THE CHALLENGES OF DELIVERING A LARGE SCALE GREEN HYDROGEN PROJECT

Petrofac

Introducing Petrofac – A life of asset energy services provider

Petrofac

Petrofac by numbers

#20
ENR Top 250 International contractors of the world

+200
Major projects delivered

9,400
worldwide employees

>4.5 MN
Annual engineering man-hours

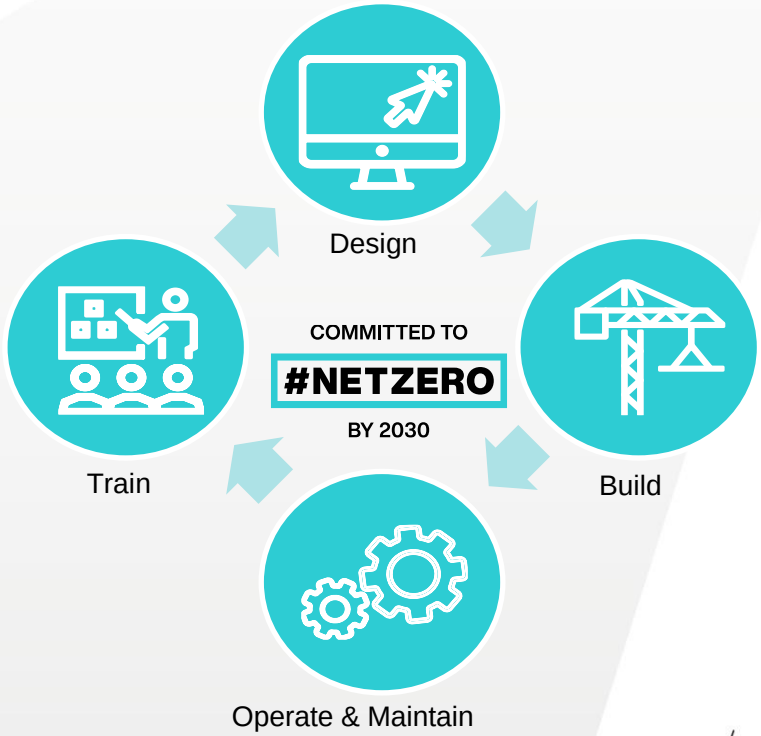
>US$2 BILLION
Procurement spend (on average per year)

>200 MILLION
Average annual direct construction man-hours

40 year
Track record

31 offices
Worldwide 29 countries

Our life of asset offering



We have the capabilities to unlock value in new energies

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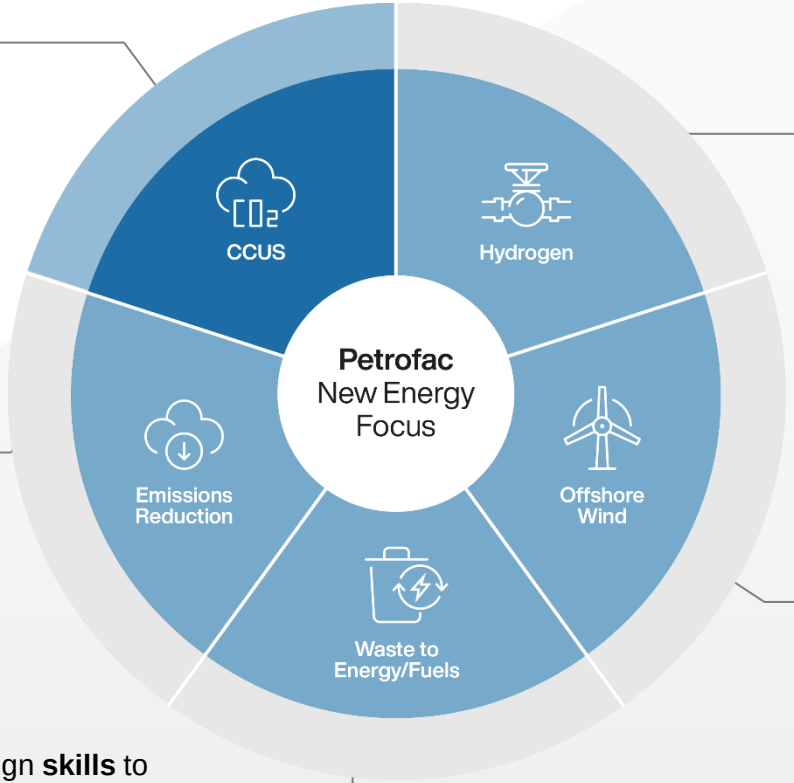
Using our expertise in **gas processing**, transport and storage to safely and economically **capture** and **store carbon**



Our **wind**, **solar** and **gas** capabilities allow us to design and build **green** hydrogen projects. Our **hydrocarbons experience** enables us to deliver large-scale **blue** hydrogen solutions

Leveraging our years of **experience** in **designing** and **operating** oil and gas assets, we support **in reducing** the **carbon intensity** of operations

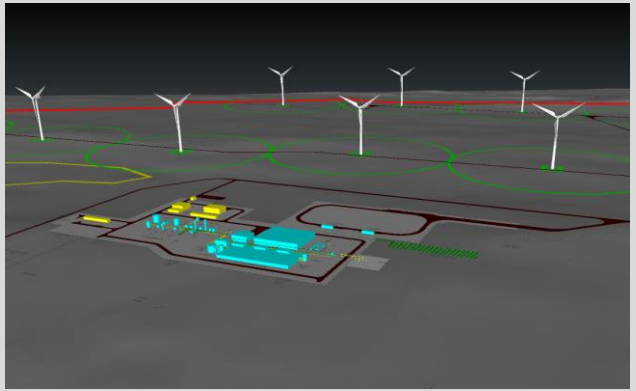
Over 10 years' of **expertise** in **designing** and operating **offshore** electrical substations, both **HVAC** and **HVDC**

Using our **petrochemical** design **skills** to transform **waste feedstocks** into valuable products: road and sustainable aviation fuels

ARROWSMITH

Infinite Green Energy
Fuelling The Future

Arrowsmith Green Hydrogen Plant



SCOPE

In October 2020 Petrofac was awarded the FEED for the Arrowsmith Hydrogen Plant Phase I by Infinite Green Energy.

Designed to produce 25 tonne/day of green hydrogen from raw water using electrolysis and renewable energy sourced from an onsite solar (90MW) and wind farm (114MW) with green grid connection back-up. Liquid and compressed Hydrogen will be delivered to the local transportation market.

The project will be delivered by an integrated Petrofac team from bases in Australia (Perth) and the UK (Woking).

Next steps:

Petrofac is seeking to follow through to the EPCm phase of the Phase 1 project in late 2022, with IBE looking to expand the project for export in subsequent phases

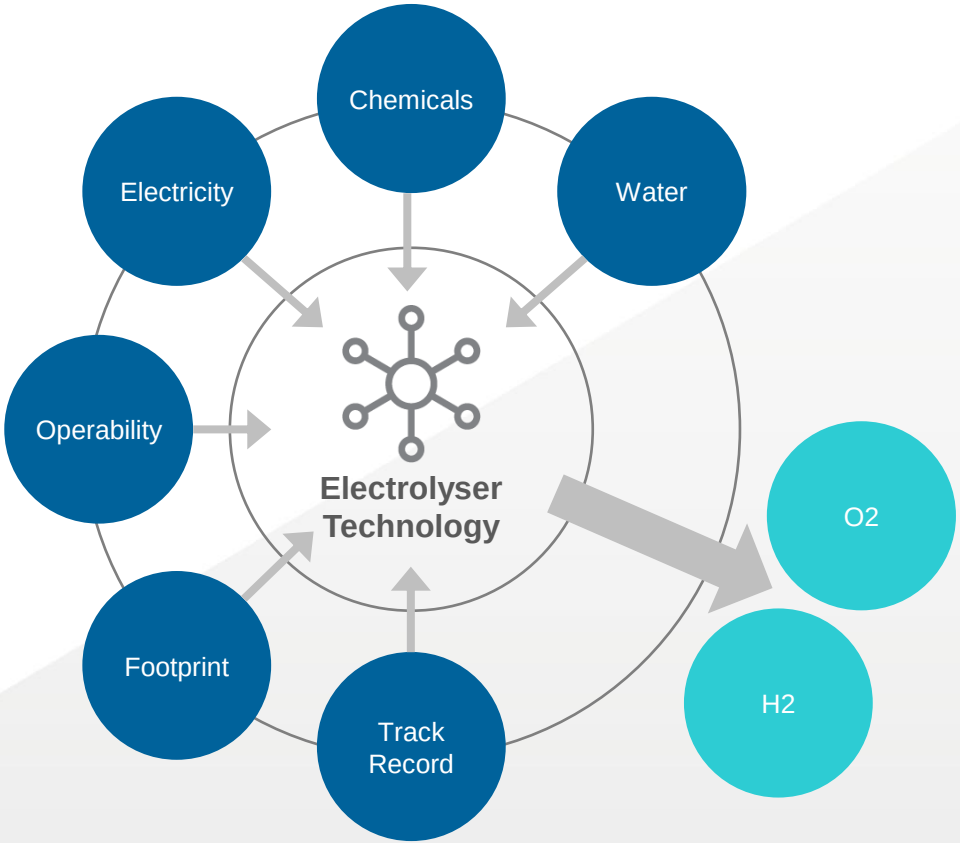
Plant is 320km north of Perth

Will save CO_2e of 83,103 t/annum

Potential to expand Hydrogen production to 255T/Day

Design challenges

1 Electrolyser technology selection



CHALLENGE

> The choice of electrolyser technology depends on several factors covering economic considerations and technical requirements.

TARGET

> High reliability with proven track record for large scale hydrogen production
> Low CAPEX
> Established supply chain and manufacturing capacity

APPROACH

> Petrofac engaged with licensors to compare technologies on a like-for-like basis
> Using licensor data allowed the team to design the balance of plant integration

Design challenges

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2 The intermittency of renewable power

CHALLENGE

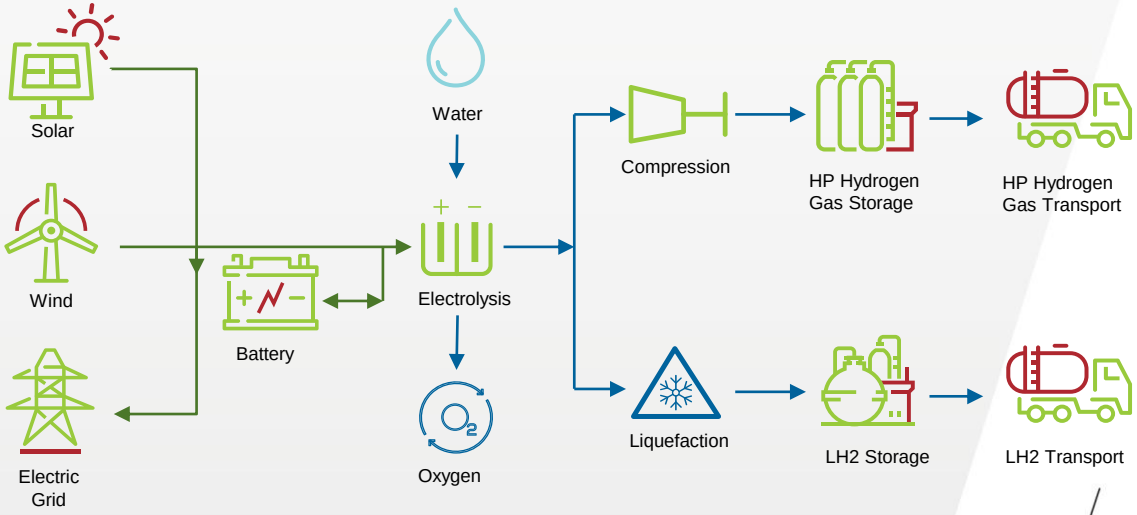
- Solar PV and Wind power are intermittent.
- Process requires a steady supply of power to maintain production capacity.
- Alkaline electrolysers require about 15 minutes to shutdown safely.

TARGET

- Steady reliable power supply to the process to meet H_2 production requirements.
- The ability to turndown the process safely in the event of total power failure.

APPROACH

- Provide connection to the local grid with electrical metering. Ability to sell excess power and buy back power when required.
- Redundancy in power, 70 MW Solar PV and 96 MW Wind whilst process requires circa to 80 MW.
- Provide batteries for safe shutdown.



Design challenges

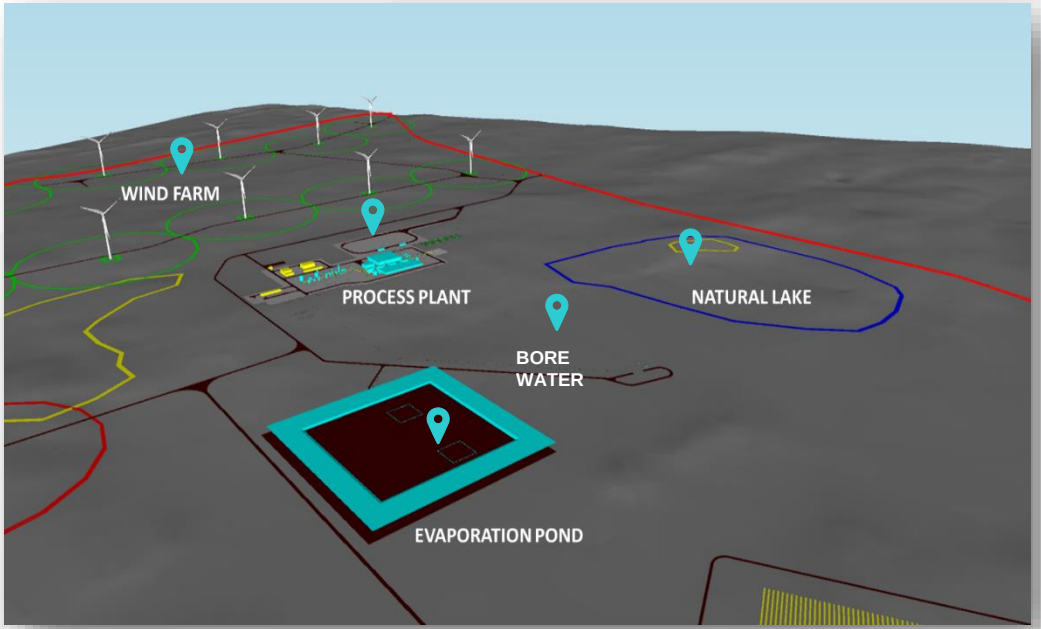
3 Wastewater management

CHALLENGE

- The initial design for 25 tpd hydrogen electrolysis required 537 tpd of feed water.
- Of which 50% is utilised for electrolysis and 50% is reject water.
- Size of evaporation pond for reject water.

TARGET

- Electrolysers require demineralised water.
- Minimise amount of reject water produced.
- Elimination of the requirement for an evaporation pond.



APPROACH

- Bore water identified as the best source for the feedstock fresh water.
- Petrofac engaged local water treatment companies to optimise the water treatment process to reduce reject water streams and ensure that stream meets regulatory requirements.
- Discharge the water to a natural lake.

Design challenges

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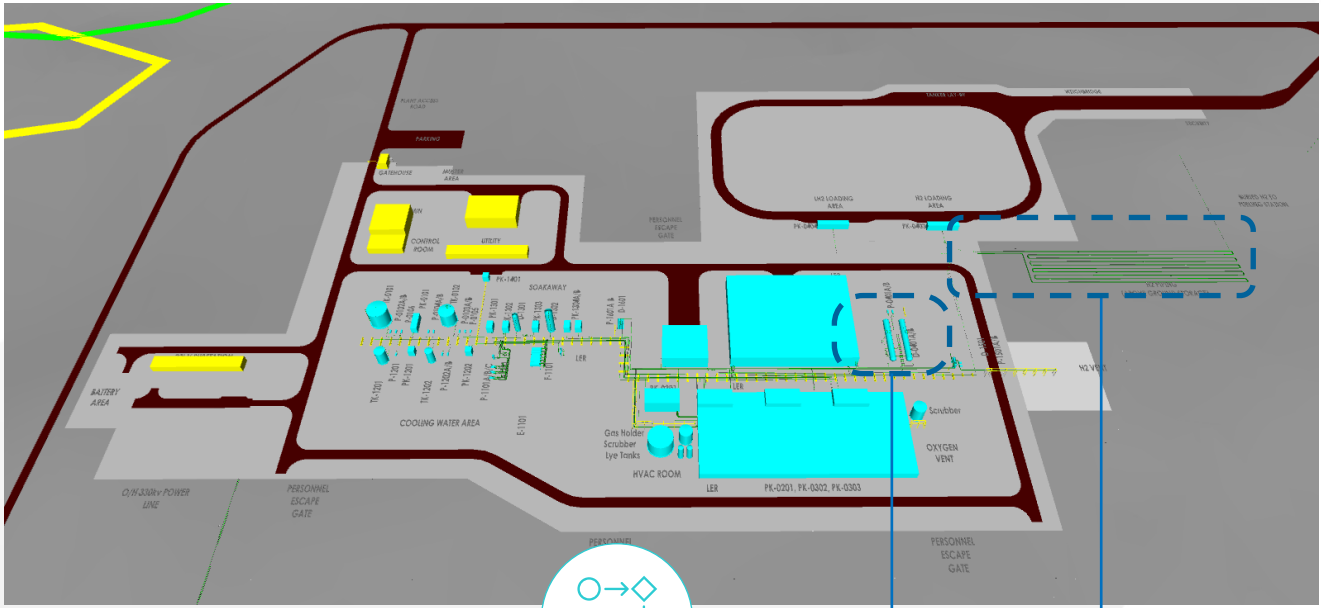
4 Large scale hydrogen storage

CHALLENGE

- Four days storage of gaseous hydrogen required at 350 – 700 barg.
- Mechanical limitations on vessel diameters with required wall thickness.
- Composite tanks are small and scale-up not available for quantities required.

TARGET

- Large scale hydrogen storage required.
- Gas and liquid hydrogen offtakes negotiated by client.



APPROACH

- Cryogenic liquid hydrogen storage - liquid hydrogen liquified at -253 ºC and at low pressures.
- Reduced gas requirements and stored in pressurised pipe work (5km) at the large site.

Conclusions

- Project requirements of reliable electrolysers with proven track record, along with lower costs has favours alkaline electrolysers, however a rigorous evaluation that considers balance of plant is needed
- Intermittency of renewable power for Green H_2 production can be mostly managed by combining renewable power assets e.g. wind and solar PV in Western Australia
- Western Australia possesses consistent winds blowing for around 18 hrs per day, as well as abundant solar irradiance during daytime
- Water access and wastewater management must be considered as electrolysers require demineralised water as feed, which may result in the production of significant amounts of reject water, depending on the quality of the feed water
- Large scale hydrogen storage is challenging with cryogenic storage requiring large amounts of energy and high-pressure H_2 gas storage constrained by material considerations.
- A few companies have proven track record for H_2 electrolysis units, hence early engagement with multiple vendors is essential to establish capabilities and conduct technical assessments
- Production costs are influenced by cost of renewable energy and cost of the electrolysis unit (and to a lesser degree, the utilisation factor)
- Green H_2 production costs will fall with falling renewable & electrolysis unit cost to reach parity with blue H_2 before the end of the decade

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