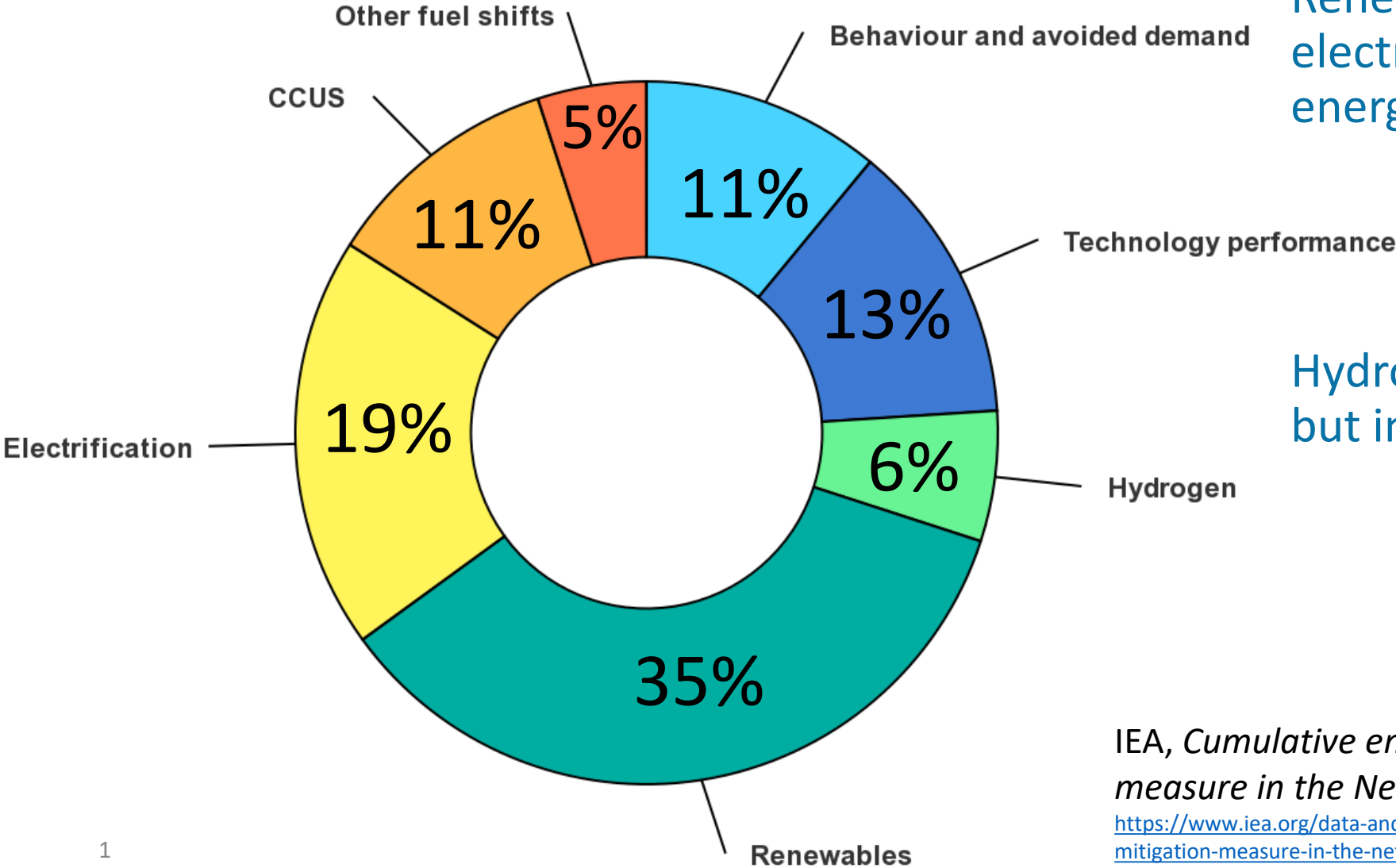


Mitigation of emissions in the Net Zero Scenario



Renewables and electrification dominate the energy transition

Hydrogen has a relatively small, but important part to play

IEA, *Cumulative emissions reduction by mitigation measure in the Net Zero Scenario, 2021-2050*

<https://www.iea.org/data-and-statistics/charts/cumulative-emissions-reduction-by-mitigation-measure-in-the-net-zero-scenario-2021-2050>

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Low emission hydrogen

Opportunities for Australia

New export opportunities

Supplying the materials used for making and using hydrogen

New industries producing low emissions products from hydrogen and renewables (e.g. steel, chemicals)

Greater energy security

Improved resilience of energy system

Employment opportunities, especially in regional areas

Incentive for more bilateral and multilateral collaboration

Interrelated Barriers

Uncertainty in markets: what applications will require hydrogen?

Current high cost of low emissions hydrogen

Complex infrastructure requirements for hydrogen supply chains across sectors and jurisdictions

Need for internationally agreed approach to certification of embedded greenhouse gas emissions

Need to rapidly scale up production and deployment of hydrogen technologies for production, storage, transport, and use to meet targets

This talk will focus on

Opportunities for Australia

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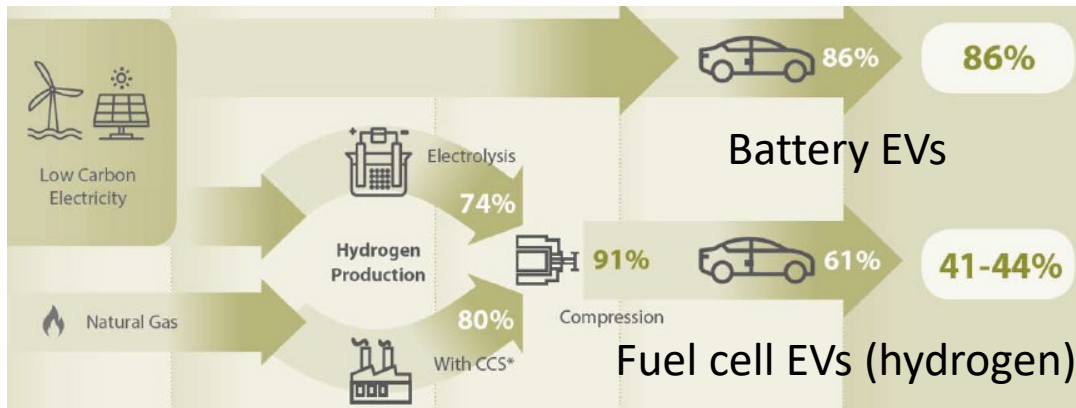
Need to rapidly scale up production and deployment of hydrogen technologies for production, storage, transport, and use to meet targets

Uncertainty in markets: what applications will require hydrogen?

Hydrogen must compete with incumbent technologies

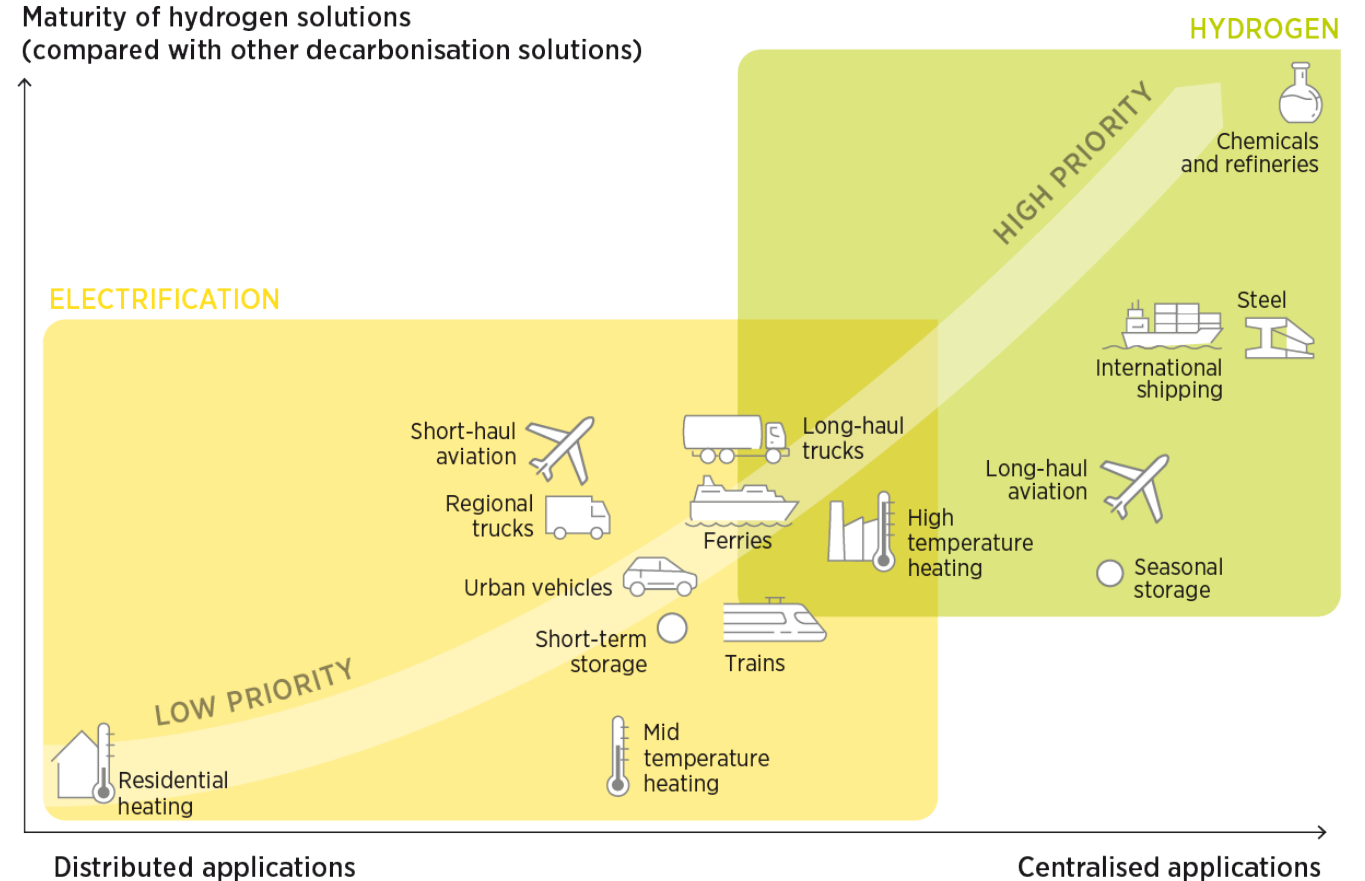
AND with other decarbonisation options – primarily electrification

- Efficiency penalty

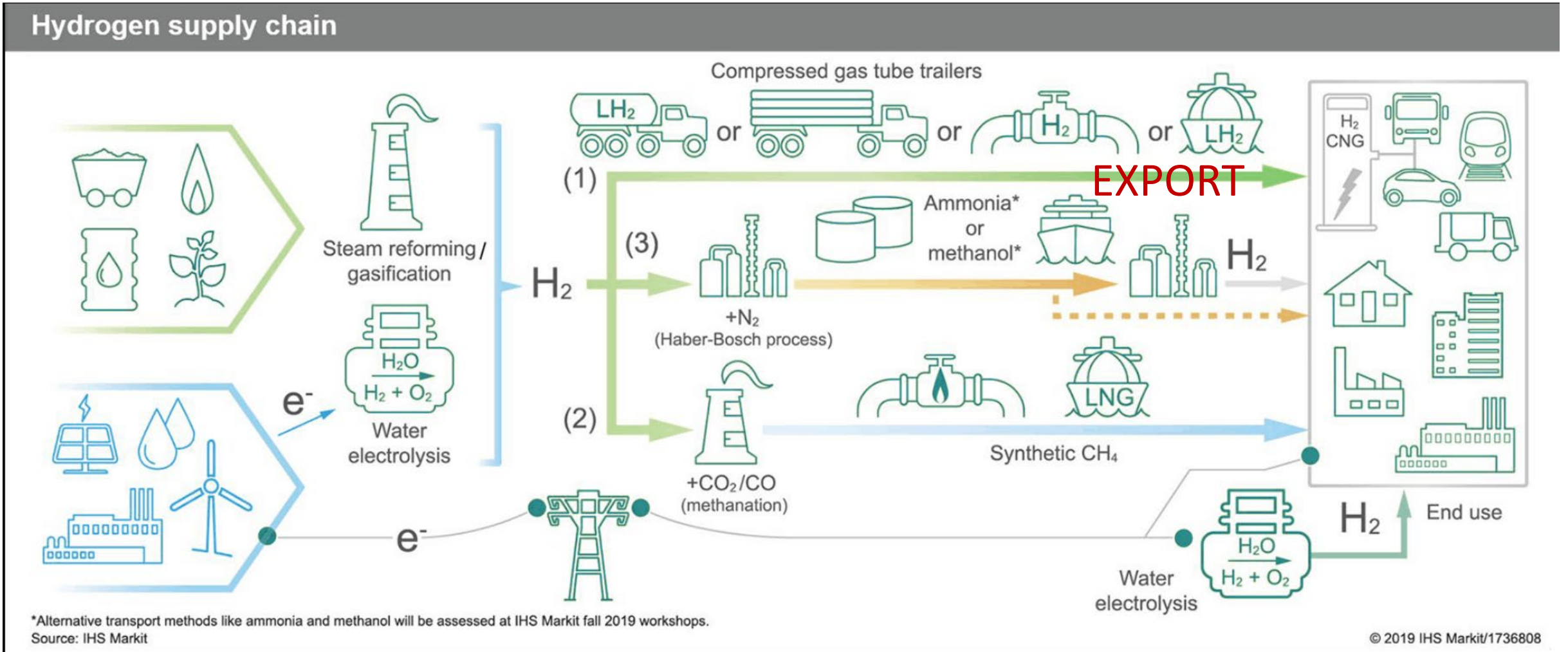


Adapted from *Hydrogen in a low-carbon economy*, UK Committee on Climate Change, 2018

- Less mature, more complex supply and distribution infrastructure



Complex infrastructure requirements for hydrogen supply chains across sectors and jurisdictions



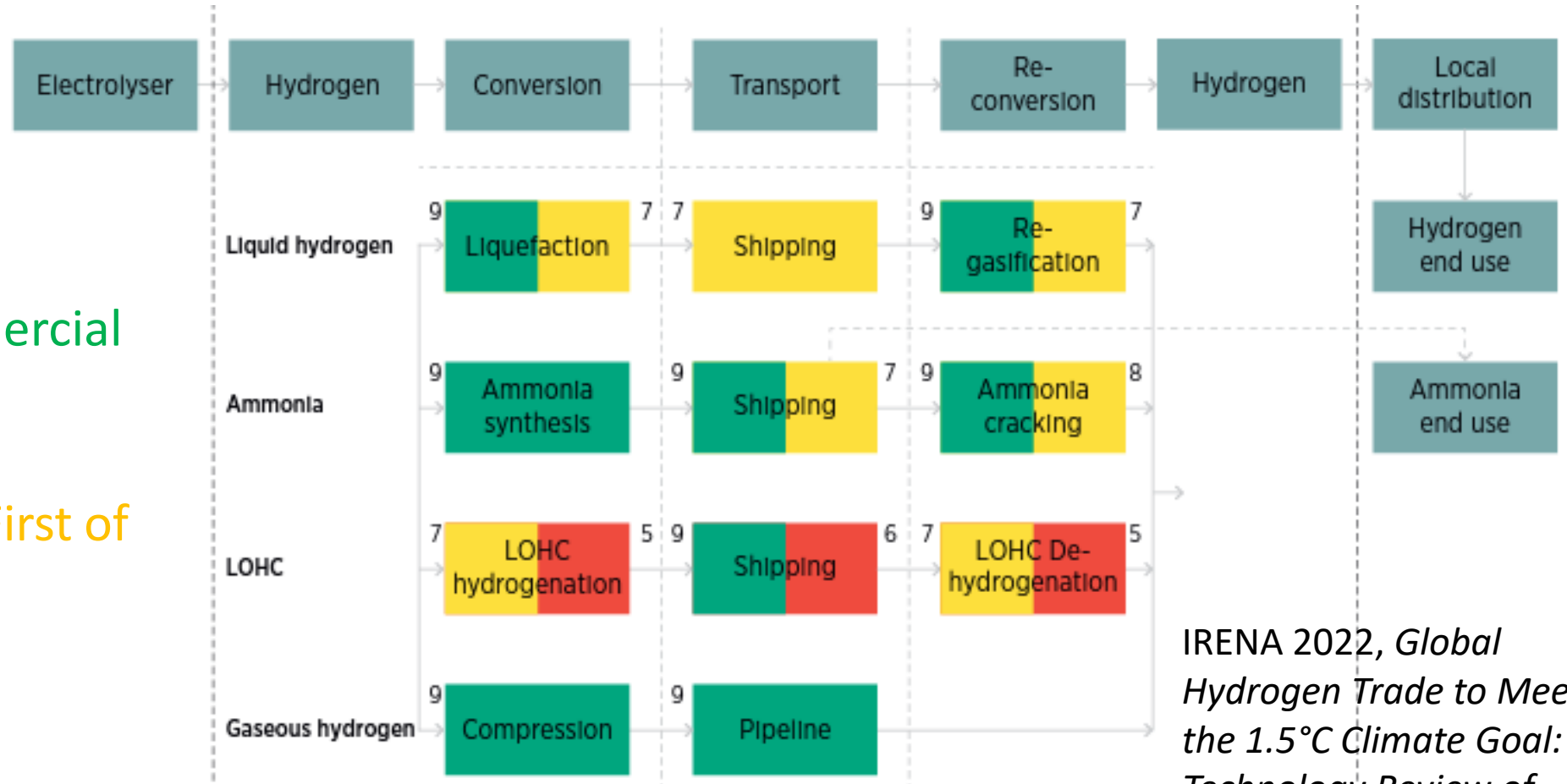
Complex infrastructure requirements for hydrogen supply chains across sectors and jurisdictions

“Traffic-lights” for technology maturity

Green = TRL 9 (commercial scale)

Yellow = 7-8 (Demo/First of kind)

Red <= 6 (prototype)



IRENA 2022, *Global Hydrogen Trade to Meet the 1.5°C Climate Goal: Technology Review of Hydrogen Carriers*

Example: Shipping liquid hydrogen

Pilot liquefied hydrogen carrier
"SUISO FRONTIER"

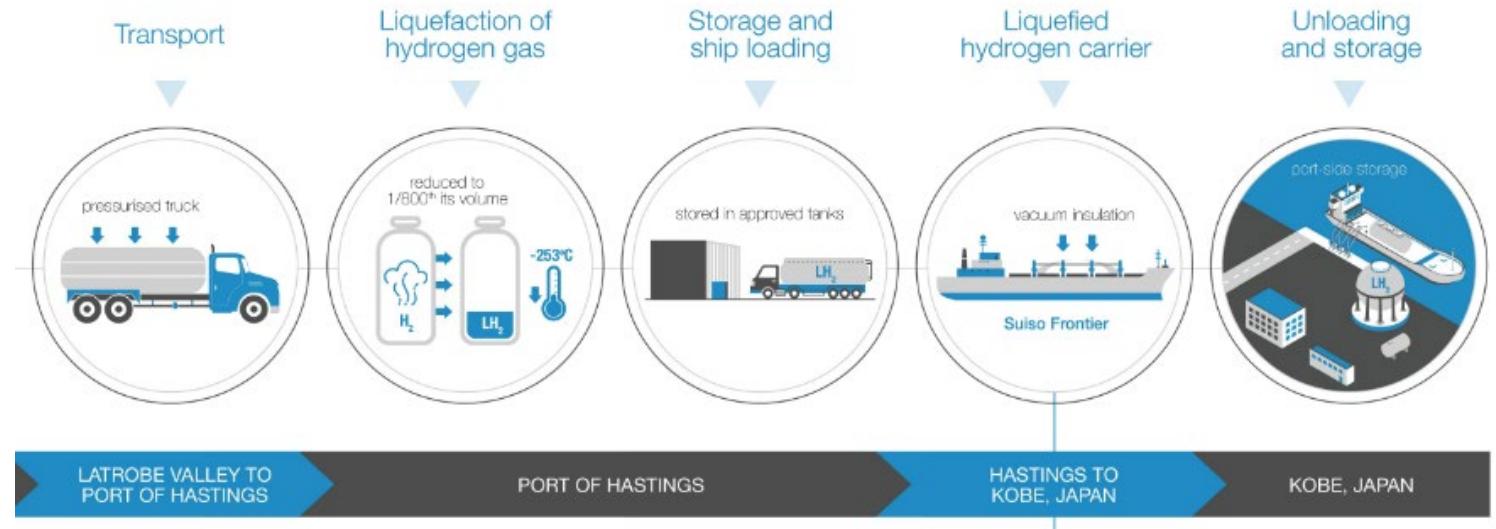


2 x 1250 m³ LH2 tanks

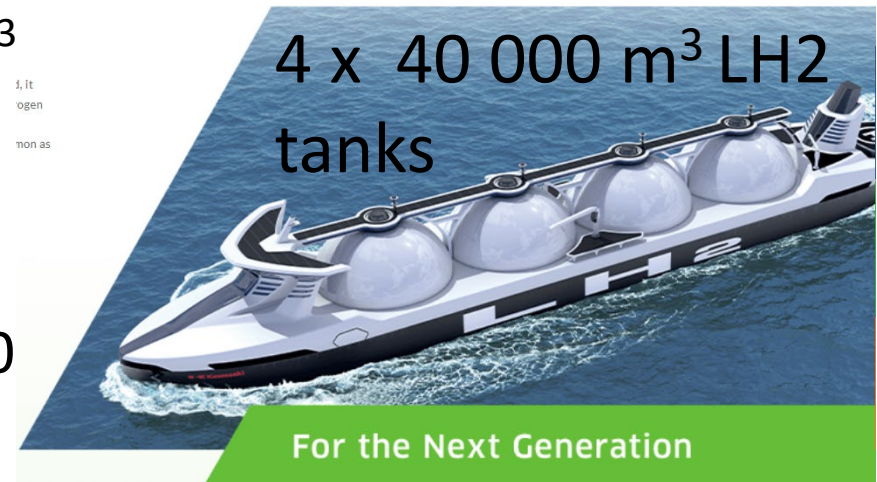
<https://global.kawasaki.com/en/hydrogen/>

<https://www.hydrogenenergysupplychain.com/>

Pilot Project Supply Chain



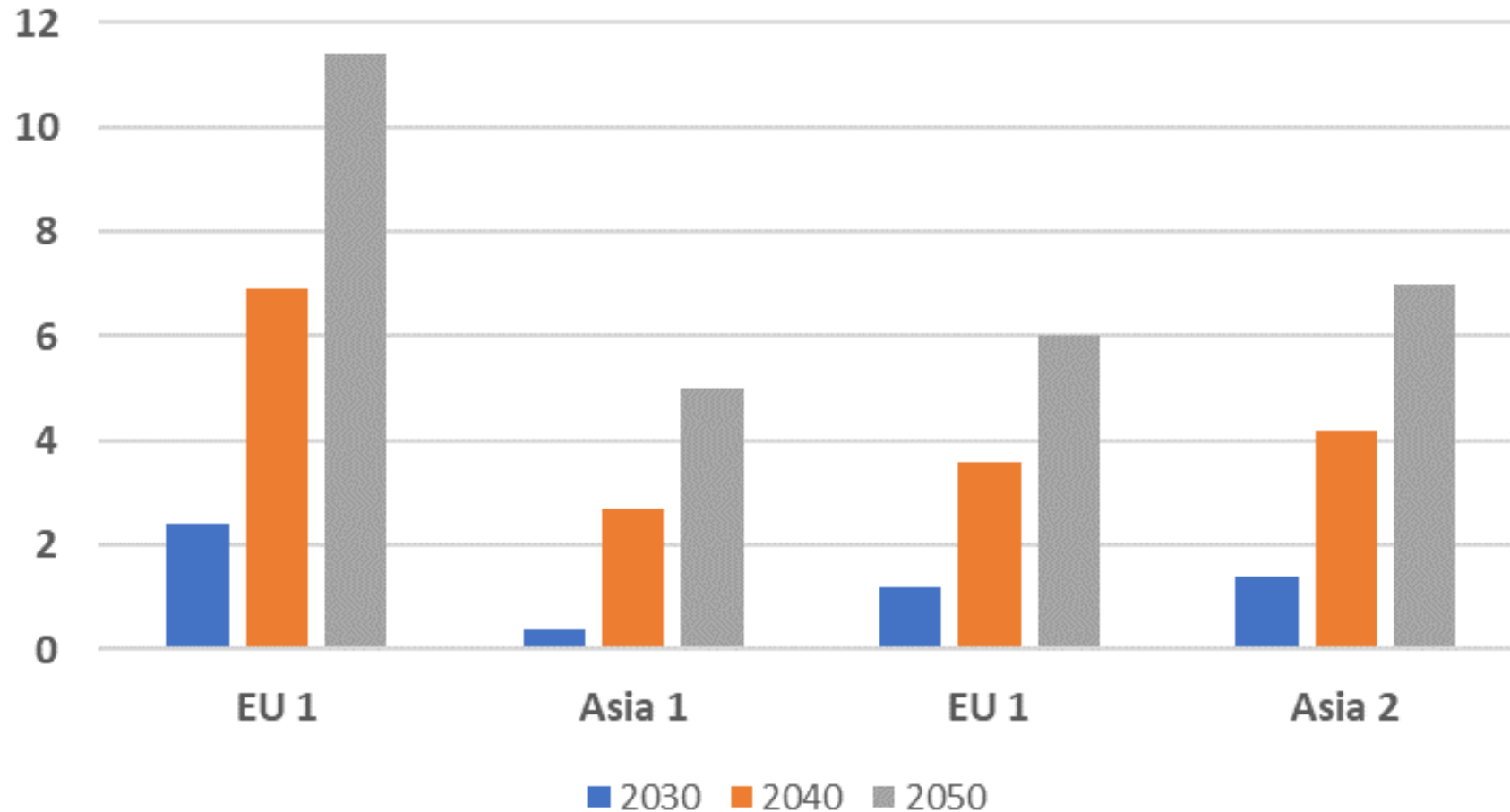
- Largest tank in operation is 3200 m³
- NASA started building a new 4700 m³ tank in 2019, operational in 2022
- Kawasaki have a design for a 10 000 m³ tank



New export opportunities: Global market for Hydrogen

- Current use of hydrogen (for energy) is close to zero
- Projections for new hydrogen demand are increasingly bullish
 - in 2018 ACIL Allen projected global hydrogen demand of 3 to 18MT in 2030
 - in 2019 the IEA projected demand of 44MT by 2030
 - in 2021 the Hydrogen Council projected new demand of 75MT by 2030
 - in 2022 IRENA estimated demand of 420MT by 2050 (of which 150MT would be globally traded)
- Australia exported 72 MT of LNG in 2021-22 (= to 30MT of hydrogen)
- In 2022 ACIL Allen examined four potential markets for H imports
 - reviewed hydrogen strategies, policies, and consulted stakeholders
 - we projected the demand for hydrogen imports in 2030, 2040, and 2050

Projected Hydrogen imports (MT, medium scenario)



Demand projected to grow from **5MT** in 2030 to **30MT** by 2050

The REpowerEU plan expects that the EU will import to be 10 MT in 2030

Australia is one possible exporter

So why import Australian hydrogen?

- Australia is a stable and reliable exporter (including of energy)
- Potential importers increasingly want **green** hydrogen
 - and Australia has the land and renewable energy needed to produce green hydrogen
- We have bilateral collaboration agreements on hydrogen technology with many countries (e.g. Germany)
 - Dr Mansmann, Germany's Innovation Commissioner for Green Hydrogen said *"I am fully convinced that 2045 and beyond that Germany will be depended on the supply of green hydrogen from Australia..."*
- In 2021 IRENA asked experts on hydrogen which countries were best placed to become major producers of hydrogen

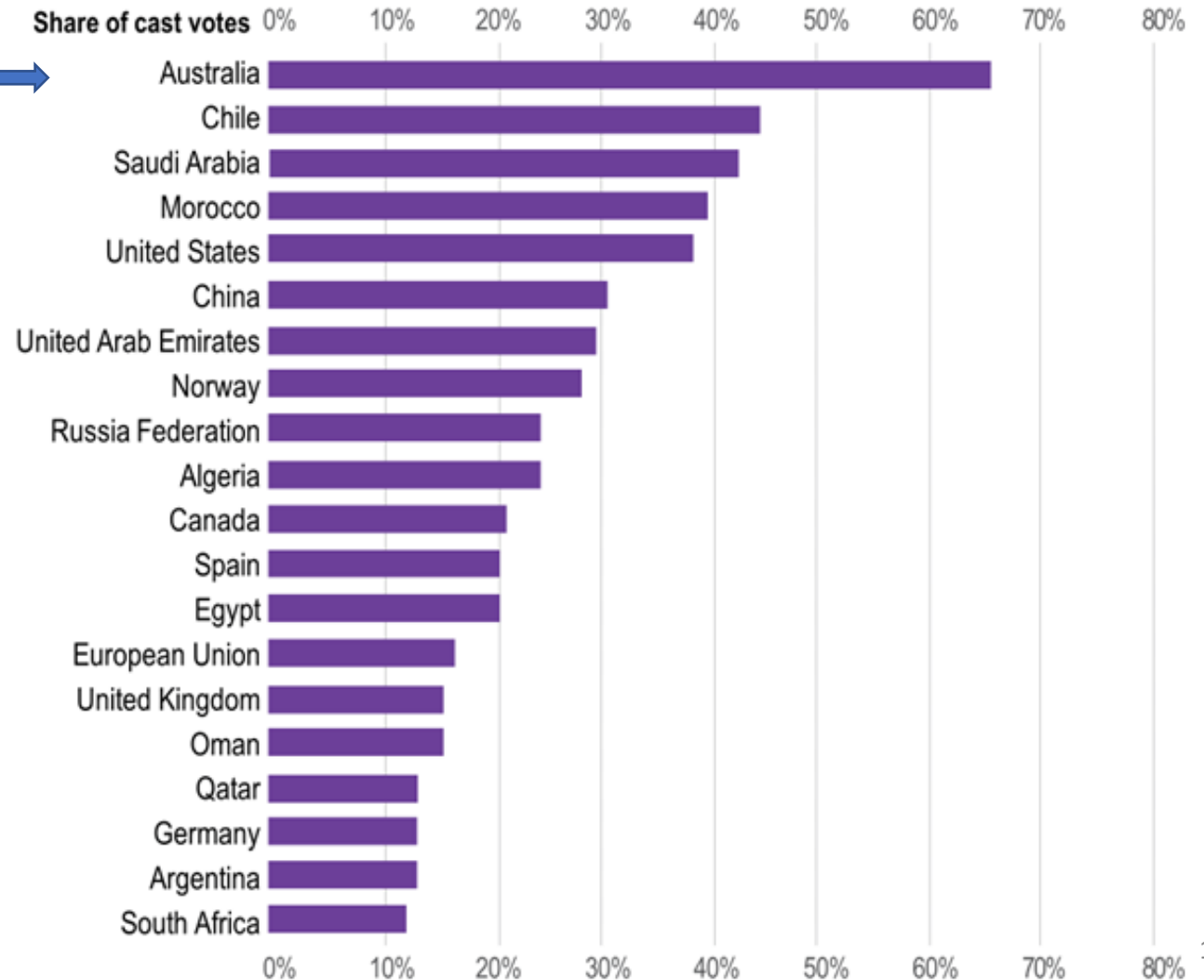
Expert views on countries best placed to export hydrogen

Australia tops the list



Australia is already the world's largest ammonia exporter

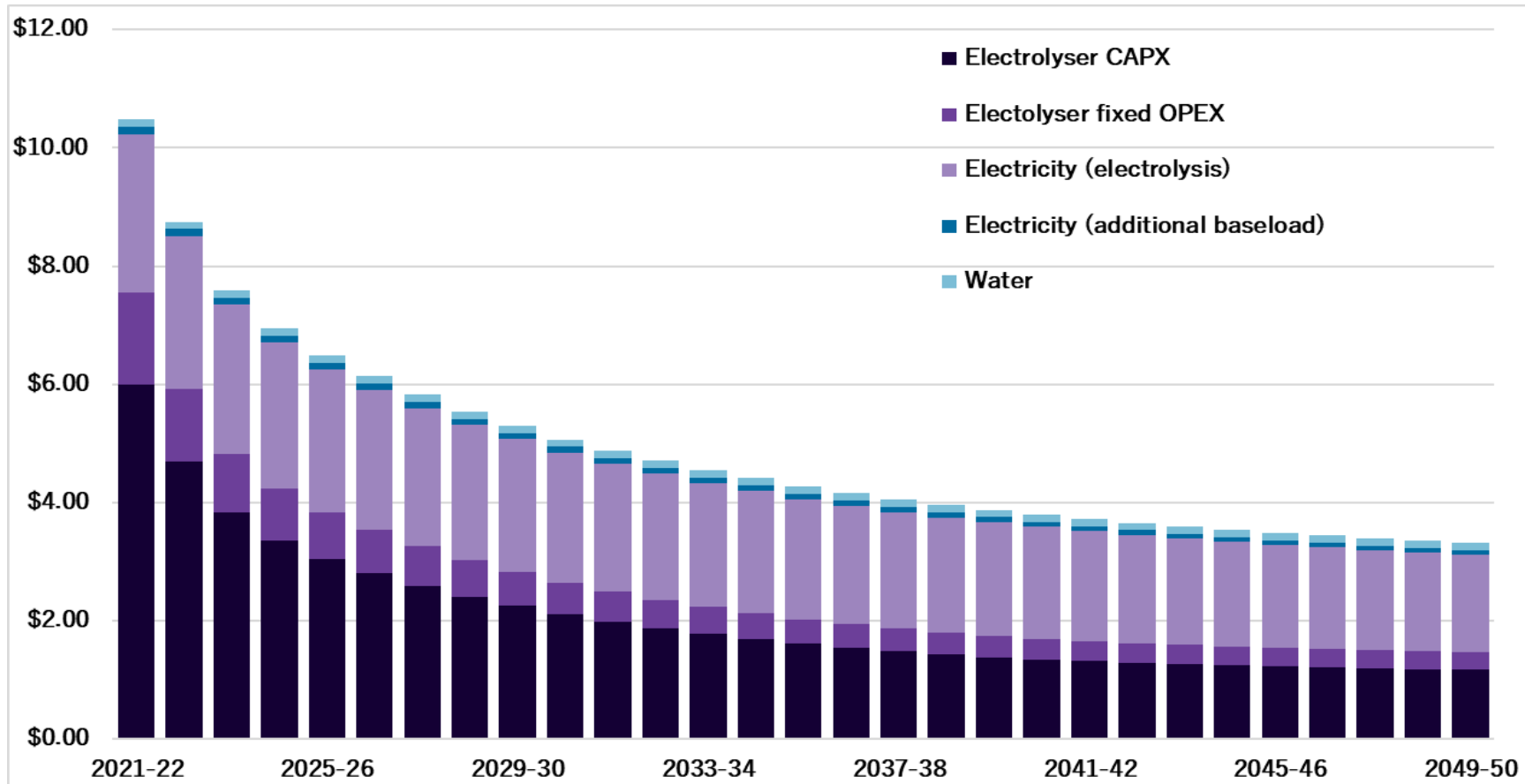
Australia is more likely to export hydrogen to Asia (Korea, Japan and Singapore)



Some thoughts on hydrogen prices

- No pricing data for international trade in hydrogen (not surprising, as there is not much trade)
- Most importers want prices of \$2 per kilo of hydrogen (or less)
 - same as Australia's "H2 under 2" target by 2030
- The war in Ukraine has seen a spike in natural gas prices, making hydrogen from electrolysis more competitive.
 - but there remains a gap between the production cost and what buyers are willing to pay
 - governments are looking at ways to bridge that gap
- Germany's H2Global double-auction program. Under the program a market intermediary will hold auctions to purchase hydrogen from non-EU suppliers through fixed-price, long-term contracts, and then conduct separate auctions to on-sell that hydrogen to EU buyers using short term contracts
 - the German govt will cover any losses from differences in the two contract prices
- US Inflation Reduction Act includes up to US\$3/kg tax credit for producing green hydrogen
- Possible Global European Hydrogen Facility - details are scant, but the indications are that it will provide support for overseas hydrogen projects that would export hydrogen to the EU
- ACIL Allen recently developed projections for cost of hydrogen production in WA.

Projected cost of hydrogen production



IRENA projects the LCOH of Australian hydrogen to be around \$2/kg by 2050.

Almost 60% of cost now is electrolyser CAPEX.

Declines to 35% by 2050

Some further reading

GENERAL

- IEA 2022, Global Hydrogen Review 2022, International Energy Agency <https://www.iea.org/reports/global-hydrogen-review-2022>
- IRENA 2022, Geopolitics of the Energy Transformation: The Hydrogen Factor, International Renewable Energy Agency, Abu Dhabi.

OPPORTUNITIES FOR AUSTRALIA

- **New export opportunities:** Burke et al., Contributing to regional decarbonization: Australia's potential to supply zero-carbon commodities to the Asia-Pacific, Energy, Volume 248, 123563 (June 2022) [[Journal Article](#)] [[Short Article](#)]
- **Supplying the materials used for making and using hydrogen:** IEA, World Energy Outlook, Special Report, [The Role of Critical Minerals in Clean Energy Transitions](#),
- **Jobs in regional areas:** Queensland Government, 2022, Hydrogen Industry Workforce Development Roadmap 2022-2032

BARRIERS

- **Hydrogen climate risks:** Collins, Hydrogen 'twice as powerful a greenhouse gas as previously thought': UK government study, Recharge, April 2022, [Short Article]
- **Infrastructure and cost** IRENA (2022), Global hydrogen trade to meet the 1.5°C climate goal: Part II – Technology review of hydrogen carriers, and Part III – Green Hydrogen Cost and Potential, International Renewable Energy Agency
- **Certification:** White et al. Towards emissions certification systems for international trade in hydrogen: The policy challenge of defining boundaries for emissions accounting, [[Journal Article](#)]

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Questions?