Webinar:

"Shaping the Future of Green Hydrogen Economy"

Green H2 and the Electricity and Gas Grids: Challenges and Opportunities for Australia

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SEDA Malaysia, 23rd July 2020

Back to the future

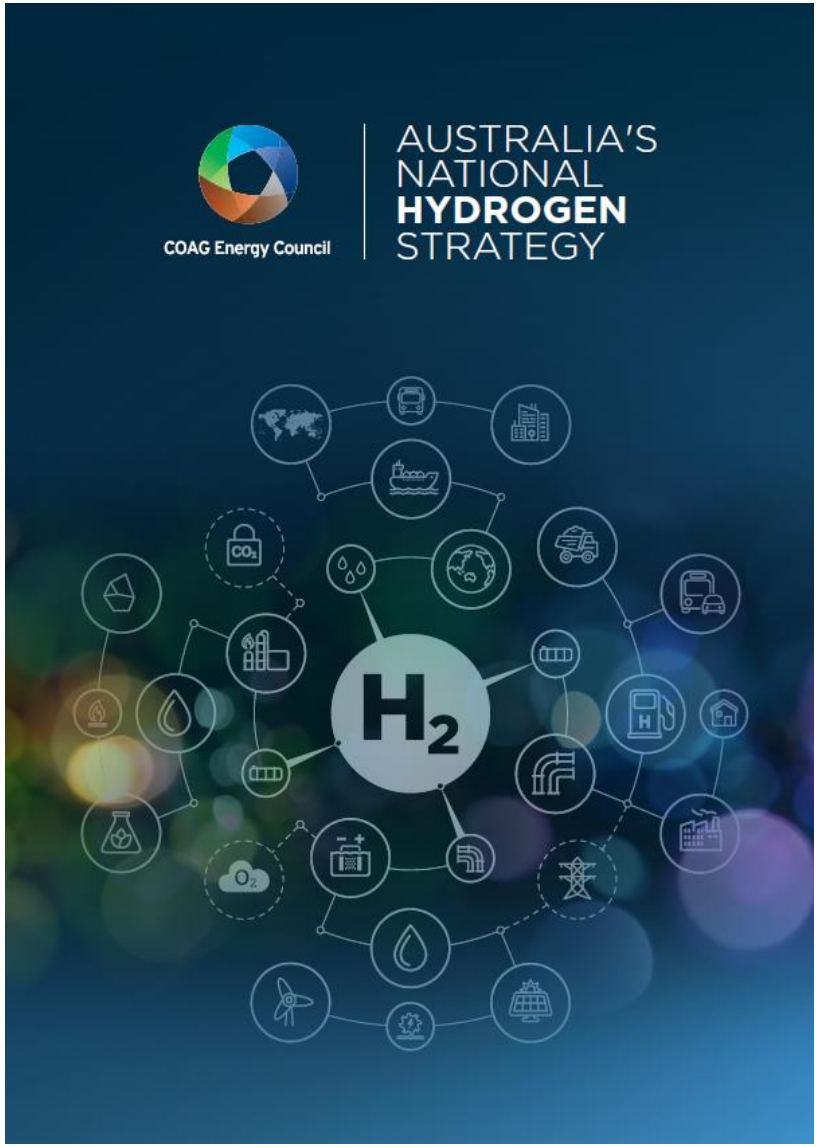
"Water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable.

Someday the coal-rooms of steamers and the tenders of locomotives will, instead of coal, be stored with these two condensed gases, which will burn in the furnaces with enormous calorific power."

Jules Verne, "The Mysterious Island",1874

Source: COAG Energy Council, Australia's National Hydrogen Strategy, November 2019

The Australia's National Hydrogen Strategy



- Released in November 2019
- Led by the Australian Chief Scientist, Dr Alan Finkel

Source: COAG Energy Council, Australia's National Hydrogen Strategy, November 2019

The Australia's National Hydrogen Strategy: some figures

Breakeven price points

This table shows the delivered prices hydrogen would need to achieve against competitor fuels.

Competitor fuel service	Hydrogen breakeven price ($/ kg H_2)
Drive 100 km using petrol (retail price $1.43/ L)[ii]	$13.31
Drive 100 km using diesel (retail price $1.50/ L)[iii]	$11.21
Deliver 1 GJ heat using natural gas (wholesale price approximately $10/ GJ)[iv]	$1.20

Water inputs

Producing 1 kg of hydrogen requires at least:[v]	
Electrolysis	9 L
Coal gasification	9 L
Steam Methane Reforming (SMR)	4.5 L

These are theoretical amounts of water based on the chemical pathway for each process. In practice water requirements for hydrogen production will vary depending on production method and technology, water content of inputs, and additional water needs for processes like cooling and input water purification.

Emissions intensity of production

Production technology	Emissions (kg $CO_{2\text{-}e}$/kg hydrogen)[vi]
Electrolysis – Australian grid electricity[vii]	40.5
Electrolysis – 100% renewable electricity	0
Coal gasification, no CCS[viii]	12.7 – 16.8
Coal gasification + CCS – best case[ix]	0.71
Steam methane reforming (SMR), no CCS[x]	8.5
SMR + CCS – best case[xi]	0.76

HOW MUCH HYDROGEN IS THAT?

1 kg of hydrogen is enough to travel up to **100 km** in a **Hyundai Nexo**

Travelling in a **Hyundai Santa Fe** uses **7.5 L** of diesel or **9.3 L** of petrol

Driving a **Hyundai Nexo** compared to a diesel **Hyundai Santa Fe** avoids **0.2 kg CO_2-e / km** driven or **20 kg CO_2-e per kilogram** of hydrogen used

1 kg of hydrogen in a fuel cell could power a **1,400 watt** electric split-cycle air conditioner for **14.5 hours**

Replacing Australian grid electricity with electricity from **hydrogen** avoids **0.75 kg CO_2-e / kWh**, or **15 kg CO_2-e per kilogram** of hydrogen used

1 tonne of **hydrogen** is equivalent to around **3.4 times** the average annual consumption of an Australian house with **gas heating**

Replacing **natural gas** with **hydrogen** avoids **0.052 tonnes CO_2-e / GJ** of **natural gas** or **6.2 tonnes CO_2-e per tonne** of **hydrogen**

Source: COAG Energy Council, Australia's National Hydrogen Strategy, November 2019

The Australia's National Hydrogen Strategy: some ongoing case studies

Western Australia

ATCO CLEAN ENERGY INNOVATION HUB

ATCO's industry leading Clean Energy Innovation Hub (CEIH) is a test bed for solar photovoltaics, battery storage, hydrogen production and use as well as hydrogen blending with natural gas infrastructure.

Australian Capital Territory

HYDROGEN FOR TRANSPORT PILOT

The first public hydrogen refuelling station in Australia will be built in Canberra and is on track to be operational in early 2020.

New South Wales

JEMENA WESTERN SYDNEY GREEN GAS PROJECT

The Western Sydney Green Gas Project involves designing and constructing a Power-to-Gas facility which will convert solar and wind power into hydrogen via electrolysis.

Tasmania

BELL BAY ADVANCED MANUFACTURING ZONE – AN IDEAL HYDROGEN HUB

The Bell Bay Advanced Manufacturing Zone (the 'Zone') is Tasmania's premier major industrial-zoned precinct that has available land and is ideally suited to large-scale renewable hydrogen industry development for export and for domestic applications.

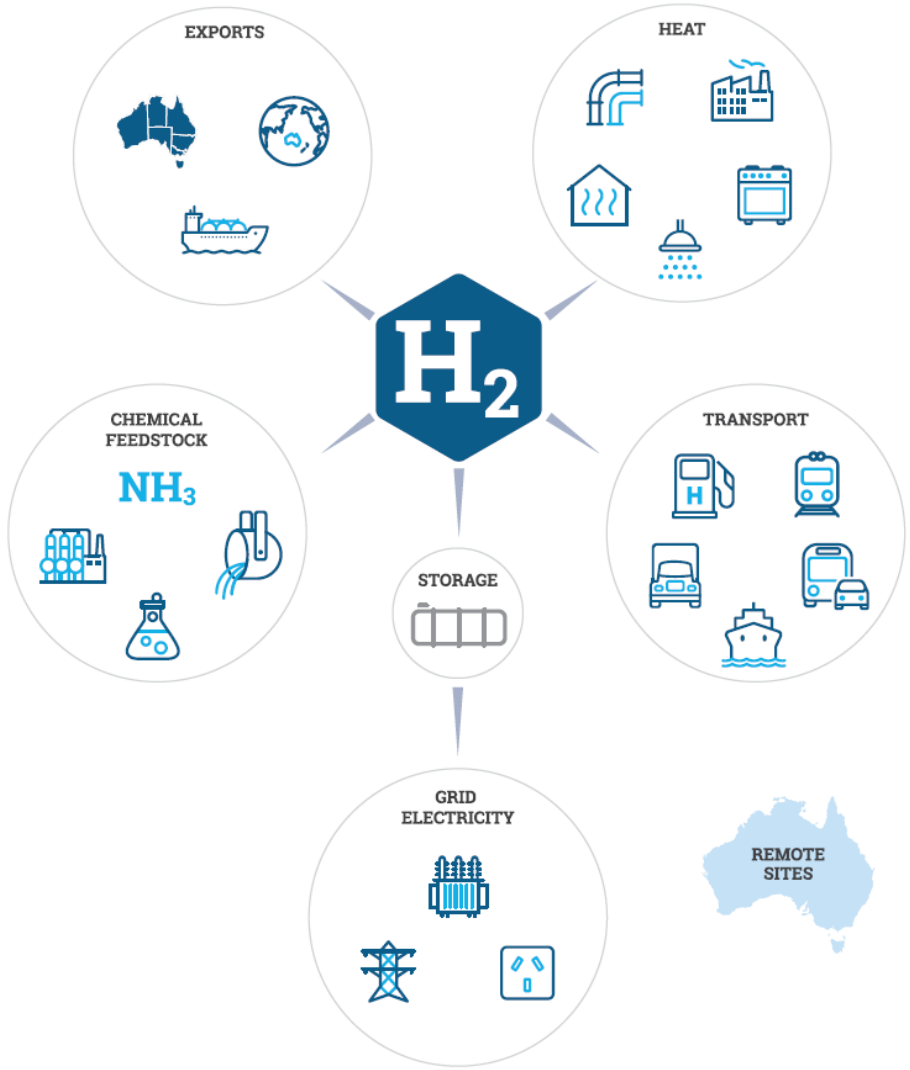
Victoria

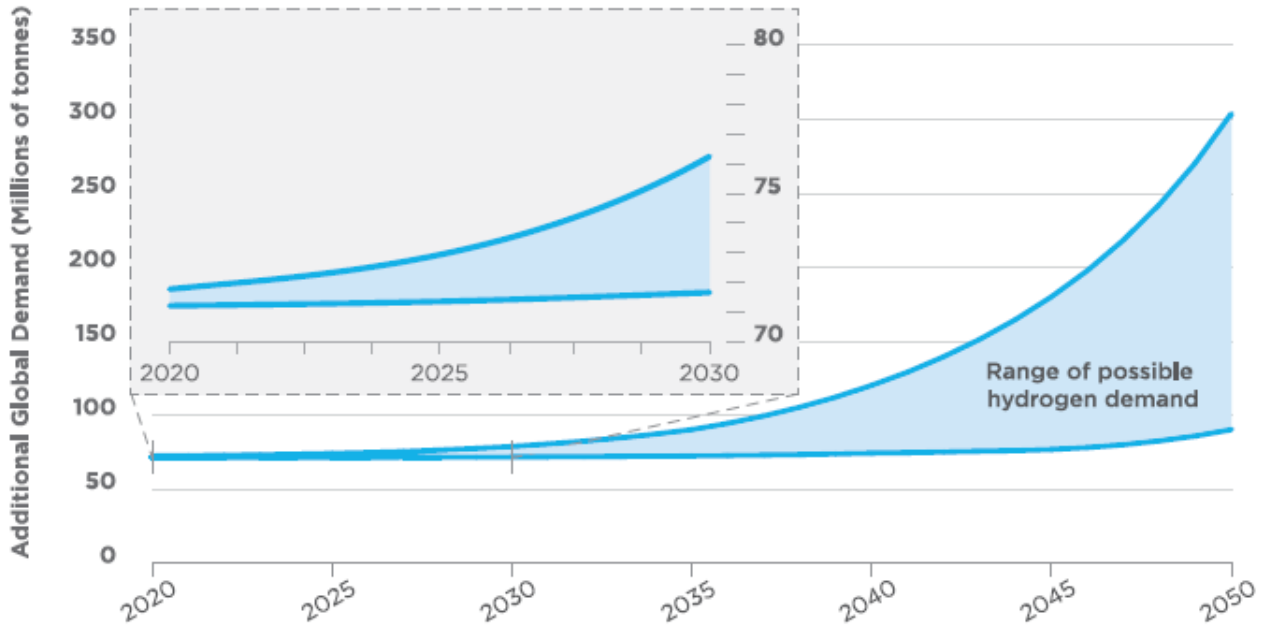
WORLD FIRST FULLY INTEGRATED HYDROGEN SUPPLY CHAIN

The Hydrogen Energy Supply Chain (HESC) Pilot Project is demonstrating a full supply chain starting with hydrogen production from brown coal in the Latrobe Valley and ending with its transportation to Japan.

Source: COAG Energy Council, Australia's National Hydrogen Strategy, November 2019

The Australia's National Hydrogen Strategy: applications and global demand

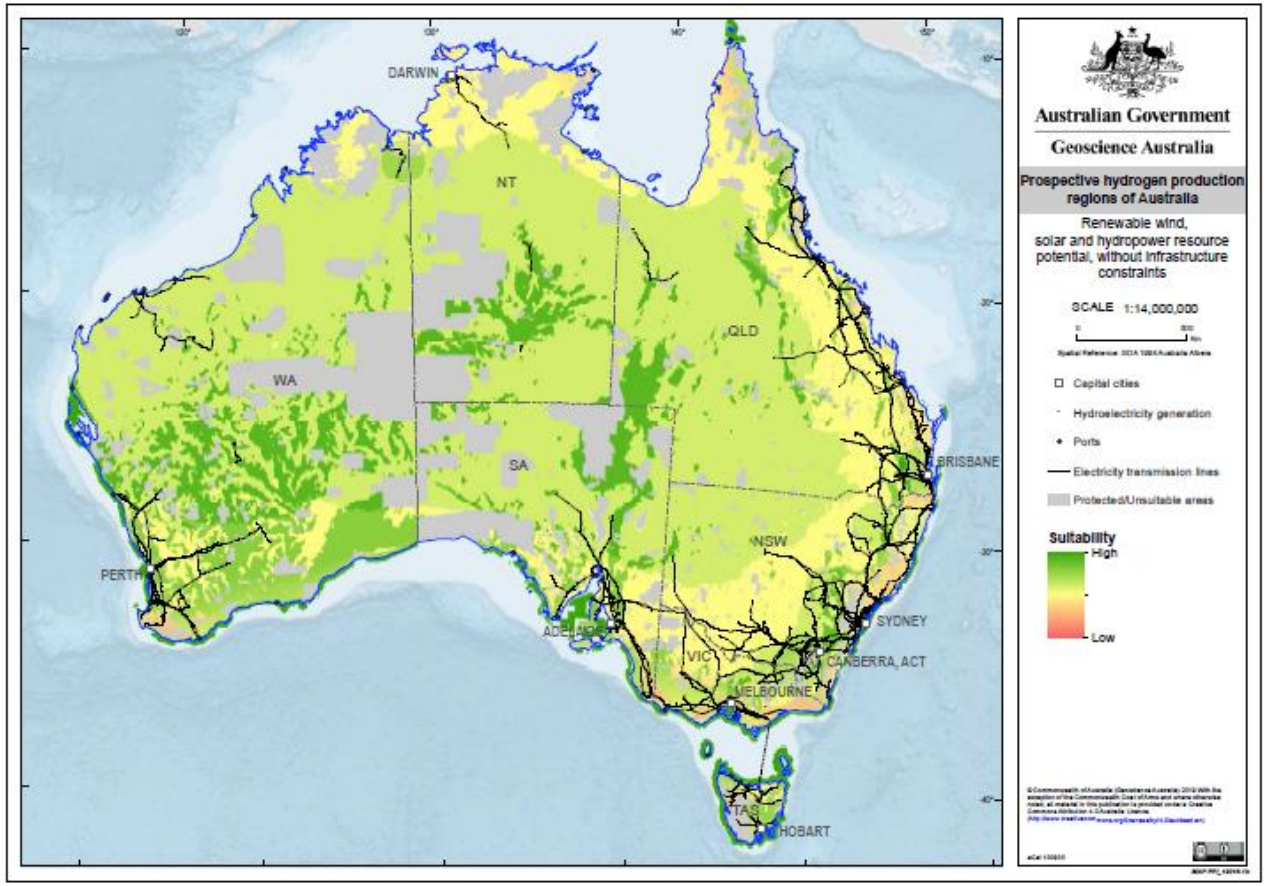




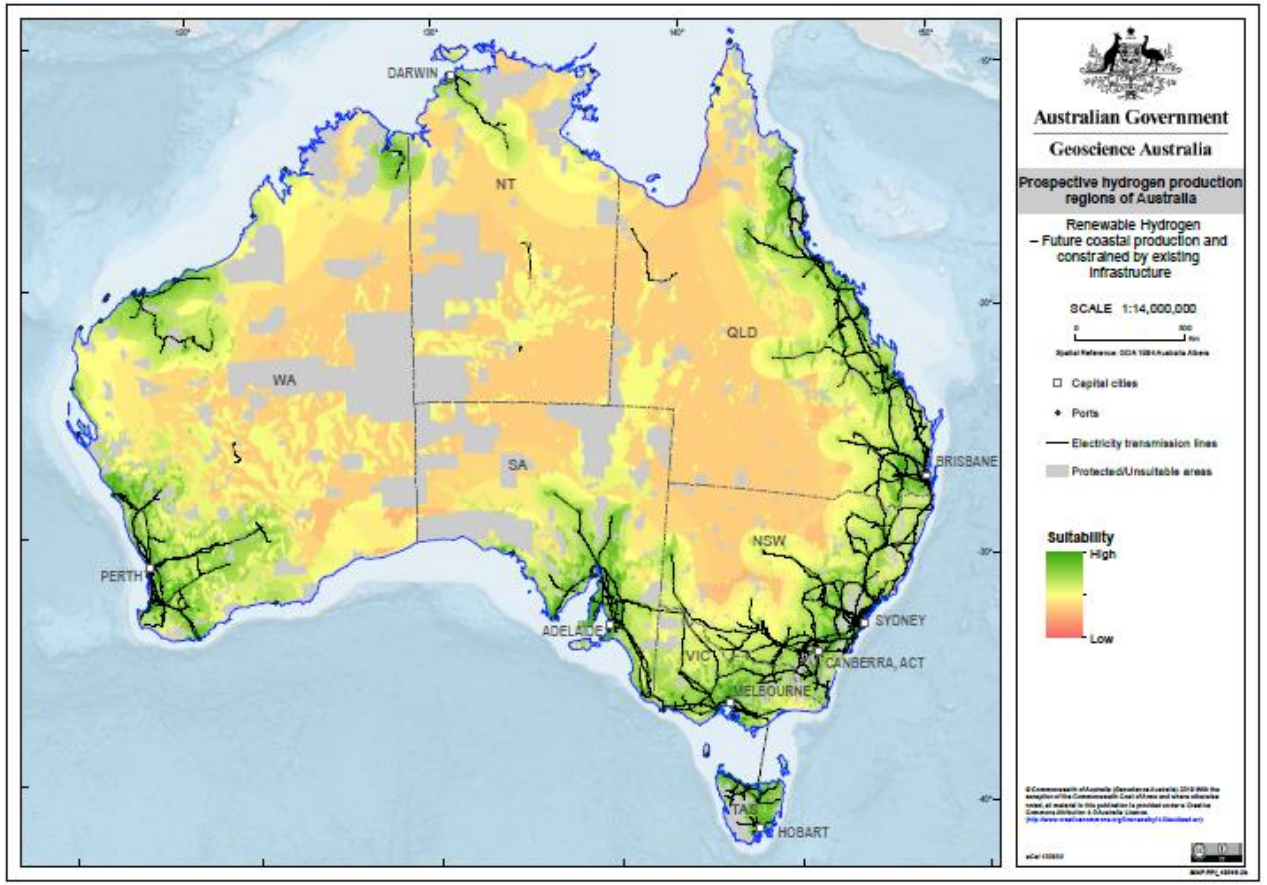
Source: COAG Energy Council, Australia's National Hydrogen Strategy, November 2019

The Australia's National Hydrogen Strategy: green hydrogen potential

Potential with no infrastructure constraints

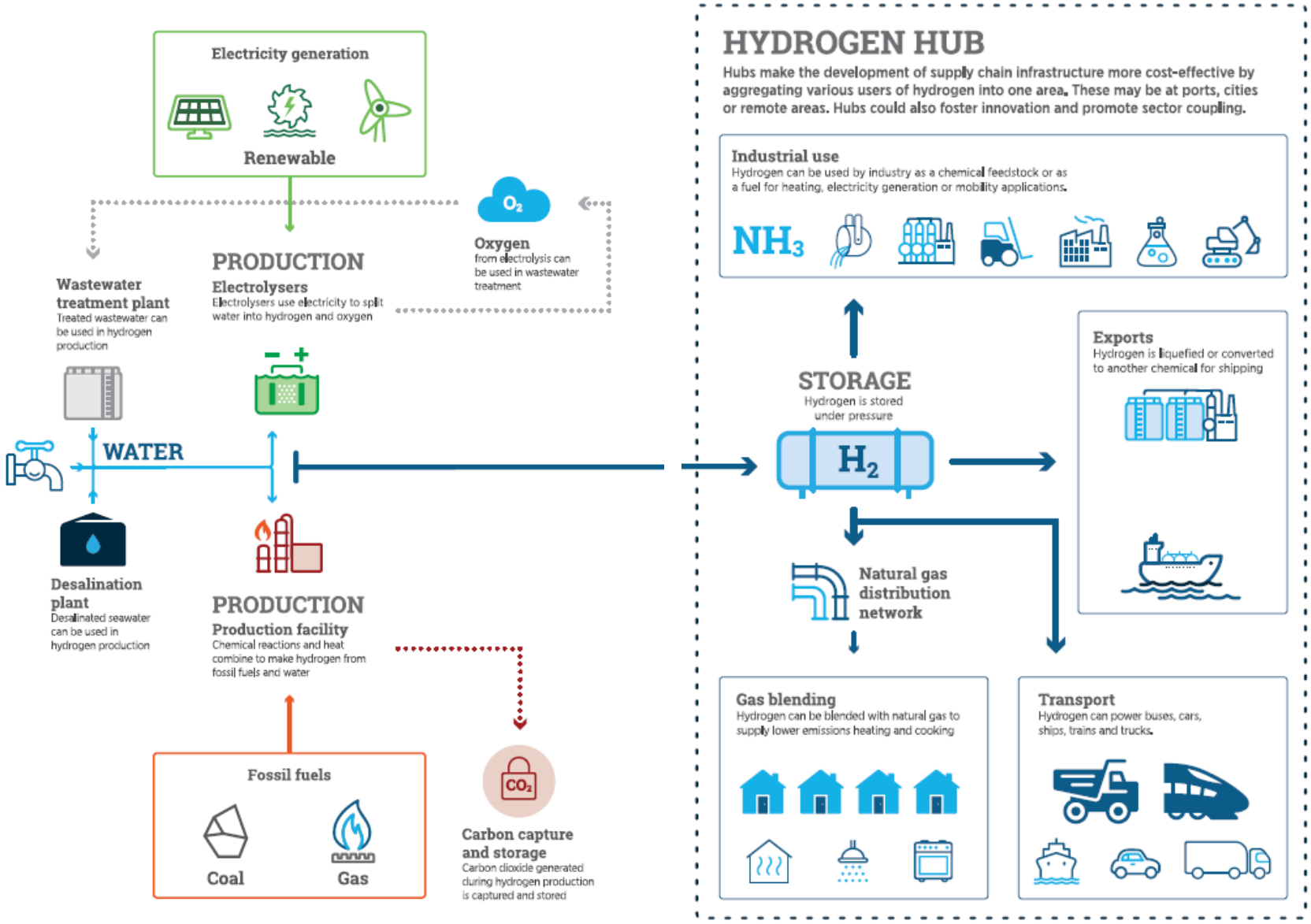


Potential with consideration for access to water, ports, pipeline easements, and electricity infrastructure



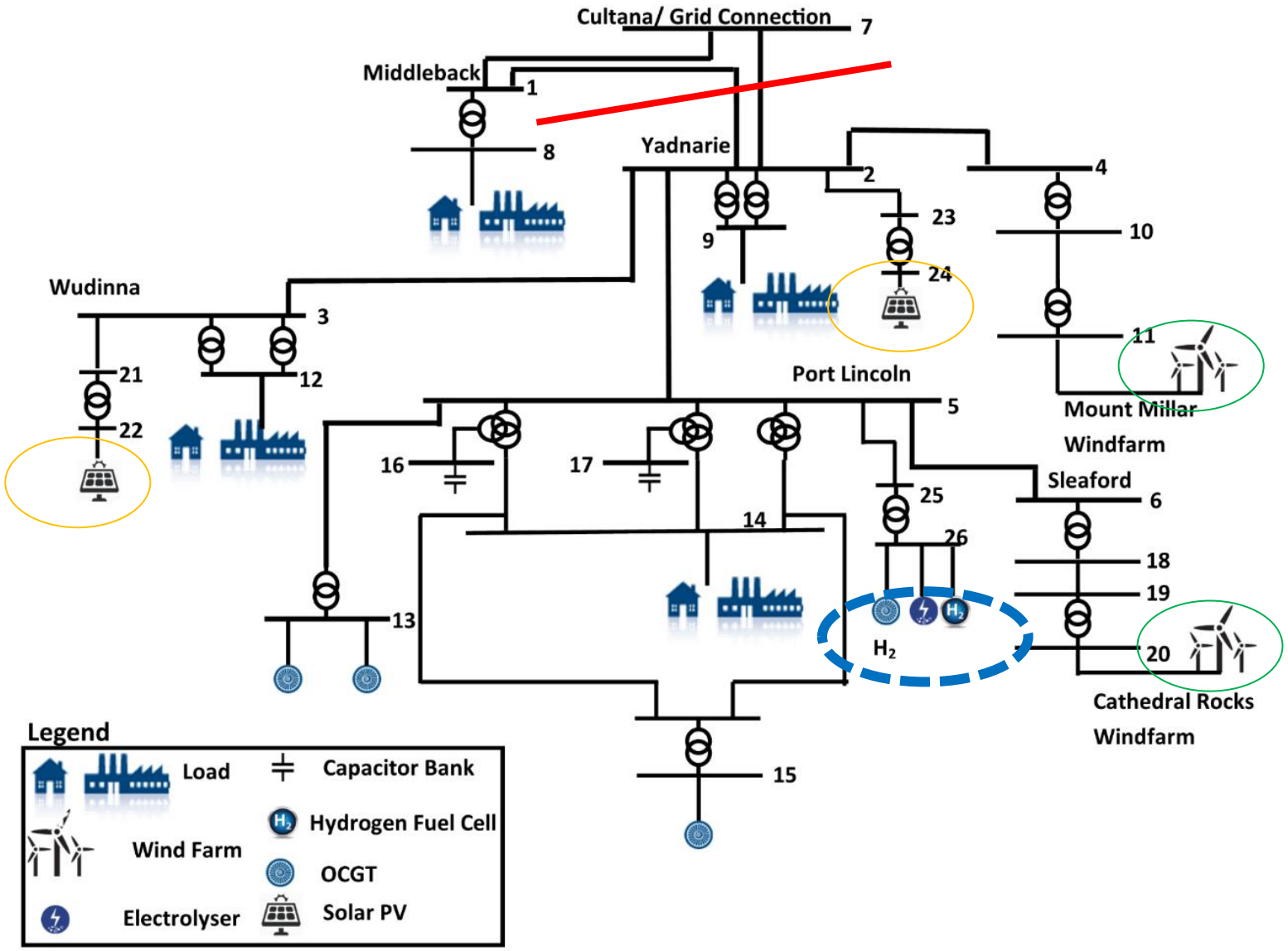
Source: COAG Energy Council, Australia's National Hydrogen Strategy, November 2019

The Australia's National Hydrogen Strategy: hydrogen hubs



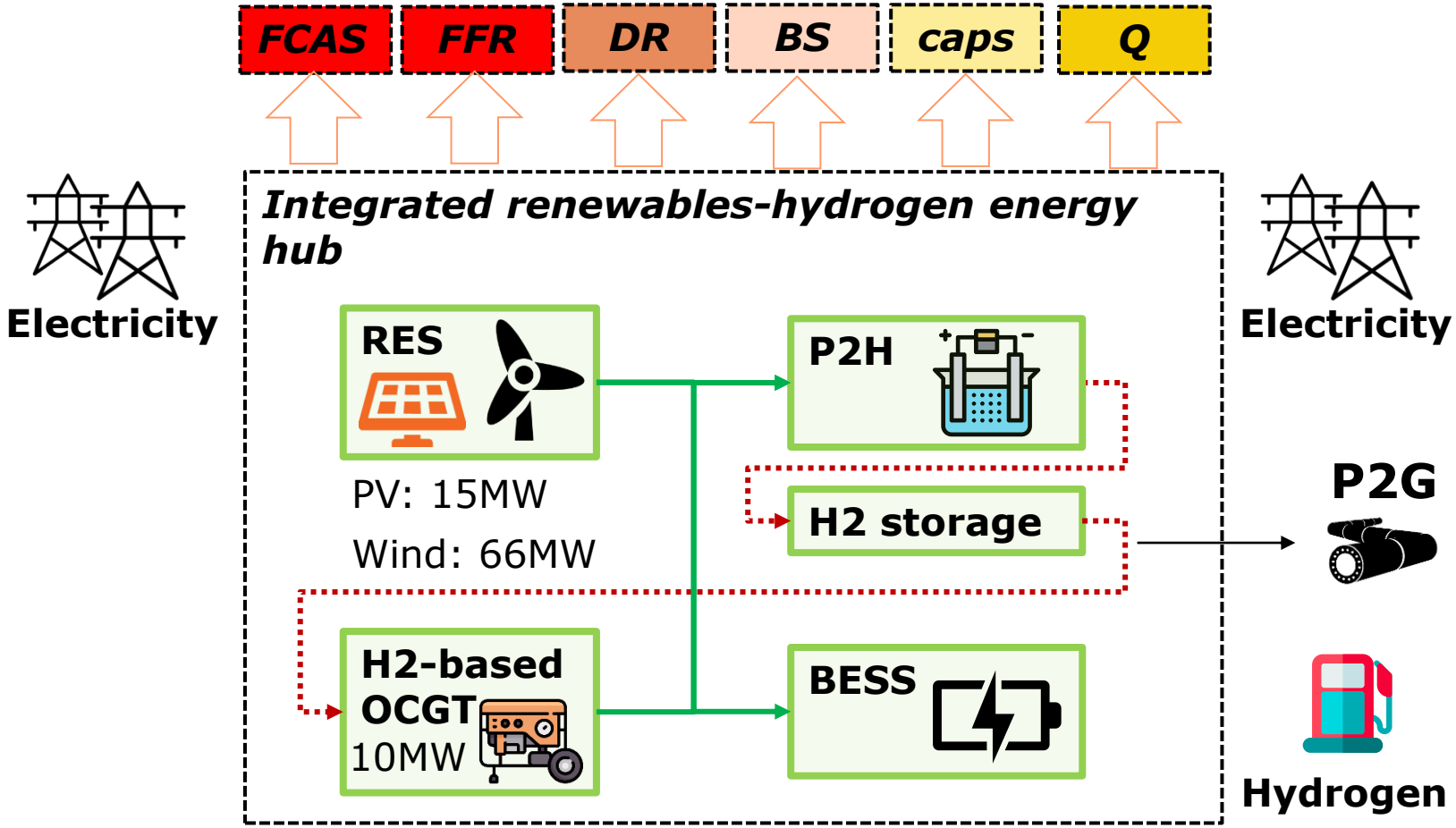
Source: COAG Energy Council, Australia's National Hydrogen Strategy, November 2019

Integrated renewables-hydrogen hub and the electricity grid



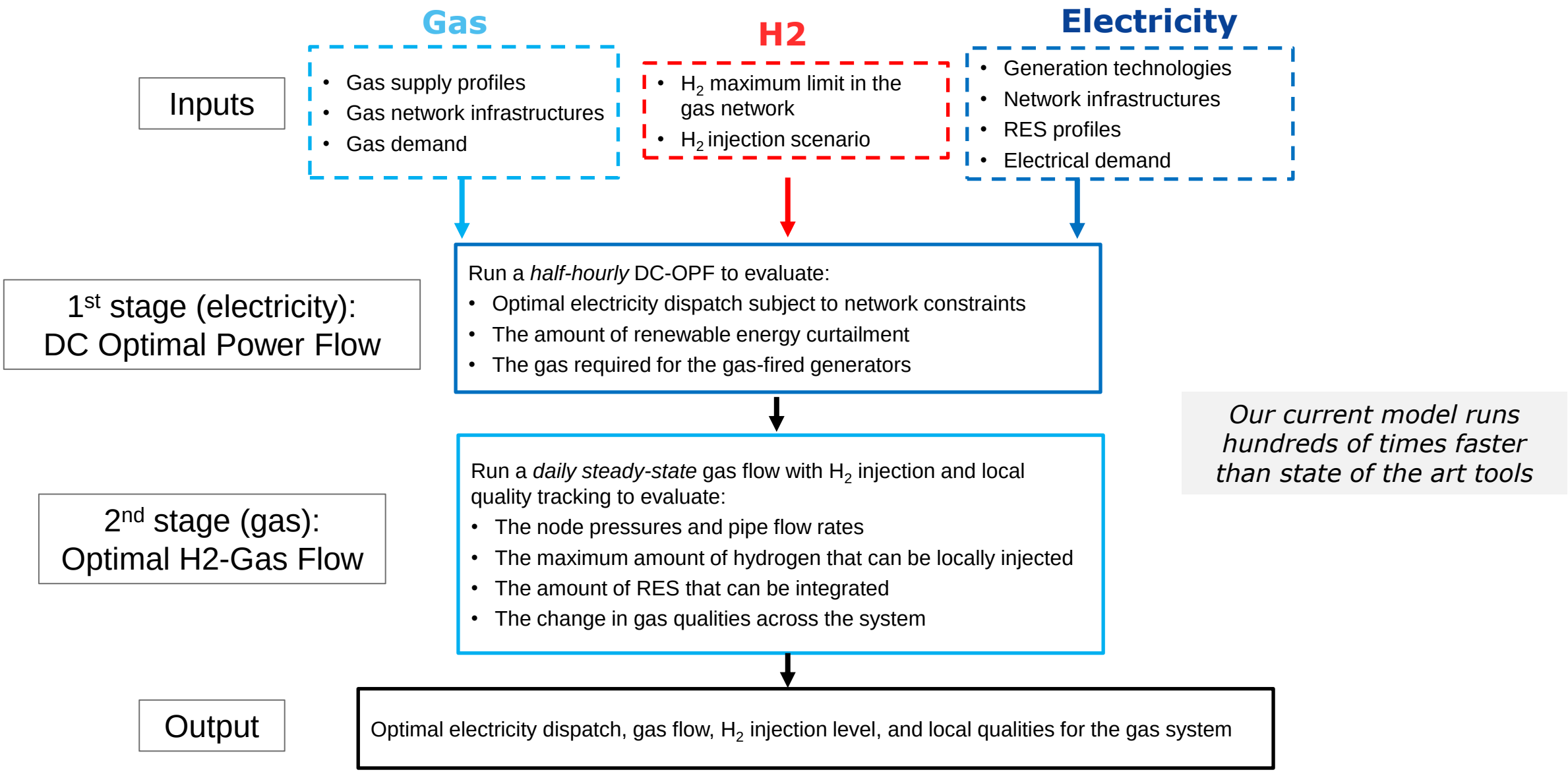
J. Naughton *et al.*, "Optimization of Multi-Energy Virtual Power Plants for Providing Multiple Market and Local Network Services", *Electric Power System Research*, *accepted for publication*, 2020

Integrated renewables-hydrogen hub and the electricity grid: flexibility and business cases



H. Wang, *et al.*, "Optimal Operation and Investment for an Integrated Renewables-Hydrogen Energy Hub with Multi-market Co-optimization", *to be submitted*

Integrated Electricity-Gas-Hydrogen System (IEGHS) modelling tool



Our current model runs hundreds of times faster than state of the art tools

Concluding remarks

- Australia has the potential and ambition to become a **clean energy superpower**, including large *export* of **low- to zero-carbon hydrogen**
- The **Australia's National Hydrogen Strategy** has cast the foundations and outlined a potential roadmap for unprecedented H2 developments
- Several **clean H2 initiatives and trials** are already taking place in all Australian states
- We are also developing state-of-the-art techno-economic modelling tools to:
  - boost the **business cases** for hydrogen hubs considering electricity markets, and
  - assess the tecno-economic benefits and constraints from **electricity-gas grid integration**

"For the anxious, progress towards a hydrogen future is too slow. But look back a few decades from now and history will record the hydrogen industry as an overnight success"

Dr Alan Finkel, Chief Scientist of Australia, November 2019

Acknowledgements

- The Future Fuels Cooperative Research Centre
- *veski* and the Victorian Government