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H_2ydrogen, The H_2ype and the Reality

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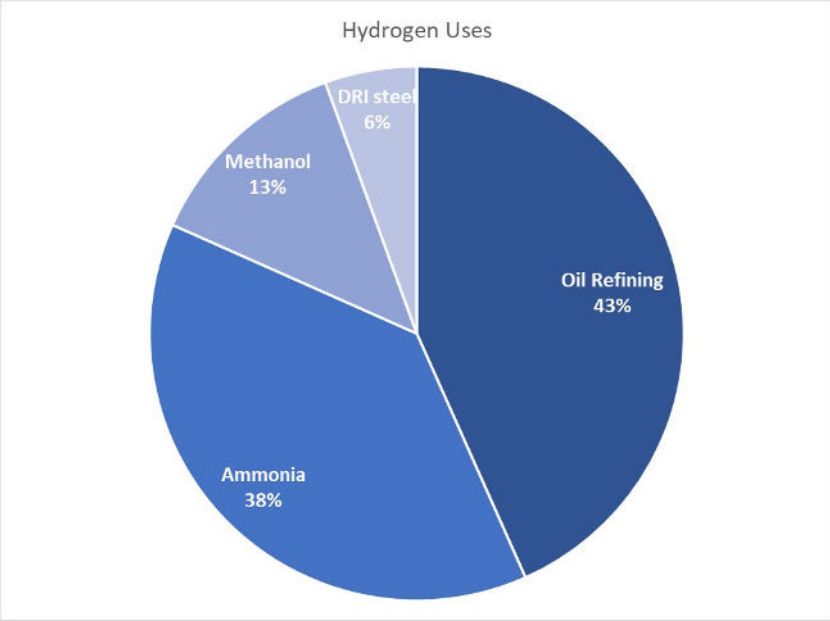
What do we know about the Hydrogen industry?

- How much Hydrogen is produced worldwide?
- What is it used for?



- 90 Mtpa (2020)

	Terminology	Technology	Feedstock/ Electricity source	GHG footprint*
PRODUCTION VIA ELECTRICITY	Green Hydrogen	Electrolysis	Wind | Solar | Hydro Geothermal | Tidal	Minimal
	Purple/Pink Hydrogen		Nuclear	
	Yellow Hydrogen		Mixed-origin grid energy	Medium
PRODUCTION VIA FOSSIL FUELS	Blue Hydrogen	Natural gas reforming + CCUS Gasification + CCUS	Natural gas | coal	Low
	Turquoise Hydrogen	Pyrolysis	Natural gas	Solid carbon (by-product)
	Grey Hydrogen	Natural gas reforming		Medium
	Brown Hydrogen	Gasification	Brown coal (lignite)	High
	Black Hydrogen		Black coal	

- How much of that is Green Hydrogen?
- How much of it is “low-carbon”?
- How much Hydrogen is produced in WA?
- How much Green Hydrogen is produced in WA?
- What is the largest electrolyser in Australia?
- The World?
- How much Hydrogen (per year) is produced from 1MW of an electrolyser?
- How much Green Hydrogen is planned for WA/Australia/Globally?

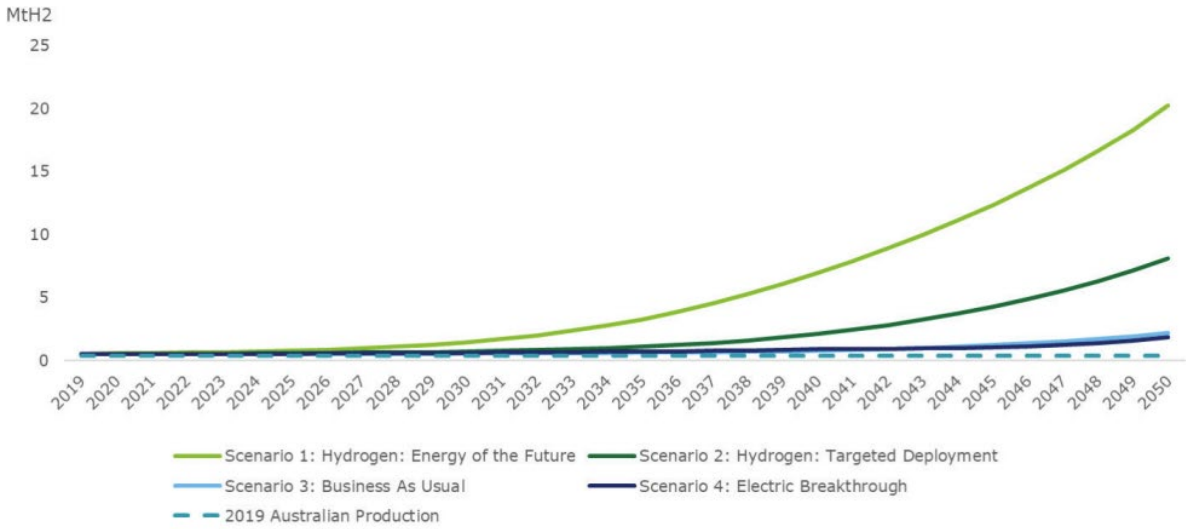
- 30,000+ tpa (0.03 Mtpa)
- 0.7 Mtpa (16 sites, including 6 refineries and a steel plant have CCUS capability),
- ~195,000 tpa (0.2 Mtpa)
- 23 tpa (0.26 MW Polymer Electrolyte Membrane (PEM) Electrolysis unit)
- 1.25MW (HypSA)
- 30 MW (China, 2021) ; 25 MW (Peru) 20 MW (Canada, 2021, 2800 tpa)
- 1MW = 60-140 tpa (max)

The Aspirations (Australia and WA)

Gov't:

- Australia National Hydrogen Strategy (2020):
  - 5 Mtpa by 2040
- UK
  - 1GW of LC Hydrogen by 2030
  - 140 ktpa by 2030

1 Mtpa H2 ~ 2.4 Mtpa LNG
1 GW ~ 140ktpa
1Mtpa ~ 7 GW



Source: Deloitte Analysis

Western Australian Renewable Hydrogen Strategy

- By 2022
  - A project is approved to export renewable hydrogen from WA
  - Renewable hydrogen is being used in one remote location in WA
  - Renewable hydrogen is distributed in a WA gas network
  - A refuelling facility for hydrogen vehicles is available in WA
- By 2040
  - WA market share of global hydrogen exports is similar to its LNG share in 2019 (~12%)
  - WA gas networks contain at least 10% renewable hydrogen
  - Renewable hydrogen is widely used in mining haulage vehicles
  - Renewable hydrogen is a significant fuel source for transportation in regional WA

Others aspirations / moonshots?

Announcements

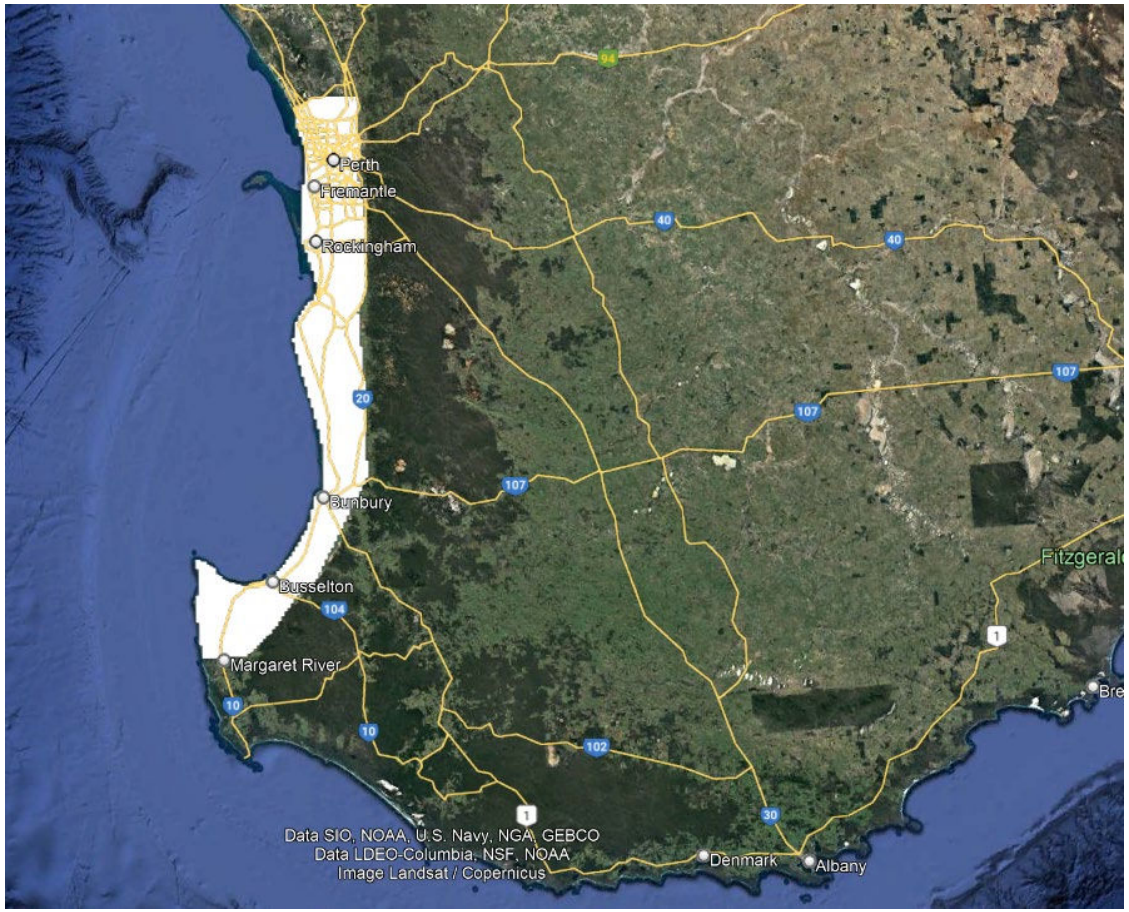
- 2018 - May 2021 “Asian Renewable Energy Hub”, by 2027/28
  - 6,500km^2 Solar/Wind, 26 GW of generation
  - 23GW for Hydrogen and Ammonia production
  - 1 – 1.8 Mtpa Hydrogen (40 – 80 tpa/MW)

  Did not get federal approval

- July 2021 “Western Green energy Hub”,
  - 15,000km^2 Solar/Wind, 50 GW of generation
  - A small country – bigger than East Timor, Vanuatu, Qatar, Lebanon
  - The equivalent of the current Eastern States “National Electricity Market” (NEM)
  - 3.5 Mtpa of Hydrogen (70 tpa/MW)

- July 2021 Fortescue Future Industries “15 Mtpa by 2030”
  - Requires ~110 GW of (firm) power and electrolysers (140 tpa/MW)
    - 2x current Eastern States “National Electricity Market” (NEM)
    - 3600x current largest electrolyser
    - 1000x largest announced planned electrolyser (100 MW Egypt)

- March 2022
  - FFI – E.On - MOU for “up to 5 Mtpa by 2030”
    - 35-70 GW of electrolysers



6,500km^2 on the Perth Coastal Plain

Planned Hydrogen Production in WA

There are several Hydrogen projects planned
The Hazer project is due to start up in 2022
Two 10 MW electrolyser projects in regional Western Australia have received ARENA funding

The Hazer group received funding from ARENA ($8 M Sep 2019) and is currently constructing a commercial demonstration plant to produce “turquoise” hydrogen and graphite from biogas.

- Hazer aims to produced approximately 100 tpa of hydrogen and 380 tpa of graphite
- It will use approximately 2 million Nm^3/year of biogas from sewage
- It is located at the Woodman Point Waste-Water Treatment Plant just north of the Kwinana Industrial Area.
- The Hazer process originated from UWA.
- Was to have been commissioned in Q1 2021 (2019) – construction defects found in Dec 2021, now RFSU anticipated end 2022.

Both Yara fertilisers and ATCO have also received ARENA funding (May 2021) for 10 MW PEM electrolysers.

- Yara ($42 M) are planning to produce 640 tonnes of hydrogen to create 3,700 tonnes of green ammonia per year at their site on the Dampier peninsular (62.5 tpa/MW)
- ATCO ($29 M) are planning blend their hydrogen produced at the Warradarge Wind Farm into the DBNGP to reduce emissions from the gas network

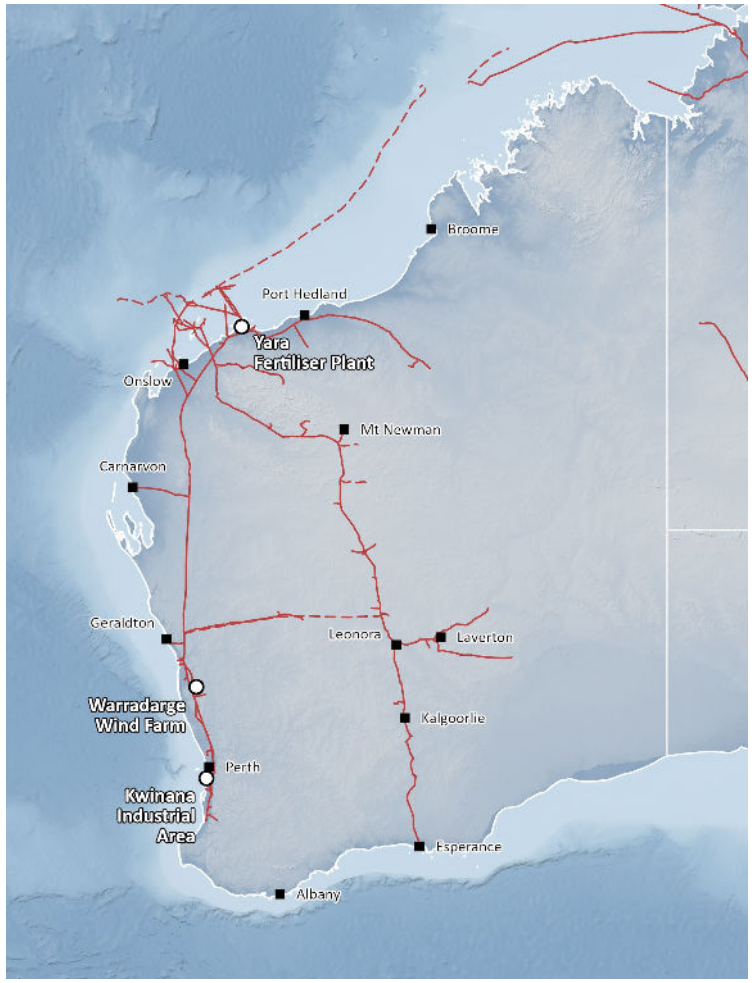
FID’s for both were anticipated in 2021, but neither project has been sanctioned.

- Yara submitted a revised proposal to the EPA in April
- ATCO website indicates they are (were) aiming for FID in Feb 2022.
- Neither project will supply hydrogen into the local Perth market, or exports.

FEnExCRC and UWA are planning a hydrogen/LNG testing and training facility at Kwinana (KETH)

- 2 MW PEM Electrolyser capable of producing 235 tpa of hydrogen (120 tpa/MW)
- No fixed dates

Election funding for hydrogen hubs in the Pilbara and Kwinana



The plans for Green Hydrogen.

Actual plans for Green Hydrogen are advancing slowly but steadily…history tells us that commercialisation takes time

Actual plans:
In WA ~1500 tpa may be operational by 2025

- Germany, 24MW PEM, end 2022 (3,300 tpa)
- Norway, 24 MW PEM, end 2023 (3,300 tpa)
- France, 40MW, may be operational in 2025, (5,500 tpa)
- Canada, 88MW may be operational in 2024, (11,000 tpa)
- Egypt, 100MW may be operational in 2024 (15,000 tpa)

Globally we may have 0.05-0.1 Mtpa by 2025.

First Hydrogen test shipment February 2022

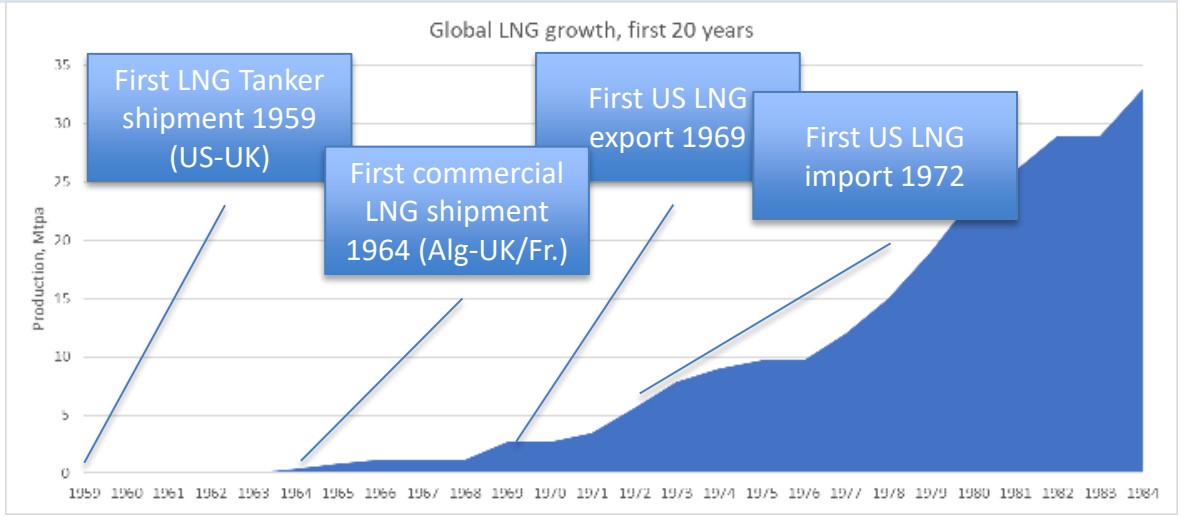
- Victoria to Japan, Suiso Frontier, 3 t (capacity 1,250m^3 or ~75 t H_2)

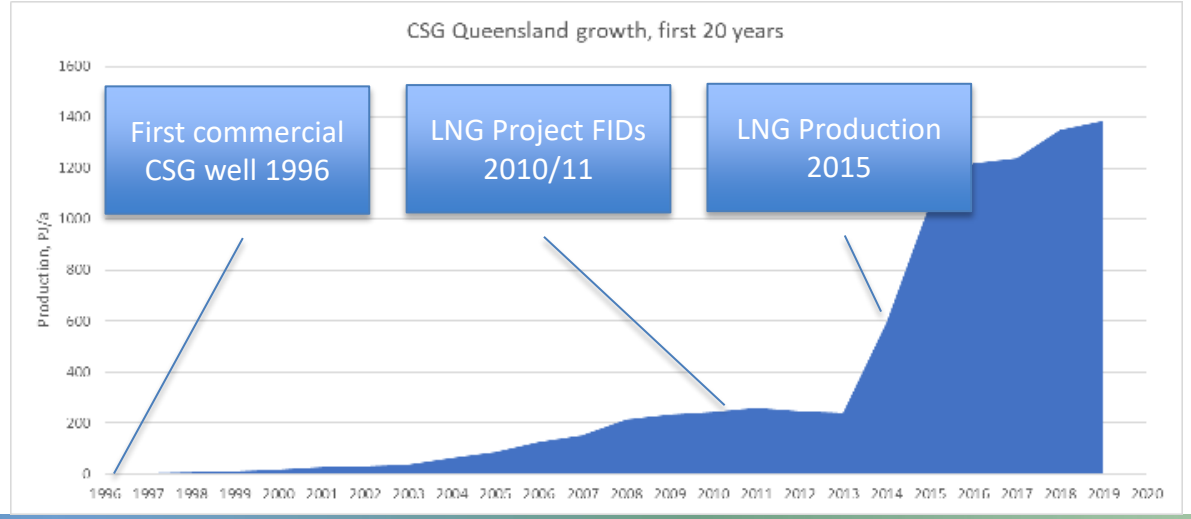
FFI Green Energy Manufacturing Centre

- Will build 2 GW of electolysers per year, starting in 2023.

Comparison with growth of LNG and CSG

- It could take 20 years to get to “scale”





The gaps in the story.

There is a large gap between aspirations and actual plans

This is something the IEA has noted, but has not made much noise about…

IEA suggests that installed electrolyser capacity could climb to 54-90 GW (7-13 Mtpa) by 2030 if all planned projects go ahead.

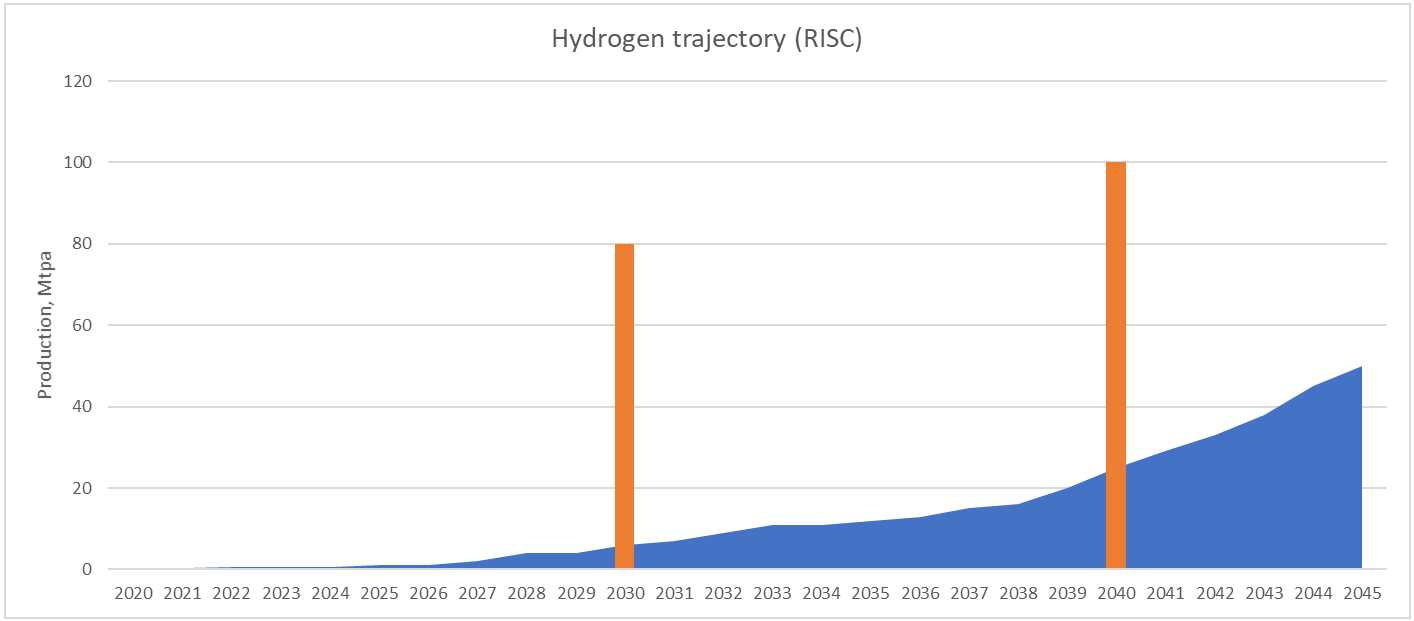
- This includes 21 GW in Australia by 2030

If we use similar projections to the LNG and CSG development timelines, and plans under the IEA Announced Pledges Scenario, globally:

- We may have 5-10 Mtpa operational by 2030
- We may have 25-30 Mtpa operational by 2040
  - This will require 180 GW of renewable electricity generation on top of any current plans to replace emissions intensive power generation

This falls well short of the IEA perceived need for Green Hydrogen in their Net Zero Emissions scenario:

- Green H_2 production of ~100 Mtpa by 2040
- Requiring 700-2000 GW of additional generation.



Closing thoughts

- Hydrogen is currently a “dirty” fuel - it results in emissions of over 900 MT CO_2 per year.
- Replacing the current production (90 Mtpa) by electrolysis would require ~630 GW of electrolysers and associated renewable power generation.
- There is a clear gap between aspirations / announcements and action / plans.
- The development of a large-scale commercial hydrogen market, if successful, is likely to take a couple of decades.
- Power requirements to support the large-scale production of green hydrogen are in addition to the requirements of replacing existing emissions intensive power generation.

- Historically we have never completely replaced or substituted out a fuel source, we’ve just added to the mix…

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