Global Hydrogen Market Prospects

And Synergies with LNG

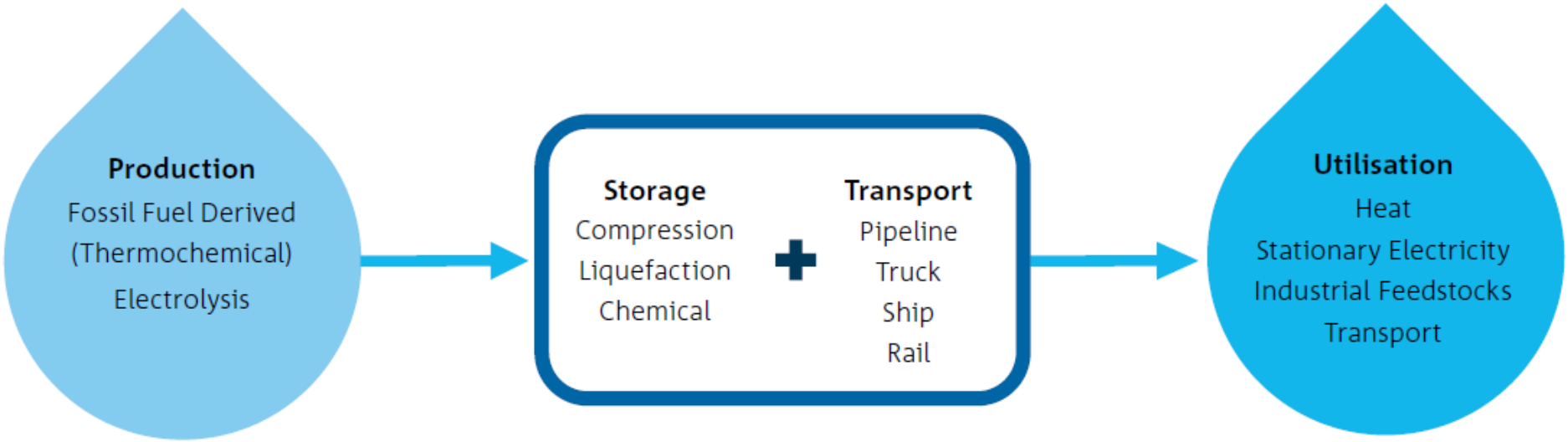
Roberto F. Aguilera

Curtin University
OIL AND GAS INNOVATION CENTRE

Outline

- Hydrogen value chain and applications
- Blue versus Green H2
- Natural gas, LNG markets & prospects
- Synergies between LNG and H2
- Constraints and opportunities for H2 transition
- Outlook for H2 in energy mix

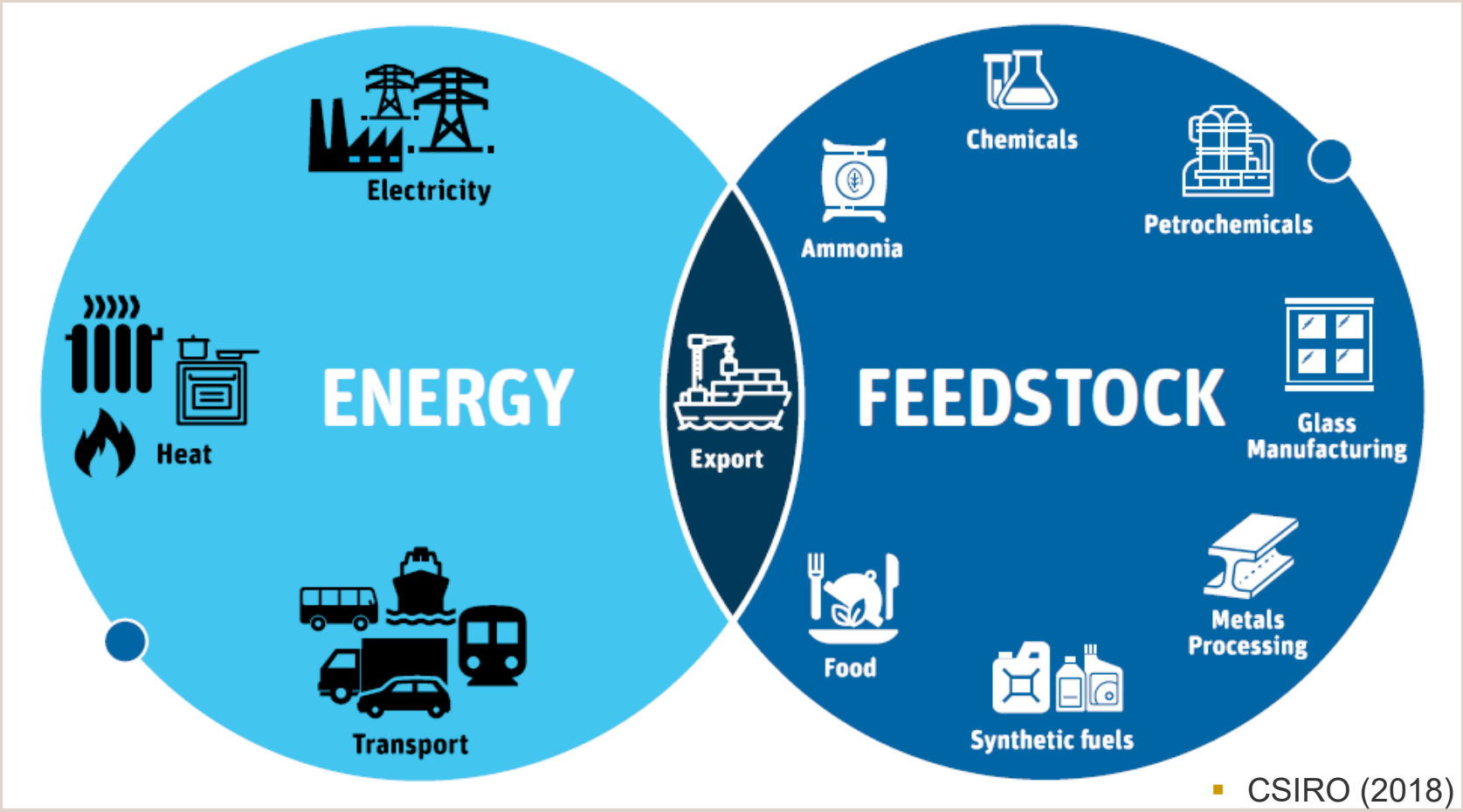
Hydrogen value chain



- Source: CSIRO (2018)

- H2 produced using various sources
- Several H2 transport methods
- Application in many end use sectors

Hydrogen applications



- CSIRO (2018)

- Like oil & gas, H2 useful as energy source or feedstock

Generation | Conversion | Storage / Transportation | Application

Green/clean hydrogen

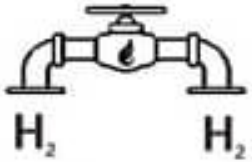
Wind or solar farms generate surplus energy

Electrolysis

- **Cost: $4-6 / kg**

Liquefied Hydrogen Gas

Natural Gas terminals



Natural Gas pipelines

Fuel cell cars, trains, public transport

Householding, appliances, heating

Petrochemicals, steel, refineries

Direct use electricity

- Source: Venture Insights (2017)

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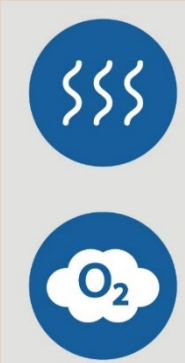
Blue hydrogen (sometimes grey)



Steam methane reforming

Partial oxidation

- **Cost: $2-3 / kg**

- Source: Energy Information Australia (2019)

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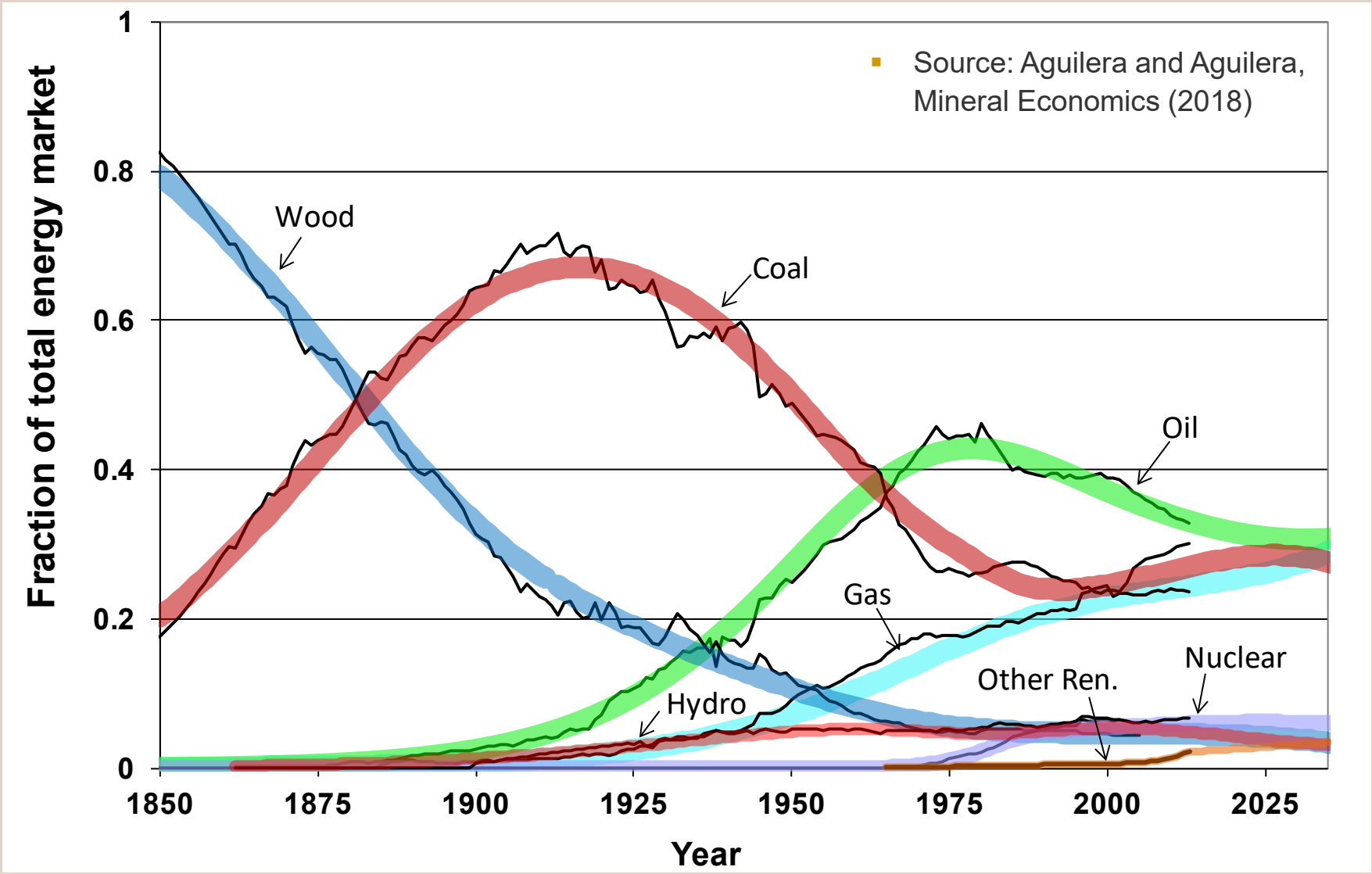
Primary energy mix (1850 - 2035)



- Low prices extend O&G use for longer time period

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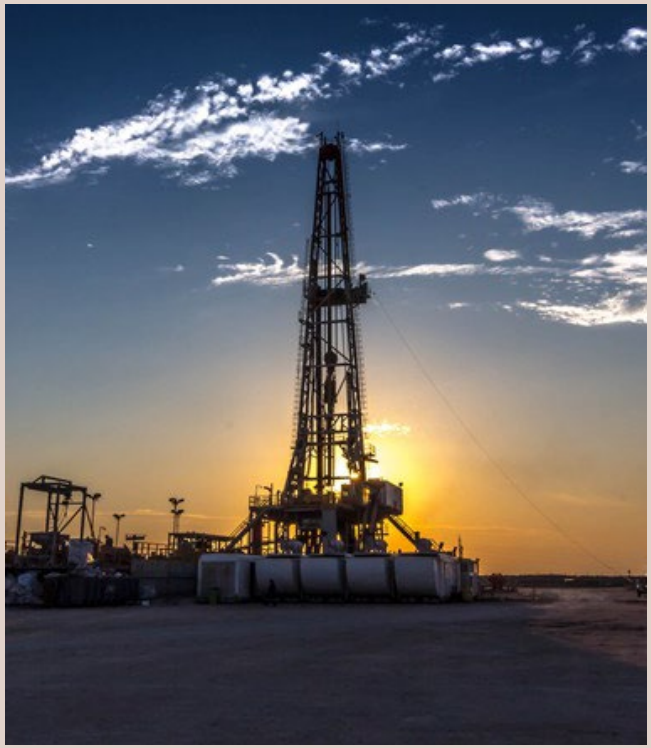
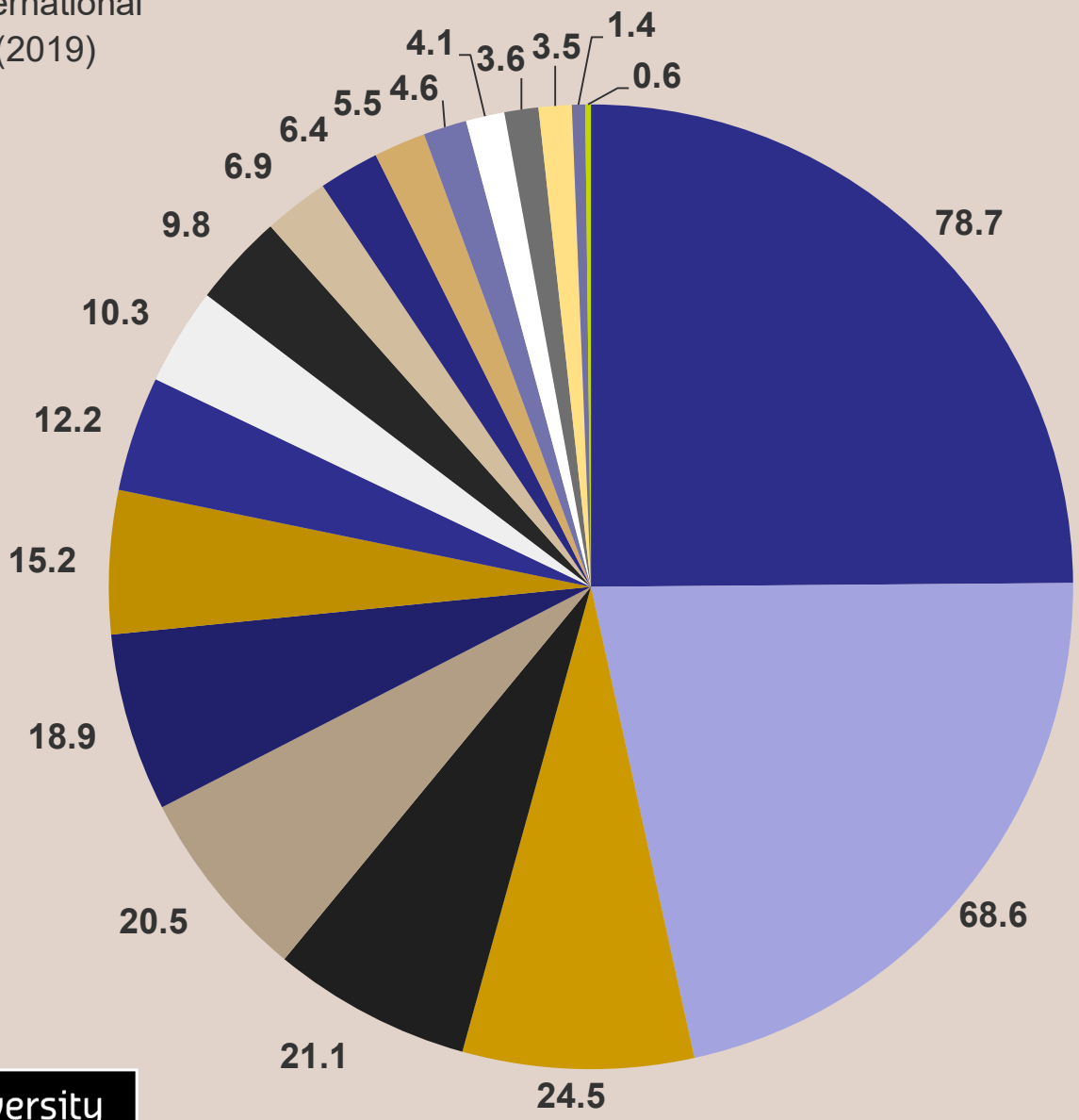
H2 links with natural gas: a valuable bridge

- Blue hydrogen
  - Domestic gas for H2 production, for consumption or export
- Gas pipeline networks can:
  - Supply gas as feedstock for H2
  - Be converted for H2 transport



LNG exports (2018), mtpa

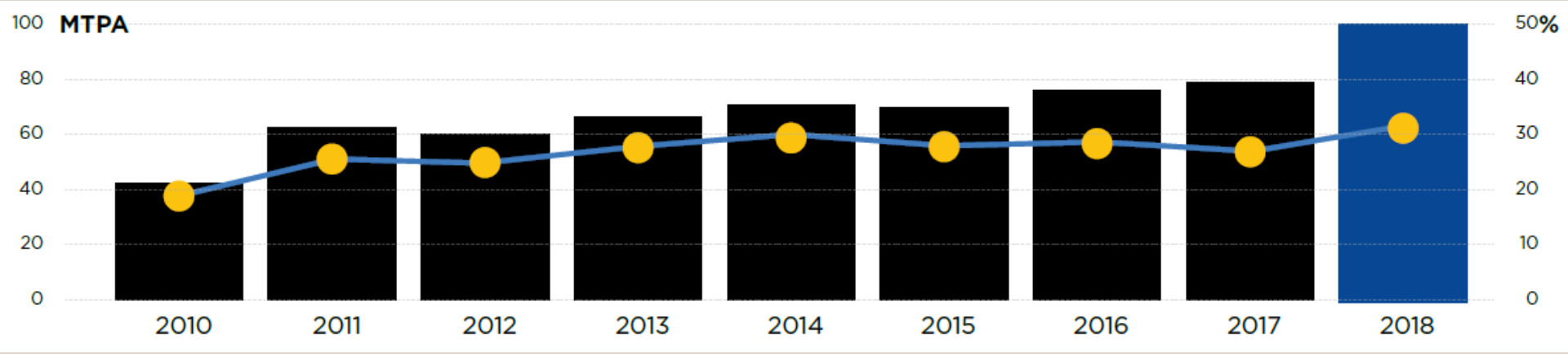
- Source: International Gas Union (2019)



H2 links with LNG

- Export LNG for H2 production abroad
- Some LNG infrastructure works with H2
  - But liquid H2 colder than LNG
- Transferrable expertise and skills
  - Industry, academia, government
- Market structures
  - Short term vs. long term

Spot and short-term vs. total LNG trade



- Source: GIIGNL (2019)

- Gas-on-gas pricing growing with global LNG trade
- But progress not so quick

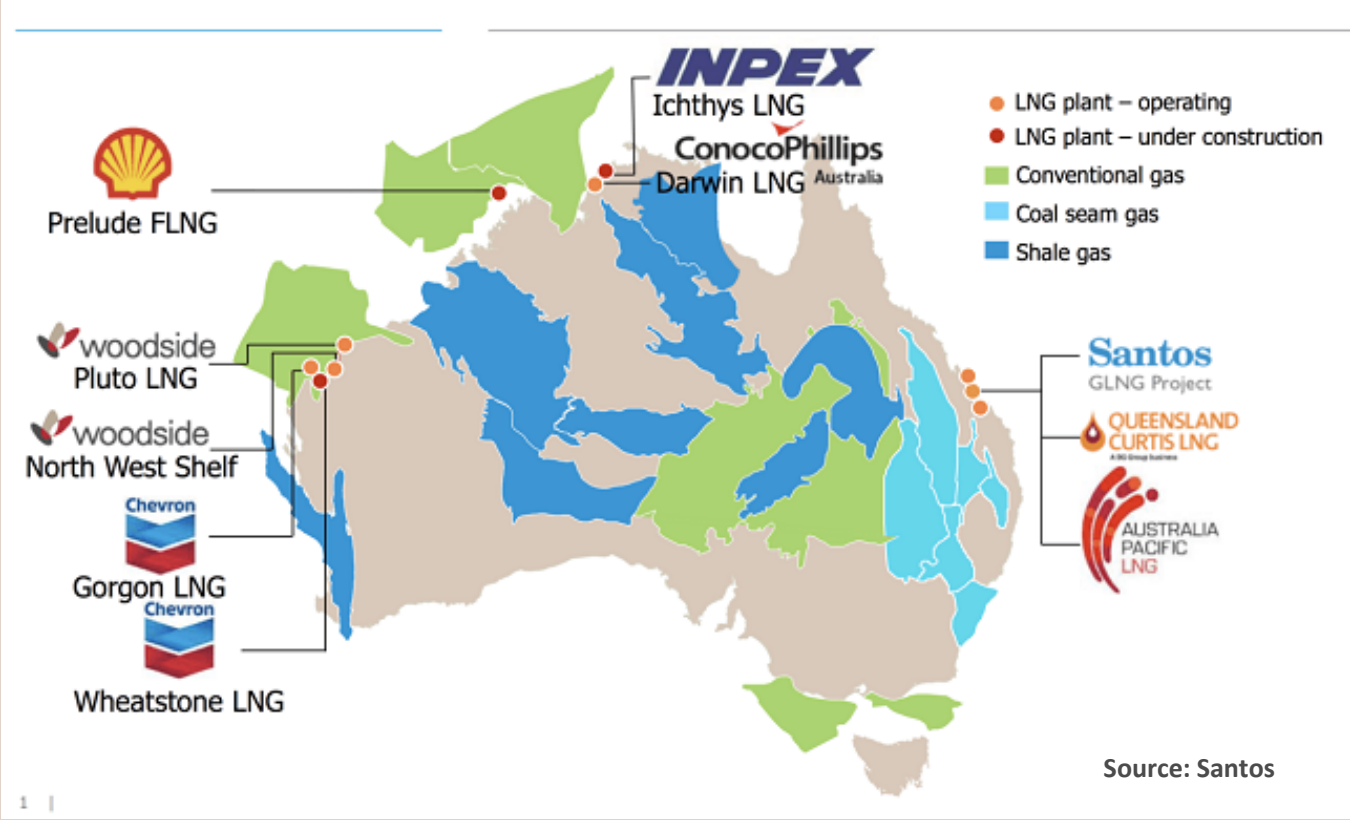
With low prices, LNG industry bringing costs down

- Improved productivity and operational efficiencies
- Better planning, cooperation, standardisation, simple construction, floating LNG
- On consumption side, floating LNG enables poor countries to increase gas use
- Lessons applicable to H2

- Source: Shell

Australia: $200 billion investment in LNG projects

- By 2020, Australia to export 85 mtpa of LNG
- Proximity to Asia makes ideal destination for exports (low shipping costs)
- Plans to leverage LNG experience for H2 development



Hydrogen development obstacles

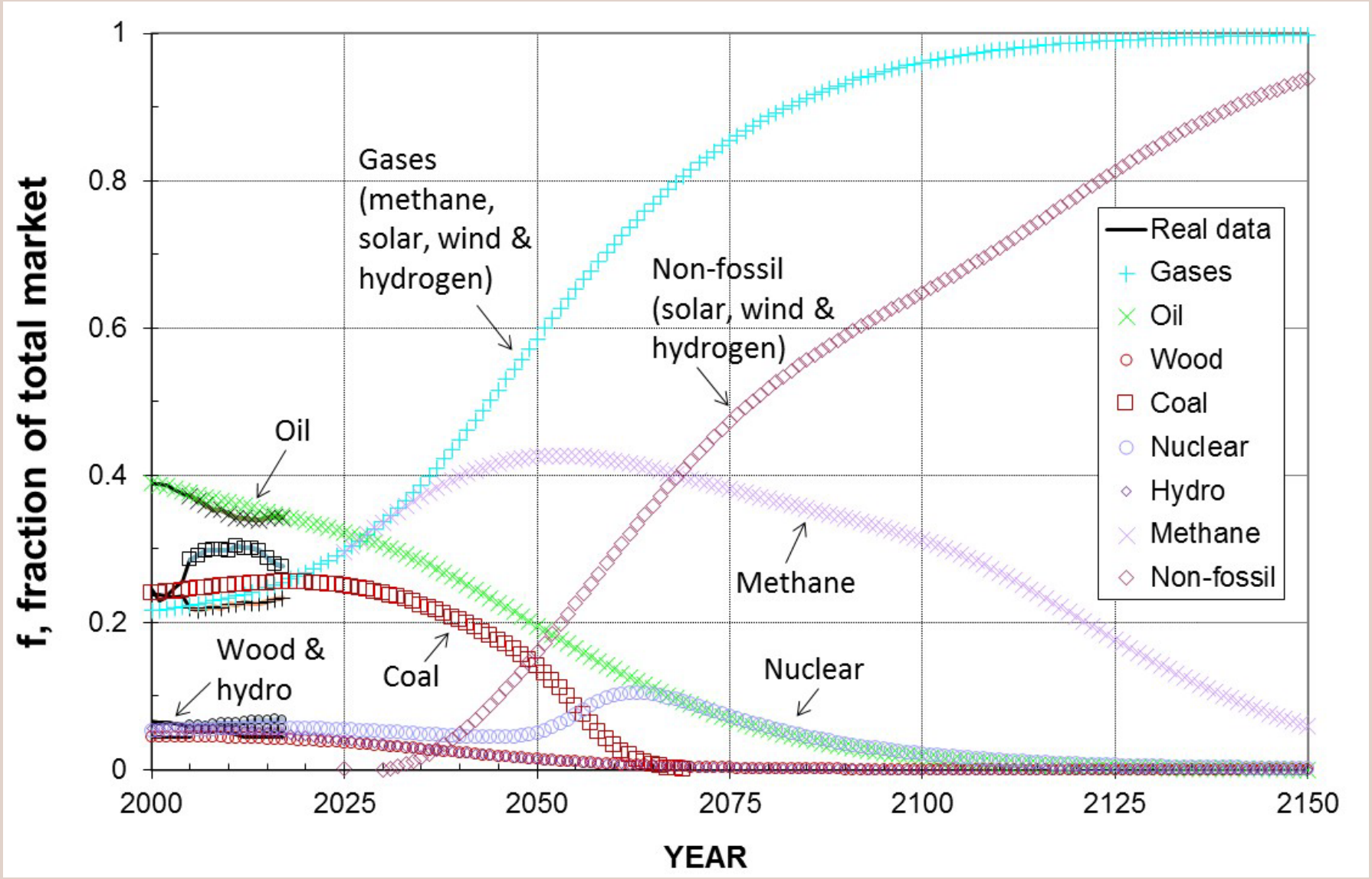
- Demand
  - Sufficient H2 demand?
- Supply
  - Commercially competitive H2?
- Infrastructure & logistics
  - Sufficient storage & delivery?
- Uncertainty
  - Policy, technology, economics?
- Transition, scale
  - Sizeable share in energy mix?

Requirements for increased H2 market share

- Policy support in coming decades
  - Eventual shift from policy- to market-based use
- Benefit from synergies with established industries
  - Natural gas & renewables
- Cost reduction
  - Versus fossil fuels & renewable sources
- Learning by doing at regional scale
  - Regional approaches based on natural strengths

Primary Energy Mix (2000 - 2150)

- Source: Aguilera and Aguilera, Mineral Economics (2019)



- Natural gas share peaks near 2050
- Non-fossil energy, like H2, leads market 2H 21st century

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Conclusions

- Hydrogen transition takes time
- Policy and technical advance are key
- Utilize gas and LNG links
- H2 as part of energy mix portfolio
- Expect experimentation period

Thank you!

Questions?

r.aguilera@curtin.edu.au

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