A storage solution for clean energy
Well known renewables

Solar

Wind power

Hydro

Geo thermal

Wave power

Fusion – 10 yrs away
WHERE WE SOURCE OUR ENERGY
2016-2017
hydrogen
Hydrogen cars

Hyundai H2 fuel cell
Tucson

Toyota Mirai H2 fuel cell sedan
CHINA’S HYDROGEN POWERED SPORTS CAR, THE GROVE COUPE

China’s HFC vehicle targets:

2020 – 5,000

2025 – 50,000

2030 – 1,000,000

From China Daily, the state run English language newspaper, April 11, 2019
Nikola Motors says it has 11 thousand pre-orders for its hydrogen fuel-cell trucks.
Chevrolet Silverado ZH2

HYDROGEN POWERED OFF-ROAD ELECTRIC VEHICLE IS BEING EVALUATED BY THE US MILITARY
IN CHINA, GREAT WALL IS DEVELOPING HYDROGEN FUEL CELL UTES
• In September 2018 the first Hydrogen train ran in the north of Germany.
• Range – about 1000 km on one tank of Hydrogen
• Speed – 140 kph
• Lower Saxony ordered 14 more by 2021
One of London’s hydrogen bus fleet
Hydrogen fuel cell power station
South Korea
440 million kwh per yr

- Another at Fusina, near Venice in Italy.
- Test site at Kobe in Japan
- Hydrogen plant in Port Lincoln in SA due for completion 2020
HFC were used in the Apollo 11 for electricity and water.
Germany’s type 212 submarine uses HFC for super stealth
Hydrogen fuel cell

- **Anode**: Hydrogen atom, Proton Exchange Membrane
- **Cathode**: Oxygen from Air, Water
- **Platinum Catalyst**: Proton Exchange Membrane

From hydrogenics.com
‘Since the meltdown of the Fukushima nuclear plant in 2011, the Japanese Government has accelerated its search for new energy sources, spending > $16 billion on Hydrogen R&D.'
H2FC SUPERGEN 2019 Conference: A vision for hydrogen and fuel cells in the UK
REGISTRATION OPEN
30 Jan – 01 Feb 2019, University of Warwick

HYDROGEN DAYS 2019
10th International Conference on Hydrogen technologies
"Through collaboration to H2 technologies deployment"
March 27-29, 2019
The National Library of Technology, Prague, Czech Republic
According to *new scientist* of 8 Sept 2018

- Japan will showcase 100 hydrogen buses at the 2020 Tokyo Olympics
- South Korea plans to introduce 1000 hydrogen buses by 2022
ARENA – the AUSTRALIAN RENEWABLE ENERGY AGENCY announced $22 million in grants for 16 research projects into hydrogen.
why Hydrogen?
Applications for Hydrogen
So, how do we safely store and transport large volumes of hydrogen?
Introducing Ammonia

Chemical engineers have long known that ammonia contains a high density of Hydrogen.

\[ \text{NH}_3 \]

- N - Nitrogen
- H - Hydrogen

Ammonia
1 cubic metre of liquid Ammonia holds 105 kg of H

1 cubic metre of liquid Hydrogen holds 71 kg of H

Ammonia
NH₃

Hydrofuel Inc, NH₃ fuel association
<table>
<thead>
<tr>
<th></th>
<th>Ammonia</th>
<th>LNG</th>
<th>Hydrogen</th>
</tr>
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Absolute zero -273°
Ammonia pipeline USA

- Over 3000 miles through
  - Indiana
  - Kansas
  - Illinois
  - Oklahoma
  - Missouri
  - Texas
  - Iowa
  - Arkansas
  - Minnesota
  - Louisiana
  - Nebraska
New CSIRO invention

Fine vanadium membrane allows small H atoms through excluding the larger N atoms
Ammonia

Stores indefinitely without deterioration

Reasonably energy dense

Easy to store – does not corrode steel containers

At 150 psi it reaches equilibrium at normal temperature: stored without refrigeration

Only fuel used is sunlight – so it can be manufactured forever. H2O and N2 are returned to their original state.
More Ammonia facts
Farmers have been using ammonia for over 100 years as a fertilizer.
• Usable in modified internal combustion engines

• Powered buses in Belgium in WW2
With liquid O2, NH3 powered the X15, the fastest piloted aircraft ever at 7274 kph.
Orica’s Newcastle plant
Water \( \text{H}_2\text{O} \)

Nitrogen \( \text{N}_2 \)

Electricity

Ammonia \( \text{NH}_3 \)

- Works at room temperature and normal pressure
- Uses very little electricity
- Only emission is oxygen
Professor Douglas MacFarlane from Monash won the 2018 Victoria Prize for Innovation and Science for making ammonia using ionic fluids without high heat and pressure.
THE HYDROGEN / AMMONIA ECONOMY (ii)

Ammonia Plant

GRID

Electricity when required

Liquefaction Plant

NH₃ gas

Liquid NH₃

Liquid NH₃

Ammonia Storage tanks

Gas fired power station & storage
THE HYDROGEN / AMMONIA ECONOMY (iii)

- Liquid NH₃
- Small off-grid power stations
- Service stations
- Industry
- Truck, rail or pipeline
- Ship overseas
- Export $$$ to industry & treasury
- $$$ CSIRO technology licence
- producing
There is no emission-free naturally occurring product to replace liquid and gas fossil fuels, so we must make our own

**Hydrogen and ammonia fit the bill**
Australia should move quickly to ensure it doesn’t miss the boat as a supplier to this rapidly developing lucrative hydrogen market.