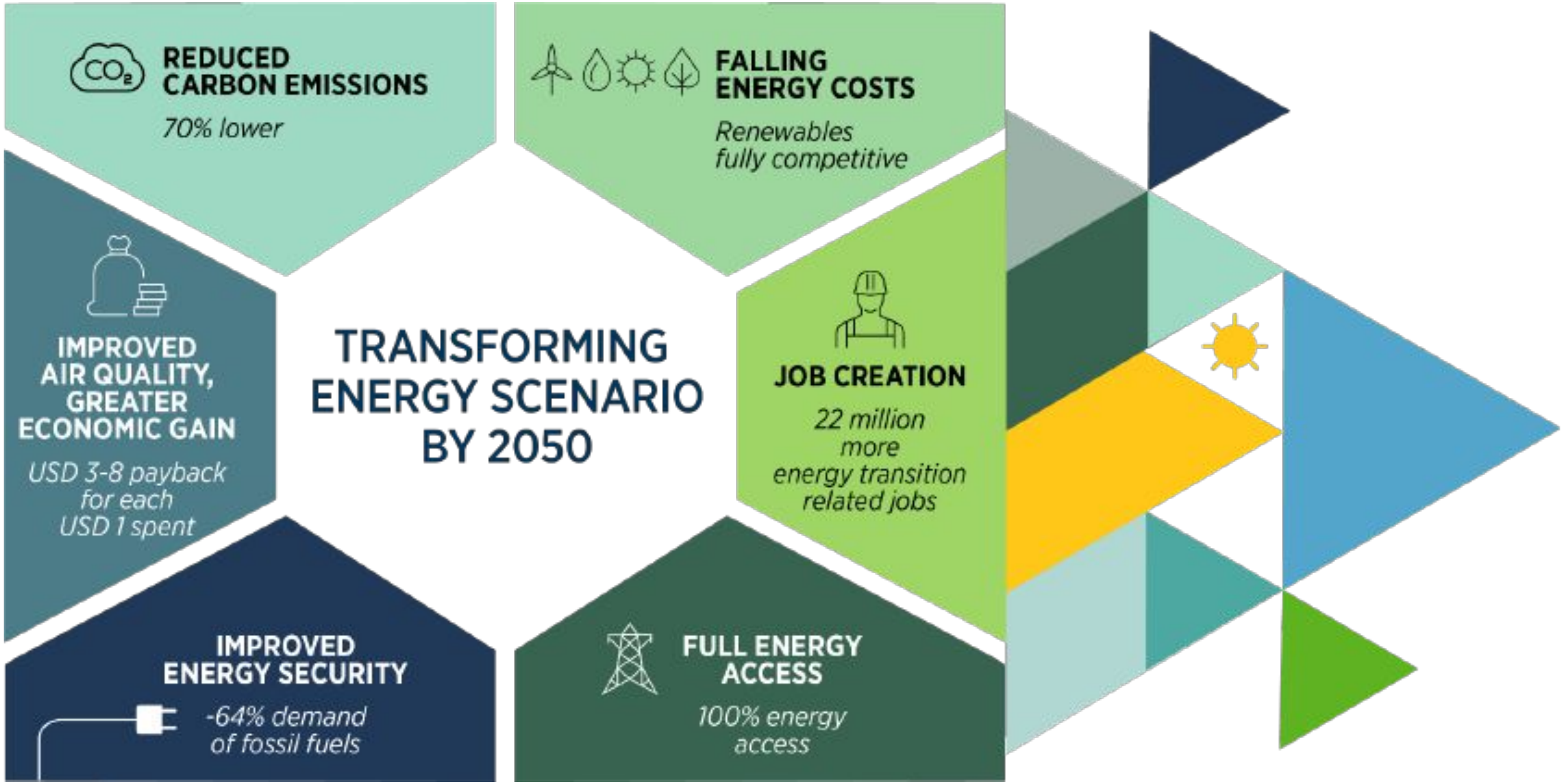
An agenda for resilience, development and equality

Roland Roesch
Deputy Director IRENA Innovation and Technology Center

Global Renewables Outlook outlines options to cut energy-related CO_2 emissions to 2050



Annual energy-related CO_2 emissions would need to decline by at least 70% below today's level by 2050.
End-use electrification, green hydrogen and synthetic fuels will play a crucial role to reach zero emissions.


REDUCED CARBON EMISSIONS
70% lower
FALLING ENERGY COSTS
Renewables fully competitive
IMPROVED AIR QUALITY, GREATER ECONOMIC GAIN
USD 3-8 payback for each USD 1 spent
TRANSFORMING ENERGY SCENARIO BY 2050
JOB CREATION
22 million more energy transition related jobs
IMPROVED ENERGY SECURITY
-64% demand of fossil fuels
FULL ENERGY ACCESS
100% energy access

Energy transformation investments to 2021-2023

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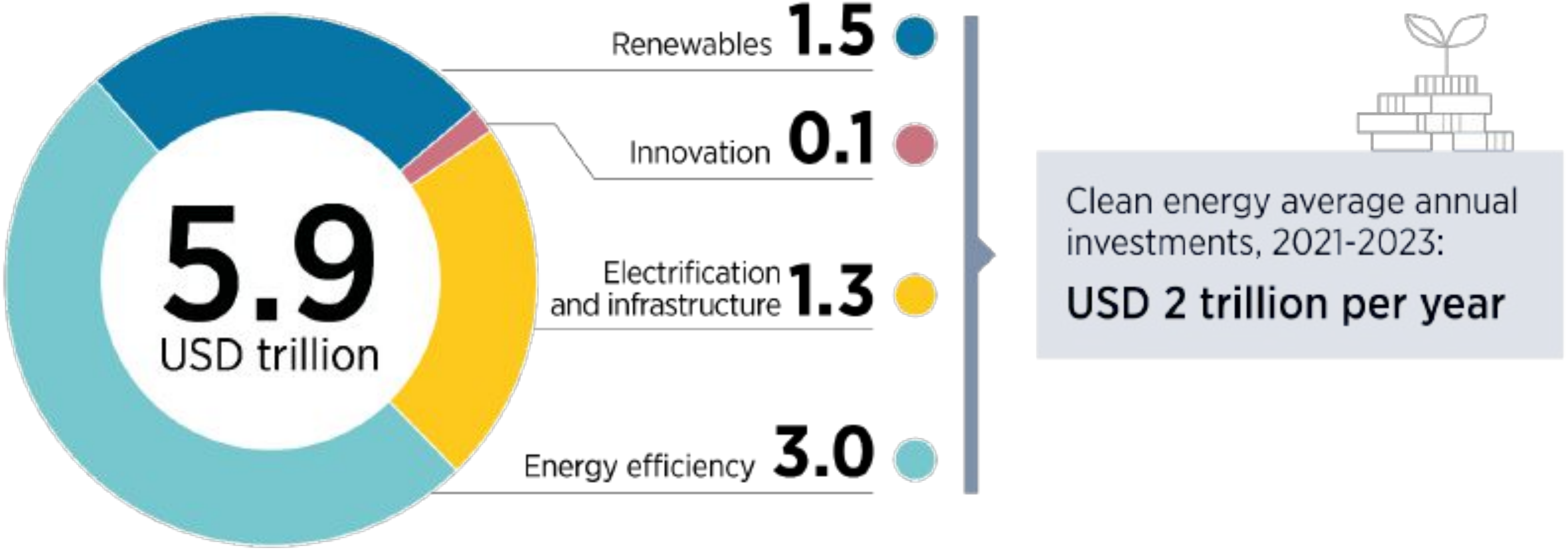
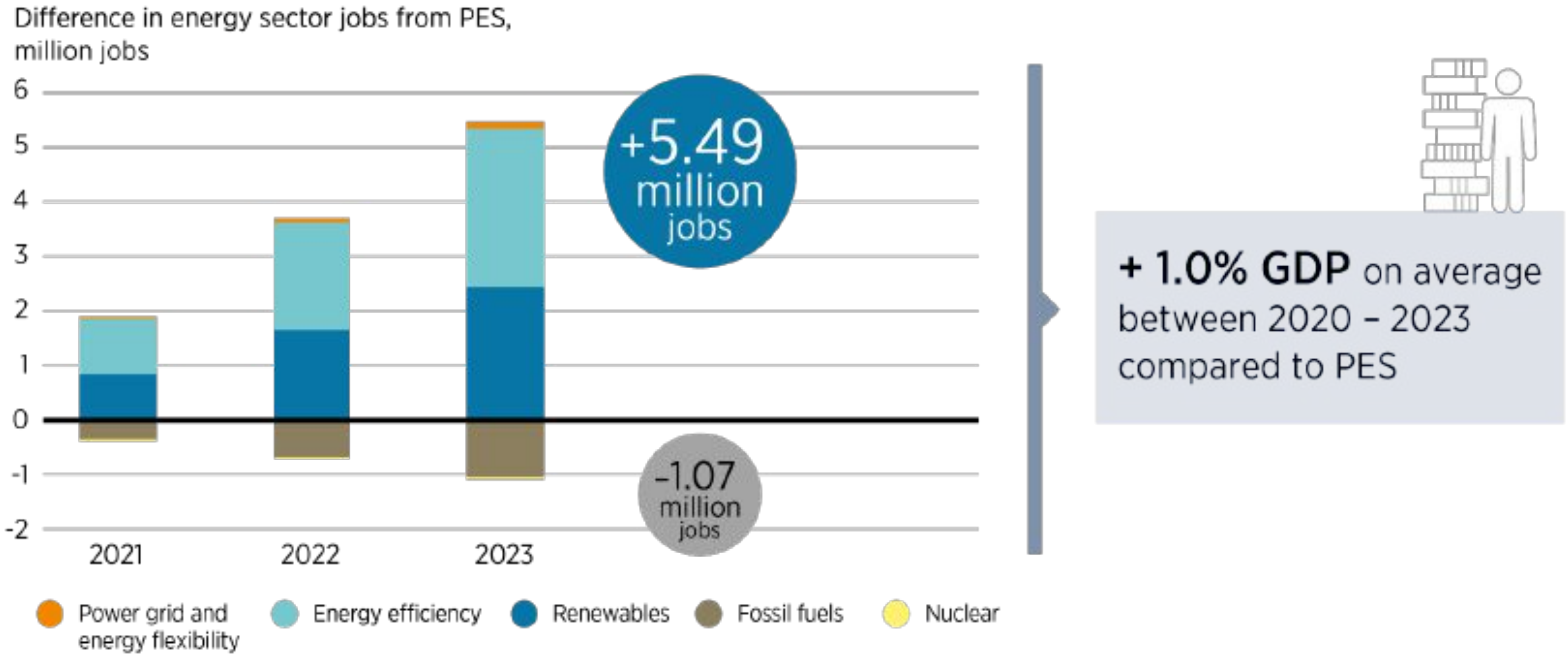
Cumulative clean energy investments between 2021 and 2023 in the Transforming Energy Scenario (USD_{2019} trillion)



Investments in energy transition technologies needs to grow two-fold between 2021 and 2023 (USD 2 trillion per year) compared to 2019 levels (USD 825 billion).

Immediate employment and GDP benefits

Changes in energy sector jobs resulting from transition-related investment (Transforming Energy Scenario compared to Planned Energy Scenario, 2021-2023)



The specifics vary from region to region and country to country – whether in terms of underlying structural conditions, the specific opportunities that can be pursued, or the scope of policy ambition.

Key policy measures needed to bolster green stimulus

AMBITION

Support implementation of NDCs and energy transition-related plans

PUBLIC INTERVENTION

Mobilise investment, encourage institutional investors and green bonds

INVESTMENT

Scale up transition-related investment in power, heating and cooling and transport

EMPLOYMENT

Support the expansion of the workforce in energy transition-related fields

INDUSTRY

Develop local industries for energy transition-related technologies

ACCESS

Continue efforts to ensure universal energy access