Hydrogen Refuelling Installation Guide

Renewable Hydrogen Production and Refuelling Project

Knowledge Sharing Report: Key Considerations for Australian Projects

Acknowledgements

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Overview

BOC's Renewable Hydrogen Production and Refuelling Project has been designed to demonstrate renewable hydrogen production at a commercially viable scale and help progress the commercialisation of hydrogen for vehicle transport in Australia.

This document highlights the key considerations when building Hydrogen Refuelling Stations (HRS) as part of our commitment to ARENA and the wider hydrogen sector to share learnings from this project.

The Project includes a 230 kw ITM PEM electrolyser at the BOC Bulwer Island Industrial Gas facility in Queensland, Hydrogen Tube Trailers for distribution, and a Linde Hydrogen Fuel Tech HRS unit to supply QFleet Hyundai Nexo (Fuel Cell SUV) passenger cars.

BOC, a Linde company, has manufactured and supplied hydrogen throughout Australia for over 80 years. BOC is committed to the safe production, handling, distribution and applicationsof Hydrogen as well as introducing new technologies into the Australian market such as Hydrogen refuelling for cars, buses, trucks and trains. Linde Hydrogen Fuel Tech has deployed over 200 HRS units internationally with four in Australia supplied, installed and maintained by BOC.

BOC supports the Standards Australia ME-93 working committee which is responsible for collaborating to develop the technical standards and guidance required for the hydrogen industry to enable delivery of safety and technical performance outcomes.

BOC has provided a lessons from learnings report for this project which may be viewed at BOC Renewable Hydrogen Production and Refuelling Lessons Learnt - Australian Renewable Energy Agency (ARENA). The key learnings that should be considered for future projects pertain to Social Licence, meeting Australian Standards and localising skills and knowledge for the emerging technology in this market.

1. Design Philosophy

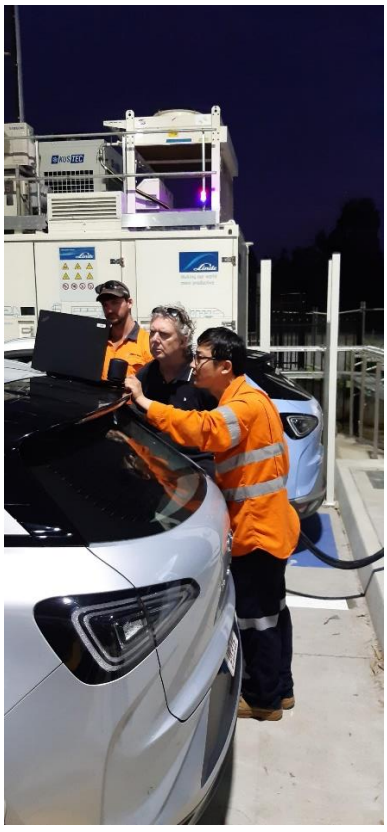
Hydrogen Refuelling Stations are typically designed around modules of compression, storage and cooling. These will be defined by the use case with the key parameters defined in the table below.

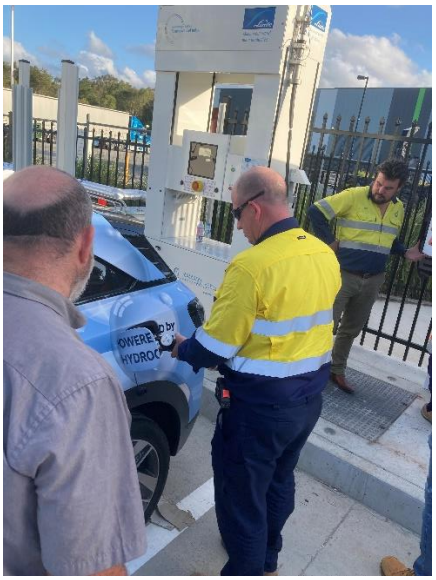
Parameter	Description
Supply Source	Hydrogen may be supplied in three general methodologies – from the production source (e.g. electrolyser), transported via high pressure tube trailers or transported via a liquid hydrogen supply chain.
Vehicle Type	Vehicle type and location will define infrastructure restrictions and requirements. Linde has created infrastructure for the following use cases: Forklifts, Cars, Trucks, Buses, Trains, Ferries
Liquid v Gas Onboard Storage	Vehicles may require liquid hydrogen or high pressure gaseous hydrogen in the on board tank.
Tank Pressure	Vehicle full tank pressure e.g. 350 or 700 bar
Refuelling Volume	How much volume will the average refuel require e.g. 6kg into a car. Note: International standard SAE J2601 should be used as a reference.
Refuelling Profile	How many vehicles will be refuelled back to back or will there be down time between refuels to allow pressurised storage to be refilled.
Target time to refuel	Time for each refuel e.g. 30kg into a bus within 15 minutes.
Optimisation Required	Communication between the vehicle and the HRS will allow faster refuelling in all conditions with optimised filling for every fill. Most vehicles are expected to have communication sensors in the future.
Future Volumes	Likely future volumes are important as they will allow provision for future storage, compression and cooling as the HRS demand increases at the site. Long term end customer contracts and potential users should be considered when scoping the HRS infrastructure.
Social Licence	Hydrogen is new to many people with education needed to ensure community support and appropriate government approvals. Signage is provided as per Australian Standards with BOC also creating an education board for the location to support increased knowledge and understanding of this project.

The output of the parameters will drive the key capital costs of the HRS. These key drivers of capital costs are compressor sizing, hydrogen cooling requirements as well as medium (<350 bar) and high pressure storage (>350 bar) volumes held on site. An experienced vendor will be able to model live the HRS requirements using software to show the impact of these key parameters changing on the physical footprint as well as capital.

Understanding the working conditions will allow an experienced HRS provider to lower HRS capital costs while maximising end user experience. Clear working parameters will also ensure a safe and efficient installation and commissioning process as shown in the pictures below.

The build to commissioning process is shown below:






amazon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Procurement

A well-defined contract with a clear technical specification is key to success in any HRS project.

HRS components are not typically manufactured in Australia which has led to challenges for all projects with the COVID-19 pandemic causing significant disruptions to supply chains. Additionally, most vendors were previously unaware of Australian Standards with a particular focus on Hazardous Area and Pressure Vessel requirements which have seen different interpretations by each state.

BOC would recommend the following factors are considered when procuring an HRS unit.

Parameter	Description
Understanding of Australian Standards	Has the vendor worked with Australian standards previously and do they understand them?
Australian Experience & Local Support	Has the vendor installed an HRS unit in Australia and do they have a local team with experience of installation, commissioning and ongoing maintenance?
International Experience	Does the vendor have a track record internationally?
Remote Support	HRS units typically run using programs – does the vendor have the ability to remotely support the units?
Understanding of Australian Conditions	Australia has temperature requirements often not seen in the main countries where HRS are manufactured. These include high temperatures, high humidity and even dust in some areas. BOC has worked with Linde Fuel Tech on additional engineering for this project to ensure the HRS can be safely operated in the higher temperatures seen in Brisbane compared to Europe.

HRS demand is increasing internationally, which means compliance with differing Australian standards may impact lead times for those vendors who have not standardised equipment to meet Australian standards.

2. Finding The right partner and location

The right partner and location are key to all HRS projects. Successful alignment between project partners will further support regulatory appliance as well as social licence at the location of choice.

BOC changed partners during this project with the key learnings on picking the right partner outlined in the table below.

Parameter	Description
Aligned safety values	Ensuring all parties have aligned safety values and approval processes.
Aligned experience in similar products	Risk assessment processes and norms around acceptable risks. Previous experience in approving comparable infrastructure is helpful.
Complimentary Skills	Ensuring all parties bring complimentary skills to ensure a stronger project to ensure speed of executing post FID.
Understood internal approval processes	Ensuring all parties understand their own internal approval processes and the appropriate decision makers engaged.
Suitable HRS location	Ensuring the HRS location is agreed with all sensitive populations considered within the proposal. Appropriate locations will be driven by regulations over time with EU legislation and the additional safety processes and engineering allowing proximity to the general population as per the picture below as societal confidence grows with the equipment.

An approved liquid hydrogen refueller in proximity to housing in Germany

External Approvals

External approvals will differ by state which adds complexity for HRS projects across state borders. BOC found Brisbane City Council extremely supportive of the HRS location at the bp Port of Brisbane Truckstop in Lytton and provided a significant amount of data around performance, safety and operations. This has been supported by over 200 Linde hydrogen FuelTech installations across the globe with a track record of safe operations key to BOC and bp approvals.

BOC has referenced the Australian and New Zealand Industrial Gas Association (ANZIGA) and international Industrial Gas standards for Hydrogen where no specific legislation or standard existed in Australia. This has supported approvals as these standards have been developed over decades of experience in the hydrogen sector.

There is a need for a national toolkit to be developed for Local Councils and other regulators to support approval processes and ensure safe and efficient approvals. National consistency will further support the hydrogen sector.

Social Licence

Social licence can be complicated based on the location, sensitive local populations as well as wider social issues in the region. Local engagement with key stakeholders early is key to both local approvals and community acceptance.

Social licence will be increased through successful and safe deployment of comparable projects across Australia with a role for companies, industry bodies such as the Australian Hydrogen Council (AHC) as well as local NERA clusters developed to support the Hydrogen sector.

National consistency on standards and standard interpretation will support social licence. Local interpretations will create confusion for those approving projects and create uncertainty for the wider community. Where standards and codes are currently unachievable, blanket exemptions should be issued by regulatory bodies e.g. dispensing nozzles.

3. Future Proofing Infrastructure

The hydrogen sector is developing both locally and internationally with innovation in the HRS sector as well vehicle technology such as a move to higher pressure filling (700 bar trucks) and even liquid hydrogen on board.

When investing in this HRS, BOC considered the following parameters in our investment case.

Parameter	Description
Future Demand	The bp Lytton site allows for expansion into the heavy trucking sector as well as starting the passenger car sector in Brisbane. BOC considers this site as key to the East Coast Hydrogen Highway ensuring this unit can be upgradeable over time as trucking demand increases.
Future Technology	BOC work closely with a range of Truck, Bus, Passenger Car and other OEMs. This allows BOC to gain insights into the hydrogen mobility product pipeline. BOC allowed room for expansion at this site. Linde Fuel Tech were the chosen refuelling partner as they have the full range of gaseous and liquid refuellers allowing BOC the flexibility to upgrade and move HRS units over time as demand increases.
Contracted Demand	Contracted demand is key to commercial viability of any project. Long term contracts can be difficult to achieve based on assumptions around costs coming down over time. Contracted indices can be used to manage this challenge.
Understood internal approval processes	Ensuring all parties understand their own internal approval processes and appropriate decision makers engaged.
Mobility of HRS solution	Fast refuelling is key to ensuring a good experience for end users with hydrogen. Speed of refuelling is a key benefit for hydrogen vehicle refuelling over electric vehicle charging. This means that large scale fast refuellers are key to adoption of hydrogen fuel cell vehicles. HRS solutions are typically modular so may be moved but costs of installation and removal should be included in all business cases.
Delivering Hydrogen	BOC has delivered hydrogen for over 80 years in Australia in Tube Trailers (typically 4-500kg per trailer). The typical delivery mode for hydrogen has been trailer swaps on customer sites. For this site BOC implemented a fixed storage solution to save space as well as reduce the number of trailer assets dedicated to this operation. This saves cost as well as space on the bp site and should be considered for future large scale deployments.

The hydrogen sector is developing quickly internationally. Strong international partnerships with HRS and vehicle partners will support the future proofing of infrastructure and lower the risks of stranded assets during a project's lifetime.

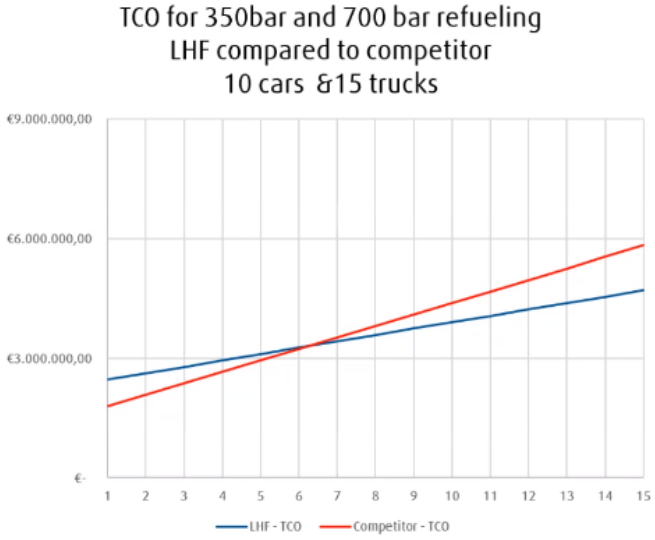
4. Utilities

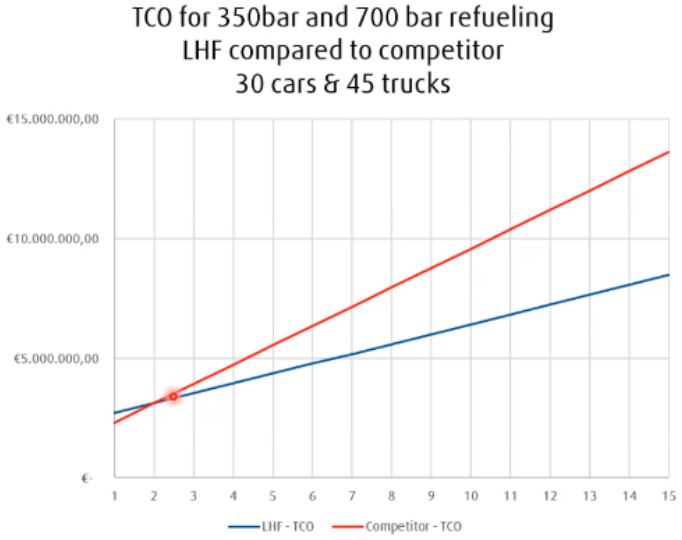
BOC worked with our sister company Linde Hydrogen FuelTech on this HRS. The Linde technology utilises the patented ionic compressor which combines outstanding performance and maximum energy efficiency.

Energy efficiency is becoming increasingly important in Australia as the cost of electricity increases. Lower energy use also supports the roll out of the Ionic Compressor at locations with limited electrical infrastructure. HRS units with larger energy requirements will have a higher Total Cost of Ownership (TCO) over time as well as adding cost to installations.

Below is a TCO model developed by Linde to show the cost benefits of lower energy use over time for the Ionic compressor.

TCO comparizon between LHF and a competitor





BOC worked with our partner bp to manage the utility connection which was simplified by low energy consumption. High cost upgrades for locations looking at HRS units may be more suitable for electric vehicles although this should be reviewed on a site by site basis based on the local vehicle use cases.

The physical location within a site will also impact the costs around installation of a HRS unit. For example moving electrical infrastructure around an existing and very busy Truckstop has added to installation costs. Working with partners to find the optimal location on site to limit moving electrical infrastructure will lower installation costs for projects.

5. Customer Experience

Customer experience and reliability is key to progressing customer confidence in hydrogen technology. BOC is working with bp Australia to ensure a customer experience comparable to using conventional fuels on site.

Customer Training

BOC will provide training to all customers as they learn how to fill their cars safely with Hydrogen. BOC expect this training to be important for the initial refuelling infrastructure in Australia and will subside over time based on community acceptance as with the traditional petroleum refuelling sector.

BOC is supplying Linde Hydrogen FuelTech HRS units which are automated meaning the end user connects the nozzle and presses a button. The communication between the vehicle and the HRS does the fill automatically which simplifies the process for end users.

There are also additional safety mechanisms on the HRS units chosen by BOC which further enhance safety meaning no hydrogen can flow without the appropriate vehicle connection.

Payment System Integration

bp has systemised hydrogen refuelling from a payment point of view. This allows the end users the same experience when refuelling hydrogen as they would experience with alternative fuels.

Fast Refuelling and HRS Design

BOC designed the HRS unit to meet the demand of our consumers. This allows them to fill up in 2-5 minutes based on their current fuel levels as well as allowing back-to-back refuelling of user's vehicles. The consequence of this is there will always be hydrogen on site for the current use case ensuring there is no need for a booking system that may add complexity to the customer experience.

Customer Remote Support (24/7)

The HRS unit BOC selected is deigned to be remotely monitored as well as supported. From the end of Q1 2023 BOC will have a 24/7 remote support process for end users – this will ensure they are supported through refuelling if required and a customer experience where they will always receive the critical fuel they require.

6. Hydrogen supply and the importance of multiple supply sources

Reliable supply of hydrogen is key to the success of all hydrogen refuelling projects in Australia. BOC manages hydrogen supply chains nationally with multiple sources across the country as well as optimised storage on site as well as at the HRS unit.

Additional storage at our production and HRS sites allows certainty of supply while BOC has a tube trailer fleet to support supply from alternative sources should our source at Bulwer Island require planned or unplanned maintenance. Alternative sourcing options ensures business continuity of this HRS operation as well as opening up further options for collaboration with hydrogen production partners.

Summary

Developing a hydrogen ecosystem can be complicated and requires collaboration from strong partners. BOC worked closely with ARENA, the Queensland Government, QFleet and bp Australia to bring this project to realisation and would like to acknowledge their valuable support.

Hydrogen remains a clear pathway for the decarbonisation of mobility and we remain committed to supporting further projects in Australia and progressing learnings for future success.

Further information may be found at Renewable Hydrogen Production and Refuelling Project - Australian Renewable Energy Agency (ARENA)