

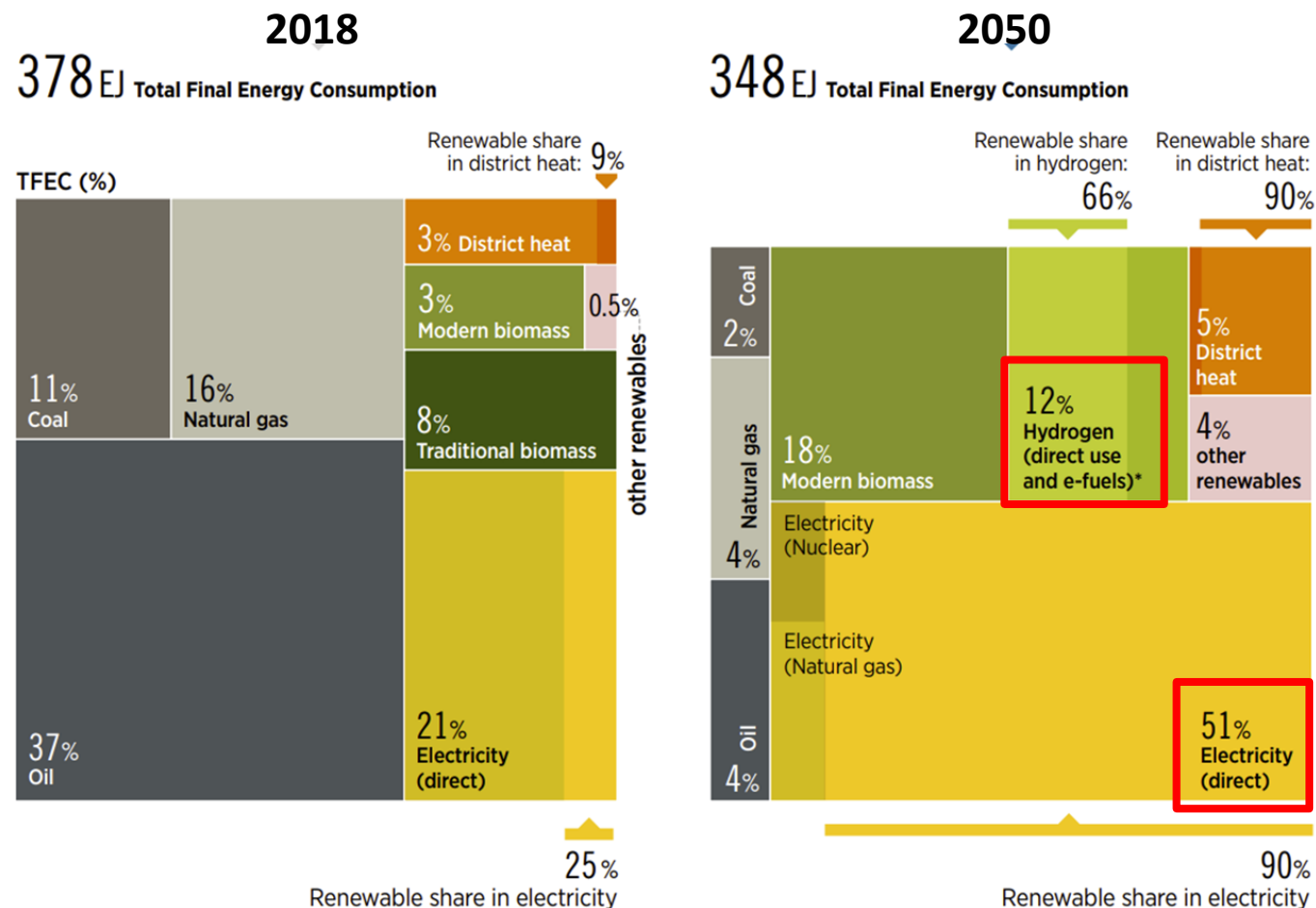
Global PtX trade in a 1.5 °C energy system

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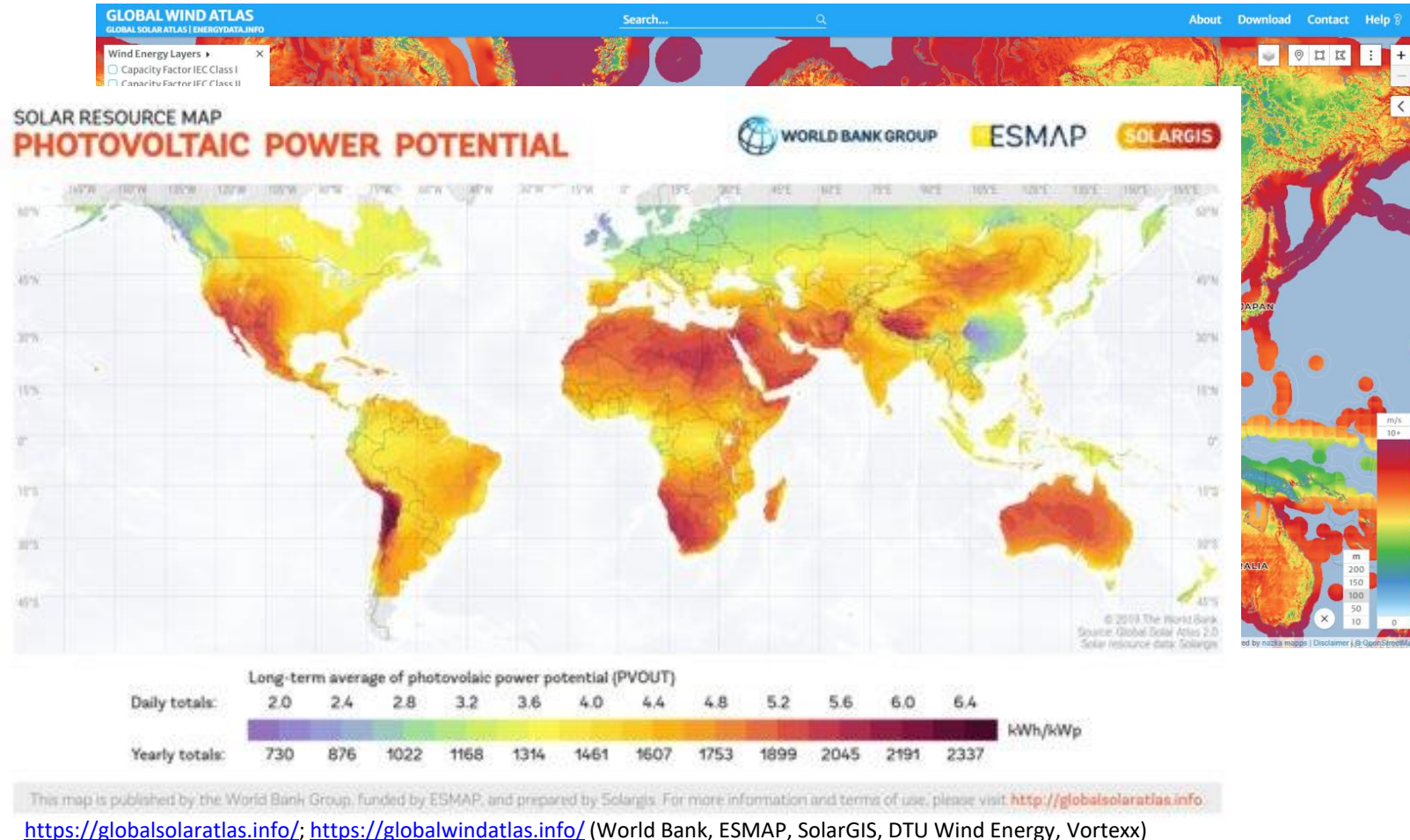
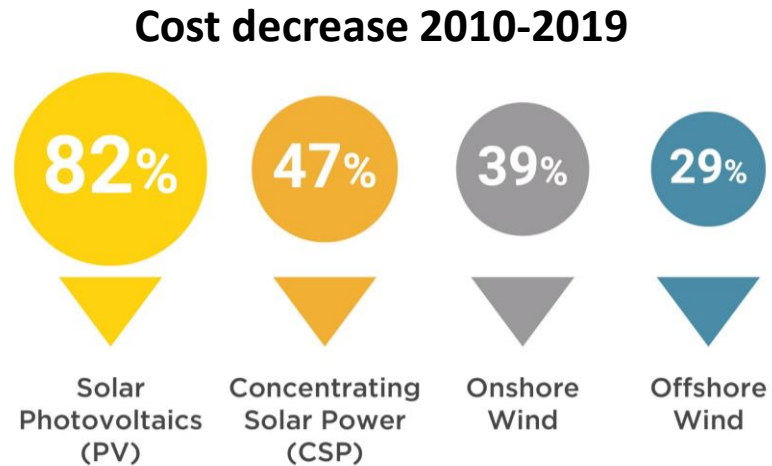
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How much hydrogen do we need in a 1.5 °C world?



Electrification and energy efficiency are the pillars of decarbonization, but hydrogen is essential for a net zero emissions future, especially for hard-to-abate sectors

Cost competitiveness of renewable power



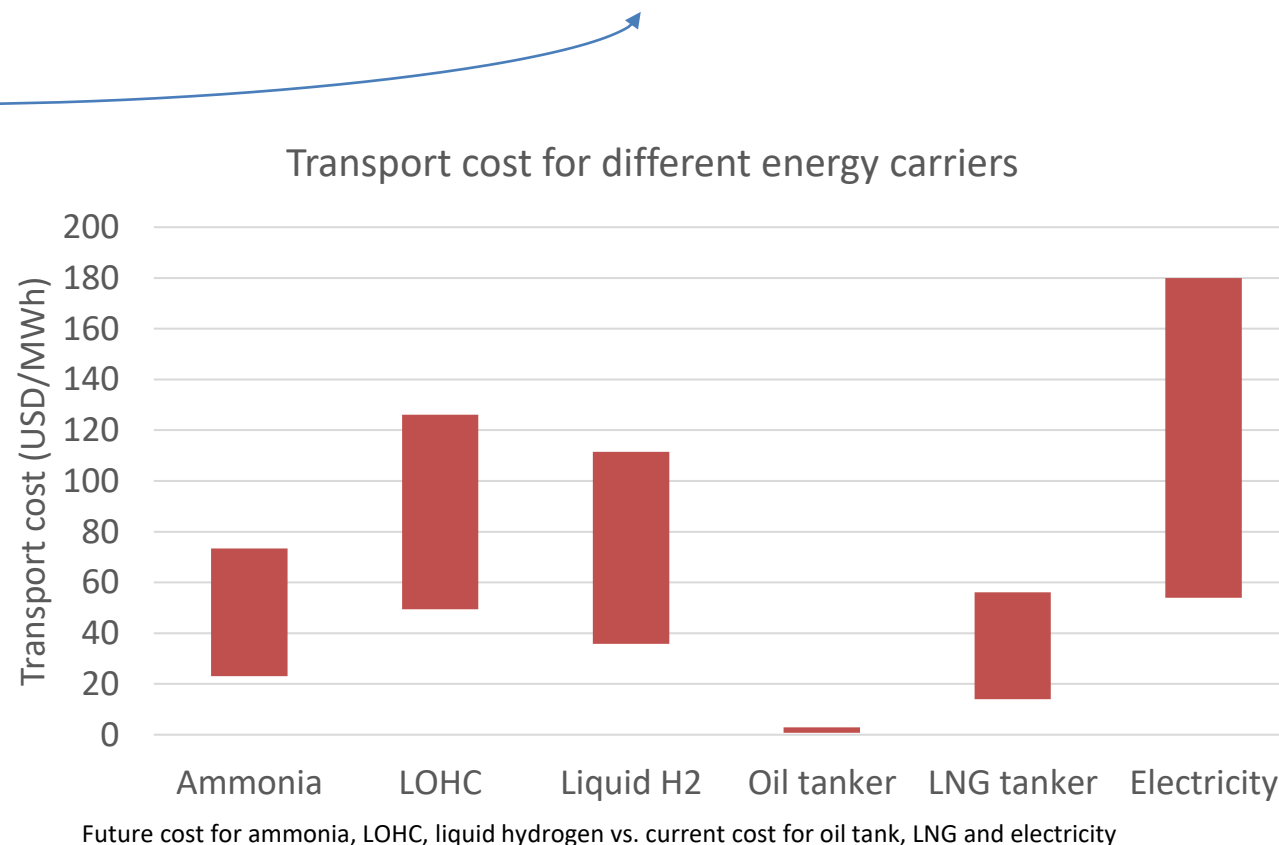
Renewable power has already reached fossil parity in many regions, but not all countries are endowed with the same quality of renewable resources

What form will trade between regions take?

Advantages and disadvantages
(best to worst)

	1 st	2 nd	3 rd
H ₂ /energy density per m ³	NH ₃	LH ₂	LOHC
Maturity	LH ₂	NH ₃	LOHC
Energy used to release H ₂	LH ₂	NH ₃	LOHC
Energy used for storage	LOHC	NH ₃	LH ₂
H ₂ release flexibility	LH ₂	LOHC	NH ₃
Final use flexibility	NH ₃	LH ₂	LOHC
Ease of storage	LOHC	NH ₃	LH ₂
Safety	LOHC	LH ₂	NH ₃
Chain energy efficiency	LH ₂	LOHC	NH ₃
CAPEX	Depends on value chain & scale		

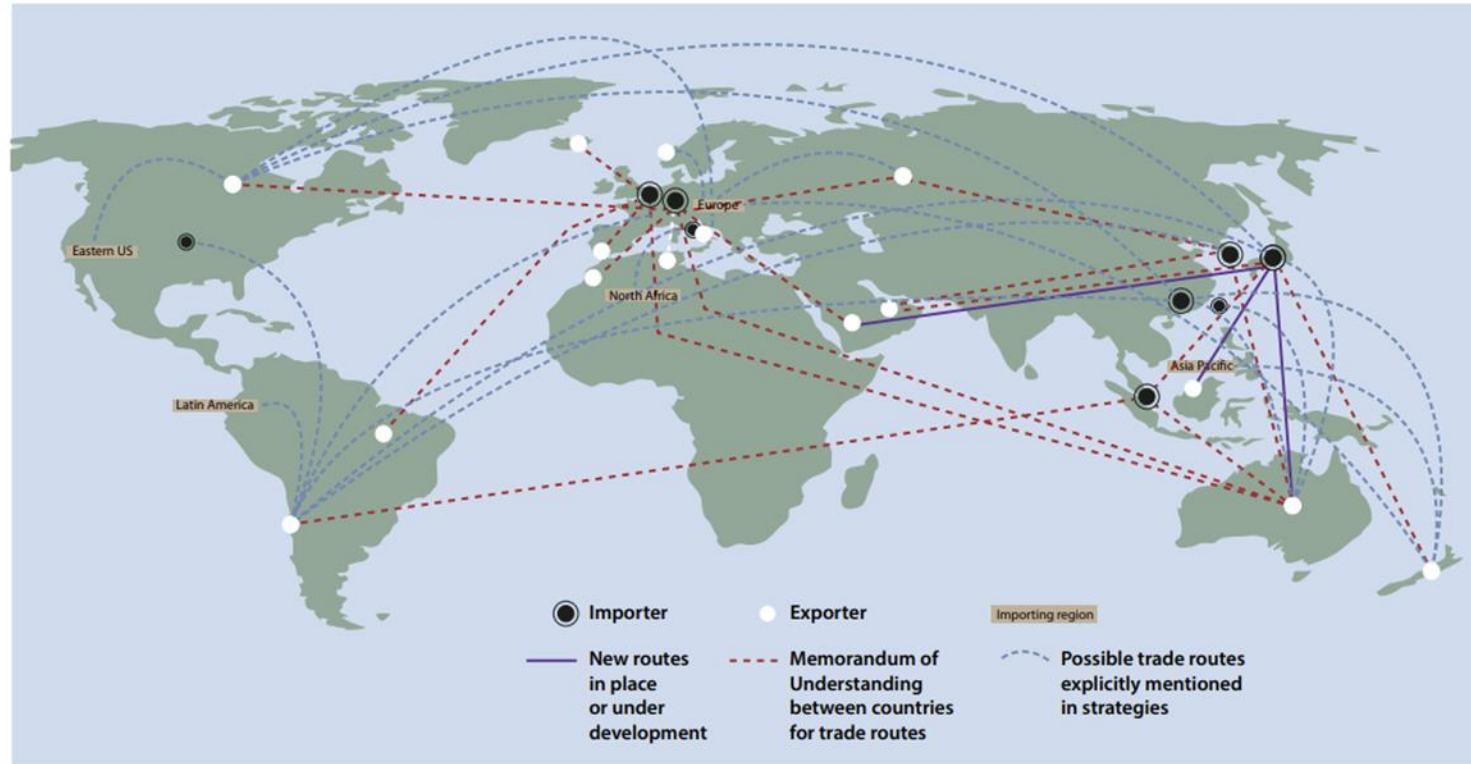
Further complicated if hydrogen derivatives (methanol, synthetic fuels, reduced iron, aluminum) are considered besides hydrogen carriers



There is no clear winner yet for a hydrogen carrier, but transport costs are higher than today's oil and gas

MoU and demonstrations are already under way

Figure 2.7 **Envisaged trade routes for hydrogen as of 2021**



Notes: Hydrogen policies are evolving rapidly. Information on this figure has been kept as detailed and complete as possible at the time of writing, however more countries may have announced or planned new hydrogen routes.

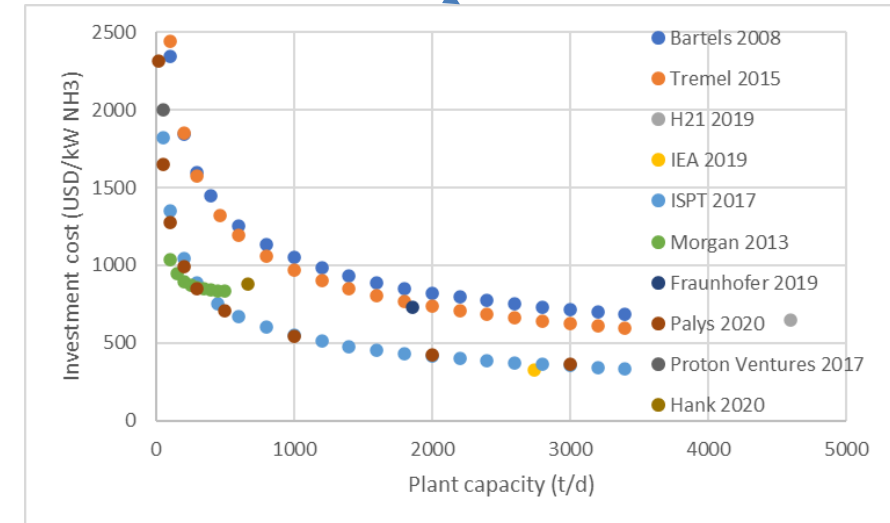
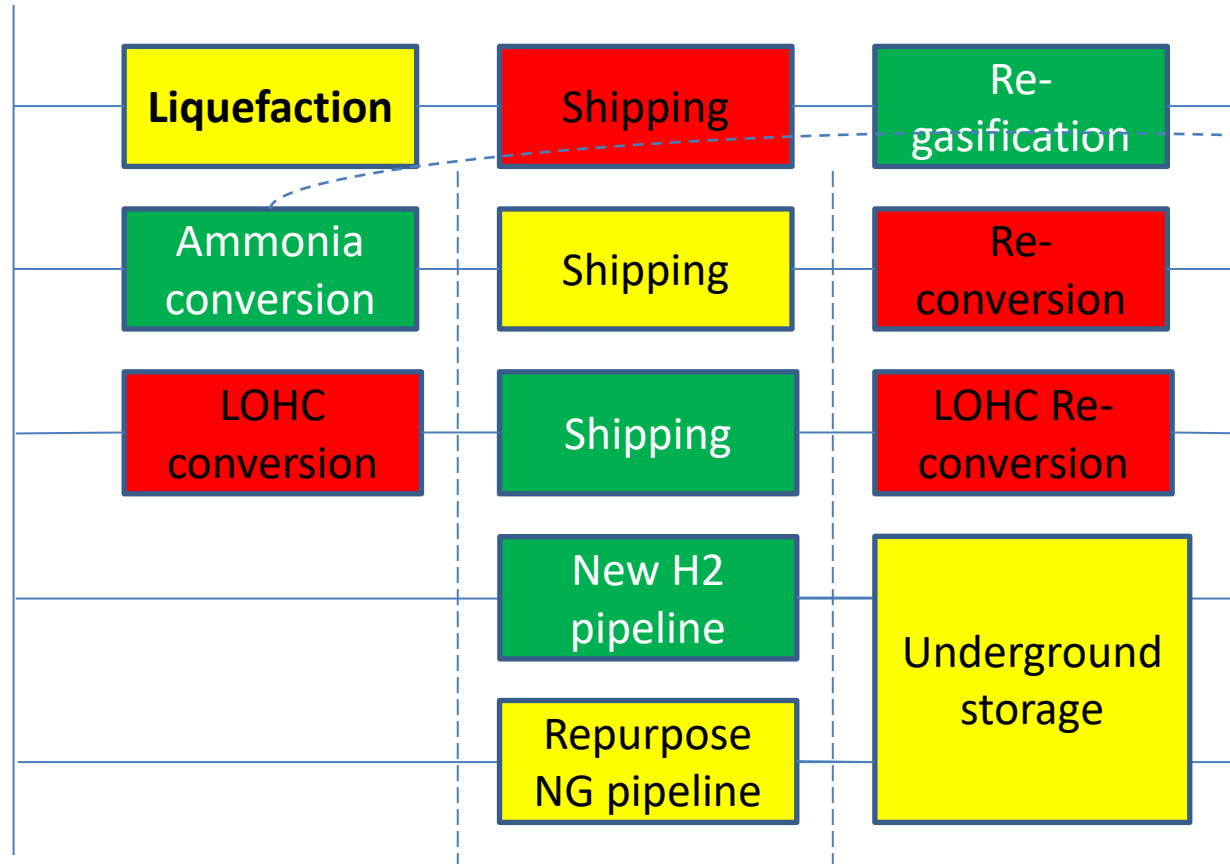
Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.

Countries are aiming for diversification of supply (demand) and pursuing multiple carriers hedging against technology development outcomes

What is needed to get there?

Hydrogen supply in exporting country

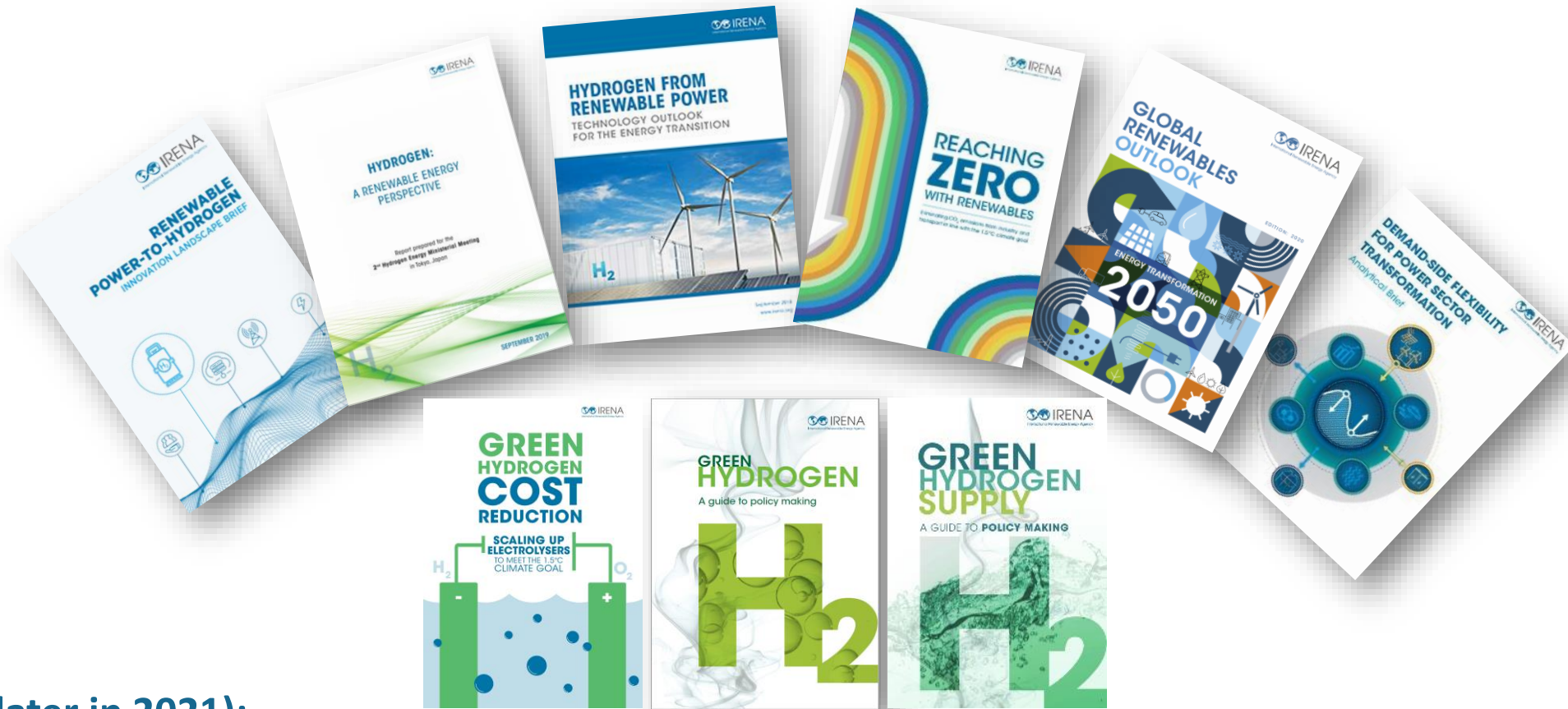
Hydrogen demand in importing country



Need for large scale

Technology innovation is key to demonstrate the steps that have low technology maturity today and economies of scale (from hubs) is needed to achieve low costs

Thanks for your attention



Upcoming (later in 2021):

- Global trade of hydrogen (carriers) in a net zero emissions energy system
- Policy brief on industry
- Policy brief on aviation and shipping

Ammonia might be an attractive option to start

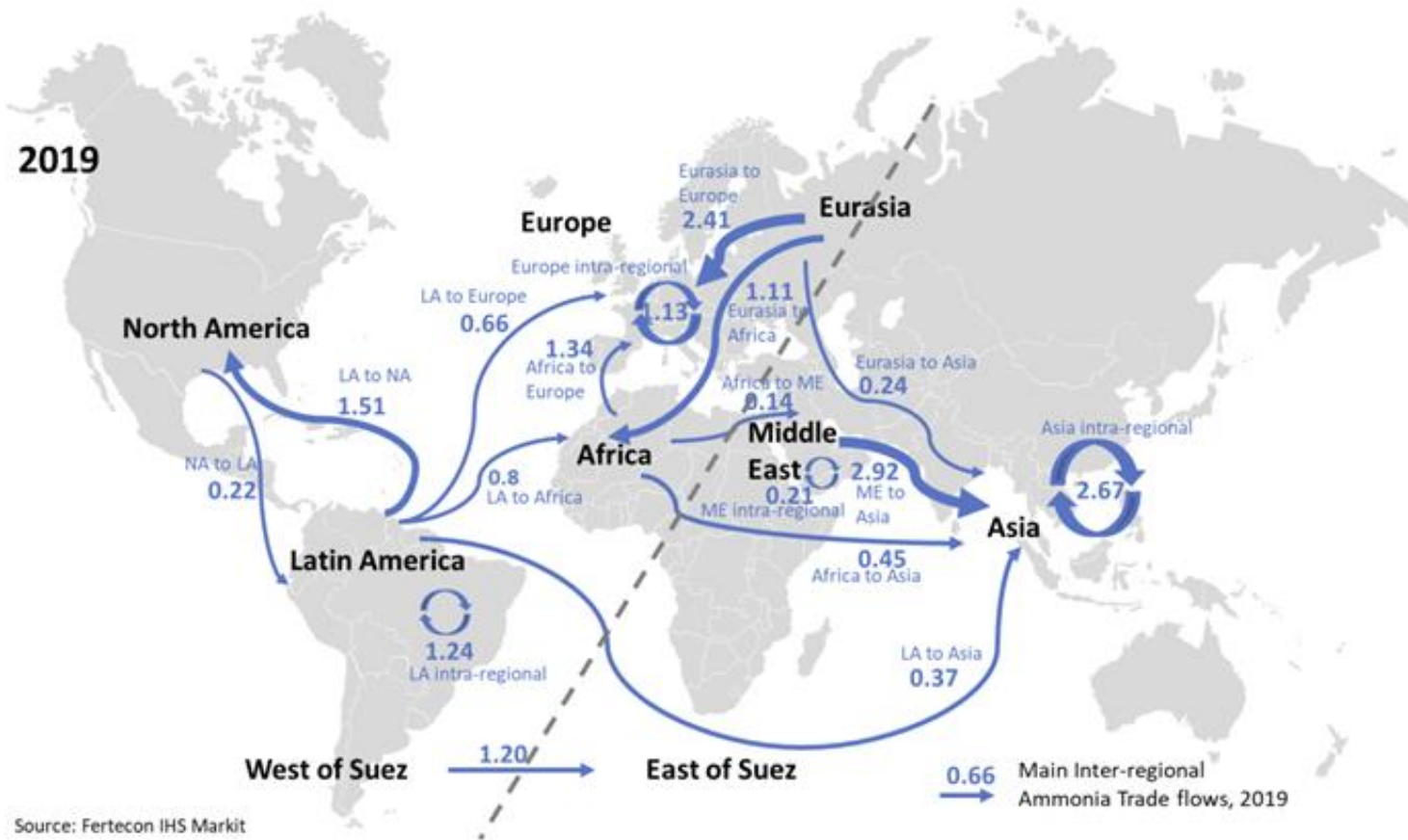


Figure 12. Map of global ammonia trade flows. Source Fertecon IHS Markit.

- ✓ Widespread infrastructure
- ✓ High hydrogen content
- ✓ High energy density
- ✓ Commercial technology
- ✓ Expected to be available as a fuel from mid 2020s
- ✗ Re-conversion energy consumption
- ✗ Re-conversion tech maturity
- ✗ Toxicity
- ✗ Process flexibility

Renewable ammonia could use existing infrastructure without the need for economies of scale and used directly instead of being reconverted to hydrogen

RD&D

- Improve technology performance
- Accelerate innovation
- Scale up multiple steps of the value chain

Partnerships

- Hydrogen alliances (with multiple stakeholders)
- Bilateral agreements for initial market
- Locally (industrial clusters, cities, valleys)

International standards

- Sustainability criteria
- Standardized design for the facilities
- Safety and regulation

Financing

- Off-take certainty
- CAPEX and OPEX support
- Public and private capital
- Market creation for products

There are multiple actions that governments can take to enable global trade