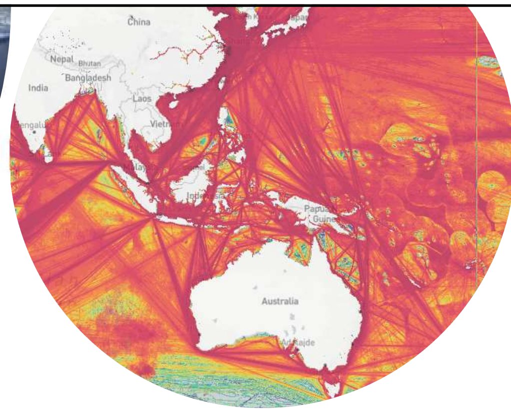

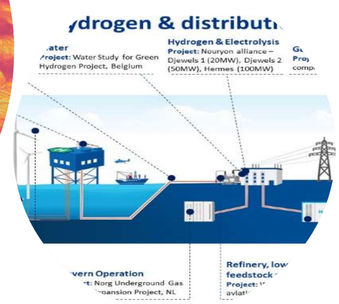

Green Hydrogen Port Site Selection

PIANC APAC 2022 – 2nd PIANC Asia Pacific Conference

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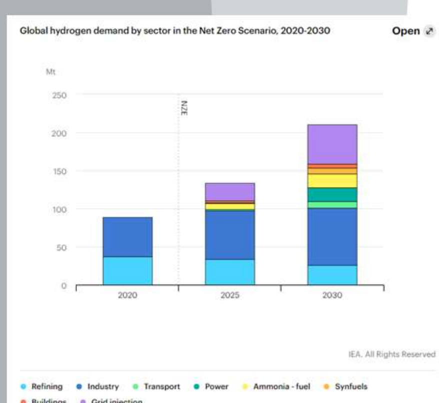
Introduction



- IEA 2050 forecast of 530 MT/annum of hydrogen for fuels
- Requires 2,200 GW of electrolysis if to be green. 3,500 GW renewable energy to support
- Global installed electricity production 7,500 GW

- Many countries don’t have sufficient year-round renewable energy resources
- Different methods to transport hydrogen, different advantages and risks

- Require export/import of hydrogen through ports to support global energy demand – range of factors to consider

IEA, Global hydrogen demand by sector in the Net Zero Scenario, 2020-2030, IEA, Paris https://www.iea.org/data-and-statistics/charts/global-hydrogen-demand-by-sector-in-the-net-zero-scenario-2020-2030

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Glossary

Vessel

A tank or other container used to hold product

Carrier

Chemical that contains hydrogen. May or may not be used directly to produce power

Ship

Floating tank/vessel, used to transport a hydrogen carrier, between ports around the world

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Selection of Hydrogen Carrier – Examples

Liquid hydrogen

- Cryogenic <-253°C
- Short pipeline distance
- Low density – large tanks and ships
- Relatively small exclusion zones required
- Already in hydrogen form at delivery
- Pilot stage only

Liquid Organic Hydrogen Carriers (LOHC)

- Liquid at atmospheric temperature and pressure
- Utilise existing petrol/diesel/crude ships and tanks, safety
- Some can be used for energy, others need to separate hydrogen
- May produce CO_2

Ammonia

- Cold (<-33°C)
- Medium distance pipeline
- Small ships for same mass of hydrogen
- Highly toxic – terrestrial and aquatic – large exclusion zones.
- Development needed to use as energy source
- Already operating at global scale

eLNG

- Similar to existing LNG, but produced synthetically
- May use biowaste source of carbon
- Existing infrastructure for transport and use as power source
- Produces CO_2

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Port Site Considerations

- Hydrogen carrier selection
- Distance from production facility to export berth
- Availability of port land for production facility
- Safety and Risk – surrounding community and industry
- S&R – port operations
- Future demand and ship size

- *Non-S&R impacts to the surrounding environment and communities*
- *Re-use of existing facilities*
- *Material Offload Facility (MOF)*
- *Water availability*
- *Power infrastructure*
- *Proximity to Renewable Energy Zones (REZ)*
- *Minimise CAPEX/OPEX*

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Offshore options – MBM, SPM, TLU, FSO, FPSO, Offshore jetty, iQuay etc.

https://imodco.com/new-energies/
https://www.orwelloffshore.com/products/cbm/#pid=8
https://maritime-executive.com/article/largest-fsru-goes-to-hong-kong-s-first-lng-import-terminal

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Distance between Production Facility and Export Berth

Carrier	Distance	Limitation	Mitigation
Liquid Hydrogen	0.5-1 km	Heat leakage	Increase insulation
LNG	1.5-2 km	Heat leakage	Increase insulation
Ammonia	Approx. 6 km	Heat leakage	Increase insulation
Ammonia	>6 km	Ship re-liquefaction plant	Slower loading as ship reliquefies product
LOHC	> 6 km	Loading control, flushing lines	

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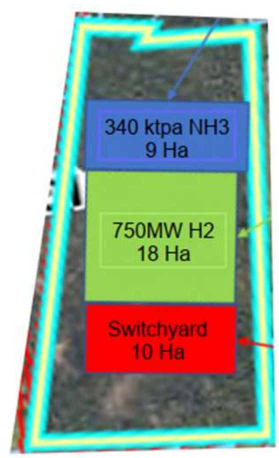
Availability of port land

- Hydrogen production
- Carrier production
- Switchgear



- Laydown area for construction
- NPI - export pipelines, roads, etc.
- Desalination
- Renewable energy production

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Safety and Risk – Heat Radiation

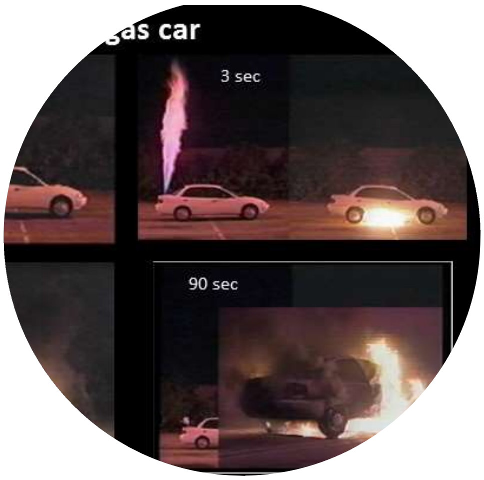

Table 1: Effects of Heat Radiation

Heat Radiation [kW/m²]	Effect
1.2	Received from the sun at noon in summer
2.1	Minimum to cause pain after 1 minute
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds exposure (at least second degree burns will result)
12.6	Significant chance of fatality for extended exposure. High chance of injury After long exposure, causes the temperature of wood to rise to a point where it can be readily ignited by a naked flame Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure.
23	Likely fatality for extended exposure and chance of fatality for instantaneous exposure Spontaneous ignition of wood after long exposure Unprotected steel will reach thermal stress temperatures which can cause failures Pressure vessel needs to be relieved or failure will occur
35	Cellulosic material will pilot ignite within one minute's exposure Significant chance of fatality for people exposed instantaneously

- Once product is burning
- Different products burn in different ways
  - E.g. hydrogen may not be as dangerous as petrol

https://hydrogen.wsu.edu/2017/03/17/so-just-how-dangerous-is-hydrogen-fuel/
NSW Department of Planning, Hazardous Industry Planning Advisory Paper No 6 Hazard Analysis, 2011

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Safety and Risk – Gas Exposure and Explosion Overpressure

- ***AEGL 1***: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
- ***AEGL 2***: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
- ***AEGL 3***: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Each of the three levels of AEGL: AEGL-1, AEGL-2, and AEGL-3, have generally been developed for each of five exposure periods: 10 minutes, 30 minutes, 1 hour, 4 hours, and 8 hours.

- Ammonia usually limiting factor
  - WA guidance interpreted as 1.5-2 km from sensitive receptors for ammonia

Table 2: Effects of Explosion Overpressure

Explosion Overpressure	Effect
3.5 kPa (0.5 psi)	90% glass breakage No fatality and very low probability of injury from overpressure.
7 kPa (1 psi)	Damage to internal partitions and joinery, but can be repaired Probability of injury is 10%. No fatality
14 kPa (2 psi)	House uninhabitable and badly cracked
21 kPa (3 psi)	Reinforced structures distort Storage tanks fail 20% chance of fatality to a person in a building
35 kPa (5 psi)	House damaged beyond repair Wagons and plant items overturned Threshold of eardrum damage 50% chance of fatality for a person in a building and 15% chance of fatality for a person in the open
70 kPa (10 psi)	Threshold of lung damage 100% chance of fatality for a person in a building or in the open Complete demolition of houses

NSW Department of Planning, Hazardous Industry Planning Advisory Paper No 6 Hazard Analysis, 2011
Committee on Acute Exposure Guideline Levels, Committee on Toxicology, National Research Council, Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 6, 2007

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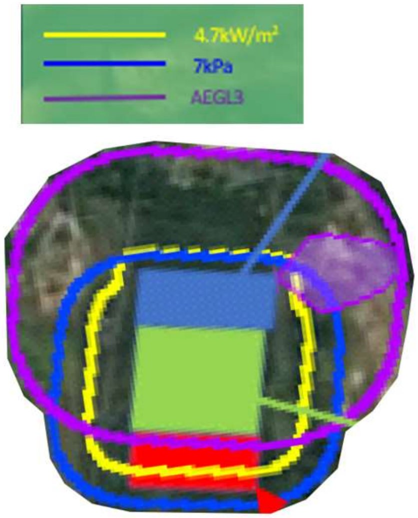
Safety and Risk – Examples

- Concept level use screening values
- Quantitative Risk Analysis later in design
  - e.g. – 750 MW H2/340 ktpa NH3
    - Ammonia (AEGL3, 60mins) is approximately 400 m
    - Heat and explosion can be kept within site boundaries



WA EPA, Guidance for the Assessment of Environmental Factors, Separation Distances between Industrial and Sensitive Land Uses, 2005

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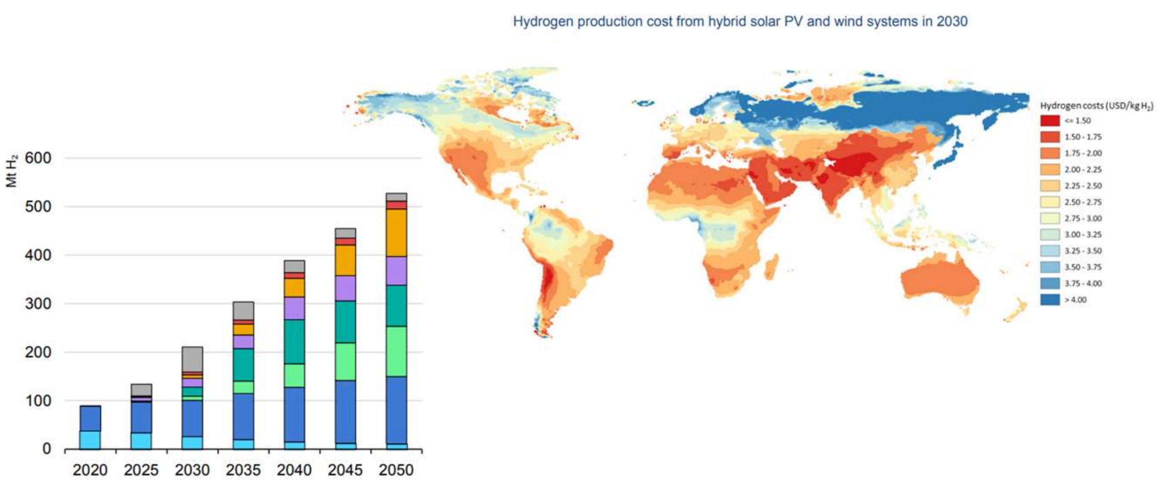
Future demand and ship size



IEA, Global Hydrogen Review 2021, https://iea.blob.core.windows.net/assets/5bd46d7b-906a-4429-abda-e9c507a62341/GlobalHydrogenReview2021.pdf

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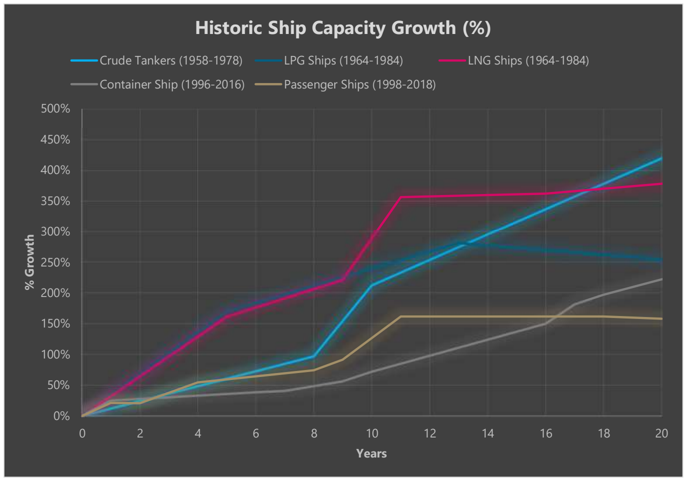
Future demand and ship size



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Conclusion

- Many factors need to be considered when undertaking site selection for hydrogen
- Still in its infancy and the market still to determine preferred options
- Each project will have specific limitations and drivers from producer, port and importer perspective

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Questions?

Hydrogen is the smartest!

The rest of the elements are denser

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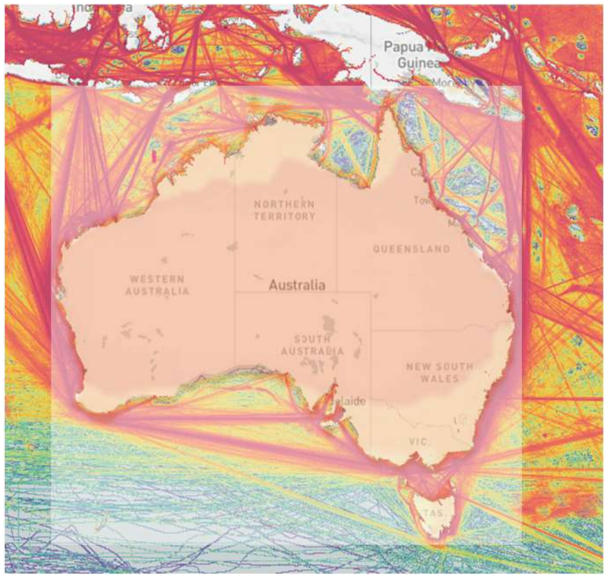

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