Viva Energy Australia
Lessons Learnt Report No.1

New Energies Service Station Project

Key Considerations for Australian Hydrogen Mobility Projects

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All images of the New Energies Service Station are artistic impressions and are not to scale.

Acknowledgement of Country

Viva Energy acknowledges and pays respect to the past, present and future Traditional Custodians and Elders of this nation and the continuation of cultural, spiritual and educational practices of Aboriginal and Torres Strait Islander peoples. We particularly pay respects to the Traditional Custodians of the land, across the nation where we conduct business.

We also acknowledge our gratitude that we share this land today, our sorrow for the costs of that sharing and our hope and belief that we can move to a place of equity, justice and partnership together.

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Overview

Viva Energy is a leading Australian company with more than 120 years of operations. While the traditional liquid fuels we manufacture and supply will continue to play a critical role as the energy system transitions to a lower-carbon future, we have a range of initiatives underway in the new energies sector, to supply lower-carbon options to the market in the future.

Viva Energy is constructing and will operate the New Energies Service Station in Geelong, Victoria, which will be a publicly accessible, commercially scaled hydrogen service station that offers hydrogen refuelling and electric vehicle recharging for heavy Fuel Cell Electric Vehicles (FCEVs) (the Project).

In an Australian first, the New Energies Service Station will have the capability to dispense renewable hydrogen in commercial quantities, supporting an initial fleet of up to 15 hydrogen-powered heavy vehicles across a range of industries operating in Geelong and South Western Victoria. The Project includes a 2.5MW Proton Exchange Membrane (PEM) electrolyser capable of producing approximately 1,000kg of gaseous hydrogen per day using recycled water and renewable electricity.

The Project will help advance demand and supply side learnings around hydrogen as a zero emission solution for the heavy commercial road transport sector.

Subject to regulatory approvals and construction timeframes, the site is expected to commence operations in the second half of 2024.

As part of our commitment to the decarbonisation journey of Australia's transport industry and advancing the broader hydrogen sector, we are sharing learnings from this Project. This Lessons Learnt Report, the first in a series for the Project, highlights the key learnings to date during the planning, designing and equipment procurement phases to build Hydrogen Refuelling Stations (HRS) in Australia. These include:

1. Managing the regulatory approvals process;
2. Design considerations for a commercial-scaled HRS;
3. Australian Standards compliance for imported hydrogen equipment;
4. Cost considerations when building a commercial-scaled HRS; and
5. Hydrogen purity implications for HRS and open fleet heavy FCEVs.

This report will be available at ARENA's website at New Energies Service Station **Project Lessons Learnt - Australian Renewable Energy Agency (ARENA).**

List of Acronyms

The following table contains a list of acronyms frequently used within this report.

Acronym	Full Name	Brief Description
ARENA	Australian Renewable Energy Agency	An Australian Government statutory agency, established in 2012. ARENA supports the commercialisation of renewable energy and other low emissions technologies by investing in innovation and knowledge. ARENA contributed to the Project via the Advancing Renewables Program.
AS	Australian Standards	National standards developed by Standards Australia. Any standards developed under the Australian Standard® name have been created in Australia or are adoptions of international or other standards.
ASTM	American Standard for Testing Materials	ASTM is an international standards organisation that develops and publishes technical standards for a wide range of materials, product, systems and services. For the Project, this refers to the test methods set out under the Fuel Quality Standards Determinations.
ATEX	ATmosphere EXplosible	ATEX is the abbreviated name of the European Directive 2014/34/EC and refers the placing on the market of explosion-proof electrical and mechanical equipment, components and protective systems which are located within potentially explosive environments.
CCMA	Corangamite Catchment Management Authority	A statutory authority of the Victorian Government. CCMA is the floodplain management authority with an interest in flooding and how the design accounts for any flooding overlays.
Council	City of Greater Geelong Council	Council operating under the Local Government Act 2020 for the City of Greater Geelong, Victoria's largest regional municipality and location of the New Energies Service Station.
DA	Development Application	The administrative instrument in applying for a planning permit from Council to carry out works for the Project subject to the Council's planning scheme and consists of Application forms, Design plans, Specialist assessments etc.
DEECA	Department of Energy, Environment and Climate Action	Victorian Government department which contributed to the Project via the Renewable Hydrogen Commercialisation Pathways Fund.

Acronym	Full Name	Brief Description
DTP	Department of Transport and Planning	Victorian Government department with an interest in access and egress design aspects for the Project, traffic regulatory requirements associated with the Project.
EPA Victoria	Environment Protection Authority Victoria	Victoria's independent environment regulator who checks and enforces compliance with the Environment Protection Act (2017) to prevent and minimise the risks of harm to human health and the environment from pollution and waste. The Project requires a permit to use recycled water.
FCEVs	Fuel Cell Electric Vehicles	An electric vehicle that uses a fuel cell in combination with a small battery to power its on board electric motor.
HEMP	Hazards and Effects Management Process	A process to identify, assess and control hazards.
HRS	Hydrogen Refuelling Stations	A vehicle service station with the ability to dispense hydrogen for use as a fuel, such as the New Energies Service Station.
ICE	Internal Combustion Engine	An engine that produces energy by burning fuel within itself, such as a vehicle that consumes petrol or diesel.
ISO	International Organisation for Standardisation	ISO is a worldwide federation of national standards bodies (ISO member bodies), responsible for creating and maintaining international standards.
MHF	Major Hazard Facility	Major hazard facilities are industrial sites such as oil refineries, chemical plants and large fuel or chemical storage sites where large amounts of hazardous materials are stored, handled or processed.
MW	Megawatt	A unit for measuring electric power and describing generation or load consumption of equipment.
NFPA2	National Fire Protection Association Hydrogen Technologies Code 2	NPFA2 provides prescriptive guidance to calculating minimum separation distances based on gas pressures and piping sizes of the hydrogen equipment to be used on site.
OEM	Original Equipment Manufacturer	A company who manufactures and sells products to customers or end-users.
PEM	Proton Exchange Membrane	The Project utilises a PEM electrolyser to generate high purity hydrogen, whereby the electrolysis cell consists of two electrodes sandwiching a proton-conducting electrolyte.

Our vision for the New Energies Service Station

Viva Energy has deep and long standing relationships with customers with over 100 years experience in the supply of traditional liquid fuel needs. This mindset and expertise has been applied to the Project, so that customers can:

- Enjoy the best experience that hydrogen refuelling technology has to offer today;
- Emphasise the benefits to adopting the technology by highlighting a key advantage of hydrogen as a fuel, i.e. fast refuelling of consecutive heavy vehicles to best replicate the refuelling speeds of incumbent diesel trucks and buses; and
- Showcase hydrogen as a viable zero emissions fuel that is well suited to heavy transport, which is known to be a hard to abate sector.

From the onset, we acknowledged that hydrogen used as a fuel for transport remains a new experience for our customers.

We drew upon industry expertise to consider aspects of traditional service stations that could apply to the Project, thereby adding some familiarity to the technology and refuelling experience to encourage greater uptake.

This helped to shape some of the principles of the New Energies Service Station, including:

- Developing a hydrogen refuelling project that looks, feels and operates similar to today's mechanisms and facilities for providing energy into a vehicle. This means 24/7 operations, access to hydrogen at all times and commercial supply structures and contracts in place for hydrogen supply, where appropriate;
- Creating a platform for transport operators to deploy a vehicle through their typical procurement processes. By owning the vehicle, this gives operators the freedom to choose amongst both existing and new vehicle Original Equipment Manufacturers (OEMs) depending on their risk appetite level; and
- Supporting diverse vehicle deployment across multiple segments of the transport industry.

Furthermore, we wanted to ensure the hydrogen supplied from the New Energies Service Station provides a reliable, consistent hydrogen supply and positive onsite experience.

1.0 Managing the Regulatory Approvals Process

With the speed of technology evolution and its implementation at times occurring faster than updates to regulations, it is difficult for decision makers in local and state jurisdictions to assess hydrogen projects. With this in mind, prior to commencing the development approvals process, Viva Energy sought specialist planning advice from both planning specialists and legal advisors. We also engaged with Council ahead of the planning application process to educate and inform them about the Project.

1.1 Project engagement with regulators and authorities

Mapping out approvals pathways ahead of engagements

The regulatory framework within the existing state and municipal legislation and guidelines (at the time) was thoroughly examined and the regulatory approvals pathway was mapped. It was established that the Project required development approval (DA) from the local council. The corresponding authorities who would either approve or object to the Project (determining referral authorities) and authorities who may provide advice to the development (recommending referral authorities) were then identified.

Mapping out which authorities were part of the approvals process allowed sufficient time for the Project team to understand these roles in addition to the planning framework. Therefore this allowed the Project team to better prepare and plan before engaging with the relevant authorities.

Approach taken to engage with the authorities

At the time of the DA process commencing, it was already established that the Project required a planning permit from the local municipal authority, and that the City of Greater Geelong (Council) was the determining authority. Under this process, the referral authorities were the Environment Protection Authority (EPA) Victoria, Department of Transport and Planning (DTP), (formerly the Department of Transport (DoT)), Worksafe Victoria, and Corangamite Catchment Management Authority (CCMA).

Having existing operations within a highly regulated industry, Viva Energy already had established relationships with these authorities. This was leveraged to engage the appropriate focal points to discuss the Project as well as pre-empt and prepare for the types of questions that would be asked ahead of the engagements.

Initial engagements with determining and referral authorities commenced early, during the first six months of Project development, to verify the planning and regulatory approvals pathway and simultaneously seek their input.

It became evident that there is a varied level of awareness and knowledge about hydrogen production and its applications across regulatory bodies and decision-making authorities.

Early engagement with regulators and other relevant agencies ahead of lodging the planning permit application provided an opportunity to:

- Educate and inform them about hydrogen;
- Discuss key areas of interest, which were then expanded upon in the application; and
- Discuss feedback and identify key matters of concern, which were addressed and expanded upon with either specialist assessments or follow up meetings.

Early engagement provided an opportunity for regulators and other relevant agencies to ask questions and follow up on any aspects that required clarification, well ahead of them receiving a referral from Council to provide comment on the planning application. Timeframes for the DA process may be affected if there is uncertainty about the development. To alleviate this, the Project team wanted to ensure any requested information was not over and above the normal expectations of a conventional service station. As a result of the early engagements, the information requested as part of the standard Request for Further Information stage of the DA process was not onerous, and straightforward to address.

Impact of onsite hydrogen production and storage

Although the assessments required as part of the planning permit application process were similar to those for conventional refuelling service station developments, there was a higher level of rigour required because the site generates and dispenses hydrogen. This differs from conventional refuelling service stations where fuels are delivered to site.

As such, conventional refuelling service stations are classified as 'service station use' in the Victorian planning scheme. Although the primary use of the site would be a service station where fuels would be dispensed for refuelling vehicles, the Project was re-classified to 'industry' as opposed to 'service station' given that:

- The amount of hydrogen generated and stored would be more than 5,000L; and
- The site was within 1,000m of residential land.

The studies that would otherwise be completed for a conventional service station development, also required additional assessment. Examples of these are presented in Table 1.

Studies	Additional assessment
Noise Modelling	Equipment for on-site generation, storage and dispensing of hydrogen may be noisier compared with conventional refuelling service stations. An understanding of equipment components that could potentially be noisy, (e.g. compressors, chillers and vents), sourcing equipment data including noise levels, equipment configurations and heights was required. The site layout took into consideration noisier equipment and placed these as far from the site perimeter as practical.
Air Quality	Air emissions had to be addressed in the application with the presence of the electrolyser. Although the generation of hydrogen would create air emissions: 90% oxygen, 10% water vapour and trace (0.03%) amounts of hydrogen, an air modelling assessment was not required. This is because oxygen and water vapour are not considered to be air pollutants by any regulatory authority in Australia (or internationally).

Table 1: Additional assessment as part of the planning permit application.

Other studies

Other studies required to support the planning permit application, similar to conventional refuelling service stations were Traffic Impact, Lighting, Ecology and Stormwater Management. Engagement of the requisite specialist consultants that would undertake these assessments and have the appropriate level of knowledge of hydrogen was an additional consideration during the planning application process.

Regulator engagement outside of the planning framework

By examining the regulatory framework early on in the Project and mapping out the regulatory approvals pathway, other applicable regulations outside of the planning approvals pathway were considered. These regulators, who were also referral authorities for a planning permit approval were also consulted as regulatory bodies for their respective areas of regulation. Their key areas of interest focussed on the scale of the Project, in particular the amount of hydrogen being generated and how this would be regulated. This is described in Table 2.

Regulator	Applicable Regulations
EPA Victoria	The Project was assessed against various prescribed activities per Schedule 1 of the *Environment Protection Regulations 2021*. Given that the scale of the hydrogen generation was less than the triggers outlined in the *Environment Protection Regulations 2021*, the Project was not deemed as a Prescribed Activity. As the Project is receiving and using recycled water, it will require a permit under EPA Publication 1995 Permissions proposal pathway guideline (EPA Victoria).
Work Safe Victoria	The Project was found to be outside of the Major Hazard Facility (MHF) regime as the volume of hydrogen gas to be stored was less than the 'threshold quantity' as set out in Schedule 14 (50 tonnes) of the *Occupational Health and Safety Regulations 2017*. Given that more than 5,000L of hydrogen gas would be stored on site (i.e., in excess of the relevant 'Manifest Volume'), WorkSafe Victoria would be required to be notified under Regulation 64 of the Dangerous Goods (DG) Regulations and the Project would be subject to the DG Regulations.
Fire Rescue Victoria	Given that more than the equivalent of 5,000L of hydrogen gas (i.e., in excess of the specified 'Fire Protection Quantity') would be stored on the Project site, this triggered the requirement under Regulation 52 of the *Dangerous Goods (Storage and Handling) Regulations* 2022 (DG Regulations) to consult with Fire Rescue Victoria (FRV).

Table 2: Applicable regulators outside of the planning framework that were consulted for the Project.

Other areas of interest for regulators were:

- The volumes and pressures of hydrogen that would be stored at the site;
- Safe distances between people and equipment;
- Specific controls to manage these distances; and
- Safety controls around the dispensers, which are the point of customer interaction.

Viva Energy's industry knowledge and experience was leveraged to address these areas and is expanded in the next section.

1.2 Project team with relevant industry experience

The Viva Energy Project team has decades of experience across a variety of disciplines within the traditional fuels industry, including expertise in hydrogen safe handling practices at our refinery operations.

To expand its knowledge on hydrogen and best-in-class refuelling practices, the Project team continues to examine international standards applied at similar hydrogen refuelling sites and installations across the world.

On a day to day basis throughout Viva Energy's operations, qualified staff and high-level specialists are required to carry out various tasks that involve technical processes and systems. Our industry is one that is highly regulated and has strict safety standards. The core skills of these staff involve safely managing critical infrastructure such as Major Hazard Facilities (MHF), high-pressure pipelines and the bulk storage, handling and distribution of dangerous goods. This experience included informing authorities about hydrogen generation, storage and dispensing.

The properties and use of hydrogen as a transport fuel source requires industry and regulators to scrutinise the appropriateness of safety controls and design standards.

These controls and standards are applied to generation, storage and use of hydrogen, as well as the ongoing safety of these facilities. The Project team applied the same detail design process that already appropriately assesses and controls hazards associated with hydrogen, similar to what is applied across other petrochemical equipment installations. The risk assessment process followed is consistent with that outlined in AS/ISO 31000:2018 Risk Management - Guidelines.

In addition, third-party oversight was provided by Viva Energy's risk assessment specialists who also undertook reviews of the team's processes to assess risk. This process demonstrated how hazards associated with hydrogen were identified and risk assessed, including how the risks were reduced, to so far as reasonably practicable. This process is often iterative and sufficient time should be factored into conducting these assessments.

1.3 Standardised Planning Approvals Pathway

Planning clauses are subject to interpretation

During the course of the planning approvals process, it was noted that there is a discrepancy between jurisdictions when assessing hydrogen planning development applications under the then Victorian Planning Framework. At the time of submitting the planning permit application, minimal regulation existed as guidance on how to classify on-site hydrogen generation within current planning framework as part of the development approvals process.

Planning clauses are subject to interpretation as there is a discrepancy between jurisdictions when assessing hydrogen development applications under the previous provisions in the Victorian planning framework. Hydrogen generation by some councils could be viewed as 'industry' use for 'industrial gas' production. By way of comparison, another hydrogen generation project in Victoria (10MW) was not classified as an 'industry' use, whereas Viva Energy's New Energies Service Station Project (2.5MW) was.

In Victoria, in August 2023, there were changes to the Victorian Planning Provisions (VPP) to:

- Have a clear definition that "Renewable hydrogen is a zero-emission industrial gas manufactured using renewable energy sources";
- Bring the responsibility for approval of large scale hydrogen production facilities into the Minister for Planning portfolio and away from local councils; and
- Recognise that the production capacity threshold of >410kg/day (equivalent to 1MW) is considered as "state significant quantities of hydrogen gas production".

The amendment introduces a consistent planning pathway for renewable hydrogen gas production for projects that meet a specified threshold quantity. This change in the VPP occurred after the development process commenced for the Project and was not advantageous for the Project. However, this will assist future Projects to have a clearer understanding of the planning approvals pathway as well as a delineation of the regulatory approving authority from the beginning. Accordingly, councils would become referral authorities.

2.0 Site Layout Considerations

As this facility will be Australia's first publicly accessible heavy vehicle HRS, the Project team aimed to deliver a site with a similar look and feel to a traditional service station. As with any other service station within Viva Energy's network, the design of the site is based on customer needs and compliance to required standards. In general, service stations should be safely accessible to vehicles, visible to drivers and have safe access for pedestrians.

Design basis for service station usability

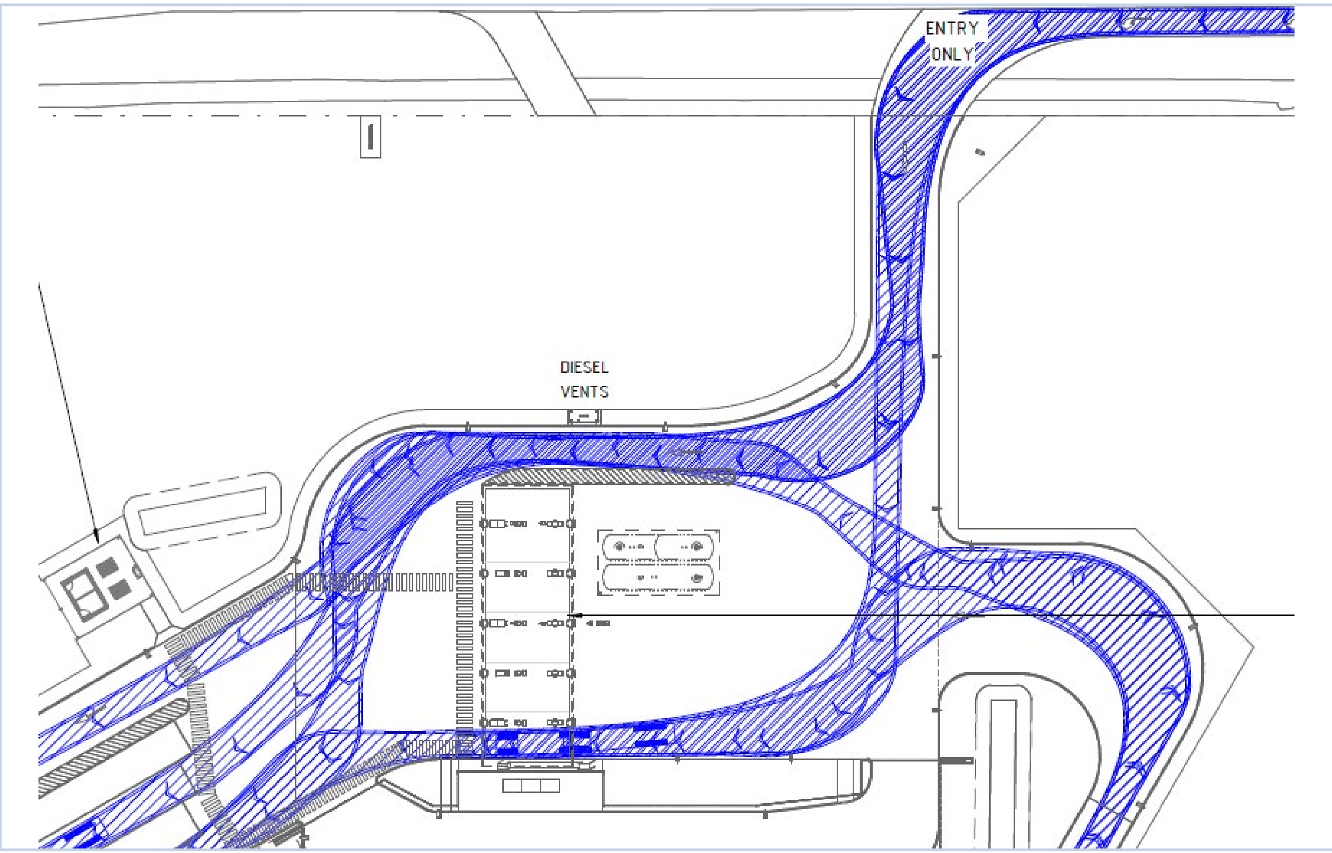
The service station is designed for heavy vehicles. We took the experience in station design for traditional fuels, and applied the same principles to hydrogen refuelling and EV charging. As per any station, specific considerations in the early stages of the design were:

- Undertaking a vehicle swept path analysis or turning circle assessment to inform the decision on where the canopy, buildings and hydrogen equipment could be located such that heavy vehicles can safely enter, queue, exit, and manoeuvre within the refuelling station;
- Access to major arterials and roads that are rated for heavy vehicles; and
- A site layout where ingress and egress access points that could accommodate a range of heavy vehicle types and sizes for future proofing.

Compared with conventional refuelling service stations, there were additional considerations for hydrogen vehicle operations and hydrogen refuelling.

These were:

- For hydrogen vehicles which start and end each shift in the same location (i.e. back to base operations) as well as catering for highway traffic. As a result, vehicle entrances were required for both north and southbound traffic. This is unusual on freight thoroughfares which are normally designed around a single entry and exit for trucks;
- Proximity to high voltage electrical infrastructure, which is required for the supply of electricity for the on-site generation of hydrogen at scale via electrolysis; and
- A reliable water supply source as required for on-site generation of hydrogen. Given that the site is located close to Barwon Water's Northern Water Plant, both recycled water and potable water supply options are available. The Project was designed to use recycled water for electrolysis, so additional consideration was given to the recycled water connection and pipe routing, beyond that which would be required if only sourcing potable water from the town mains.



An example of a vehicle swept path analysis for a site servicing heavy vehicles

2.1 Hydrogen equipment siting and separation distances

Due to the nature of hydrogen gas as a flammable substance, there were additional considerations for the layout of the hydrogen equipment component of the service station. The layout of hydrogen equipment needs to consider a range of other factors to develop a design that minimises risk to people and the equipment itself, including how this interacts with other elements of the site.

To help address gaps in technical guidance for hydrogen projects, Standards Australia's ME-093 Hydrogen Technologies Committee has adopted several International Organization for Standardization (ISO) standards for hydrogen generation and refuelling.

These technical standards aim to enable delivery of safety and technical performance outcomes for hydrogen projects. The recently adopted standard for Australian hydrogen refuelling service stations, Australian Standard AS 19880.1:2023 Gaseous hydrogen – fuelling stations (AS 19880.1) defines the minimum requirements for the safety and performance of public and non-public fuelling stations that dispense gaseous hydrogen.

This standard informed the approach taken to define separation distances and layout of the hydrogen equipment. The design of the hydrogen refuelling service station was then subject to risk assessments to meet process safety compliance. This step examined the potential hazards present and mitigations that may be required to be put in place to manage risk.

These risk assessment tools are part of a business-as-usual skillset for Viva Energy given they are required to be part of any project within its Geelong Refinery and terminal footprint or any other similar installation.

More specifically, AS19880.1 requires that site layouts are based on a risk-informed approach to safety distances, such as a Qualitative Risk Assessment (QRA) or are as prescribed by regulation. However there is currently no prescriptive guidance at a state or national level on what separation distances to apply.

This differs from other regions, such as the United States, where the National Fire Protection Association Hydrogen Technologies Code 2 (NFPA2) provides specific detail on calculating minimum separation distances to apply between equipment and other sensitive locations on site.

As a result, an iterative process was undertaken to design a layout, and review if the risks as determined through a QRA met the risk acceptance criteria at each step. As part of this process, the following factors were taken into account:

- Detailed equipment information from OEMs such as pipe diameter, pressure level, number and type of connections;
- Likelihood of impact from equipment affected by a failure to adjacent equipment;
- Use of potential risk mitigation measures such as fire walls; and
- Acceptable risk criteria used for assessment.

It is noted that if separation distances were more prescriptive for a hydrogen refuelling station, such as in NFPA 2, facility design would require less time and cost to develop.

Risk Acceptance Criteria

To assess if the level of risk is acceptable, a risk acceptance criteria needs to be defined. This is the reference point or threshold against which the risk is evaluated. Ultimately, the risk criteria is influenced by the size, nature and location of a Project. For example, a facility located in a residential area would have lower risk thresholds compared with the same facility located in a rural area.

Although a QRA is required, there is no specific risk assessment criteria defined for hydrogen generation or refuelling facilities within existing Australian Standards.

Instead, there are varying levels of guidance and criteria defined for land use safety planning, which differs between states. As an example, Victoria only defines a criteria for MHF, which most refuelling stations, including this Project fall outside of. By comparison, NSW has defined criteria for different zoning and land use, as well as for specific incidents or exposure scenarios such as heat radiation or explosion overpressure.

Although the Project was not designated as an MHF, it applied WorkSafe Victoria land use planning guidance for MHFs to define the risk acceptance criteria for the QRA and layout.

Depending on the location of the Projects, facility owners may need to decide and justify the risk criteria to be used in risk assessments.

Risk Contours

Risk contour mapping provides a visual representation of the spatial distribution of risk under a certain scenario or incident from a facility, as determined through a QRA. The key risk associated with high-pressure hydrogen gas facilities are leaks, which in the presence of an ignition source, may result in jet or spray fires and generation of overpressure.

Through the QRA process for this Project, Viva Energy have found the following factors to have a significant impact on overall risk:

- Design pressure of the facility;
- Number of leak points, influenced by number of individual pieces of equipment;
- Credibility or the likelihood of catastrophic failure or rupture; and
- Potential of confinement or accumulation of hydrogen leaks.

Additional technical detail on the considerations for quantitative risk assessments can be found in Appendix A.

Hazardous areas considerations

Just like conventional service stations, there are hazardous areas on a hydrogen refuelling station. A hazardous area is one in which an explosive atmosphere is or may be present. As part of safety in design, ignition risks must be managed in these areas.

For a hydrogen refuelling station, hazardous areas must be determined and considered when designing the equipment layout and tubing routes. The extent of these areas are generally smaller than the separation distances for equipment.

However, particularly where fittings are used for tubing, routing should consider where potential explosive mixtures may arise and ensure that ignition sources are located outside of these hazardous areas, or otherwise controlled.

Scalability and future proofing

The chicken and egg scenario plays out when designing a service station to accommodate evolving technology. There remains a high level of uncertainty in rate and timing of FCEV uptake, as well as a quickly evolving market in hydrogen technologies. For example, in recent months, a number of truck OEMs including Daimler and Volvo have expressed commitments to produce 700 bar gaseous heavy FCEVs. Given the high capital costs associated with hydrogen refuelling station infrastructure, designers may wish to design the facility with future-proofing considerations in mind. This may include provisions to accommodate future capacity and different refuelling pressure levels. They should consider not only allowing sufficient footprint, but be reviewed with all above considerations in mind. There is naturally a cost impact to any project to allow for this.

2.2 Replicability of hydrogen facility layout between sites

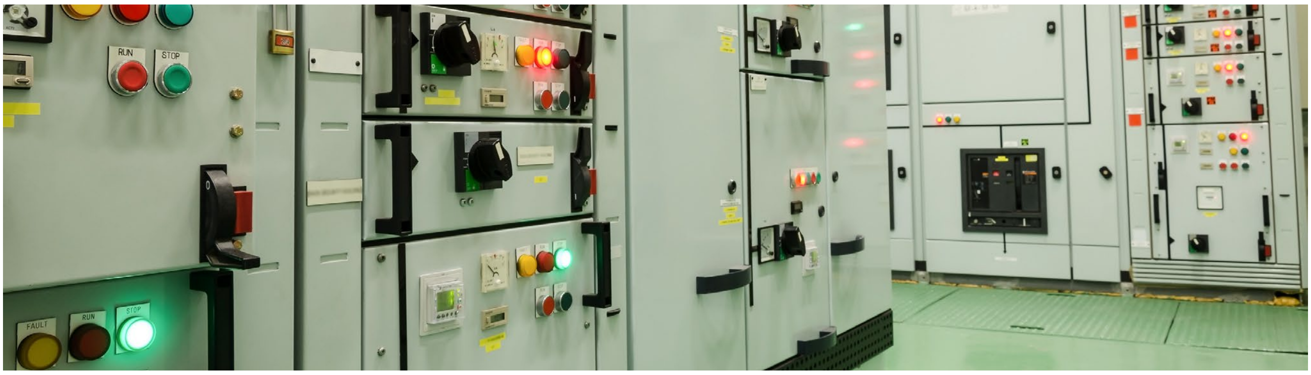
The layout of a hydrogen refuelling service station is similar in most respects to that of a traditional service station. Service stations must be safe for customers to access, have good visibility, optimise vehicle movements, and accommodate site layout constraints such as separation distances.

Whilst the components of a service station are relatively standard, hydrogen refuelling service station layouts cannot be simply replicated to alternative sites. Their configuration and layout will vary, depending on site attributes such as whether they are a new site or additions to an existing site, the physical site location and land size, land use zoning and surrounds, and road access.

The ability and cost-effectiveness to replicate the hydrogen facility layout between different sites is dependent on similarities in land availability, the relative location of existing utilities and services, and relative location of the fuel dispenser to the plant area. A "cookie cutter" approach may be possible where there are minimal constraints, such as a large greenfield area, and the site risk criteria is the same; however, this is not often the case. It is more common that sections of the facility design for one site can be adopted for an alternative location, however with modifications to other areas of the plant to accommodate site-specific constraints.

3.0 Australian Standards Compliance Considerations

The hydrogen equipment such as the electrolyser, storage vessels, and hydrogen dispensers for the New Energies service station were procured from overseas vendors, with no viable Australian options. However given that the equipment is to be used in Australia, the design and documentation is required to align with Australian Standards. In order to address compliance against the relevant Australian Standards, a gap analysis was completed.



3.1 Australian Wiring Rules and Overseas vendors

Many Australian standards for equipment design and installations are adapted from international standards, such as IEC or ISO standards with modifications to take into account Australian/New Zealand conditions.

In these cases, there are often only minor differences between international and Australian/New Zealand standards. However, some Australian Standards are not adapted from international standards, and will often have significant differences to international requirements for particular topics. This is the case for AS/NZS 3000:2018 Electrical Installations (AS/NZS 3000), or more commonly known as the 'Wiring Rules'. The Wiring Rules is a comprehensive standard that sets out the requirements for the design, installation, and maintenance of electrical installations in Australia. These rules are crucial for ensuring the safety of people and property, as electrical faults can lead to fires, electrocutions, and other hazardous situations. This standard has been developed by Standards Australia and industry experts and is applied on a mandatory basis in accordance with various State legislation.

Overseas vendors are often unfamiliar with the requirements of the Wiring Rules; therefore, when vendors have not supplied equipment into Australia previously, early examination of the requirements for design, construction and verification of fixed electrical installations is highly recommended.

This is particularly important as without assurance that installations are compliant to the Wiring Rules, regulators will not allow electrical energisation of the installed equipment.

During the detailed design of the Project, a significant amount of time and effort was expended investigating electrical compliance questions relating to the hydrogen equipment required under the Wiring Rules and the associated standards referenced within.

Working closely with overseas vendors to ensure differences are identified early on in the design process by means of a gap analysis with particular focus on the Wiring Rules is important as this can impact selection of sub-componentry, production schedule and even site layout considerations. Understanding the applicability of the Wiring Rules to different parts of the facility is also key to defining the design.

It is important to highlight that the gap analysis conducted for this Project only assists the market if the same model and make of equipment is purchased by others. For every new or different overseas models entering the Australian market, a gap analysis may be needed if the vendor isn't familiar with Australian standards. Project teams should factor time in the design process to undertake these types of gap analysis.

Is containerised equipment an Installation or Machinery?

Containerised equipment is currently a common mode of supply for parts of hydrogen installations due to their transportability and modularity. However, within the local setting, there is ambiguity in the application of the Wiring Rules which is relevant for 'fixed electrical installations,' when importing equipment as containerised systems.

This is because there is a separate Australian standard AS/NZS4024.1204: 2019 Safety of Machinery – Electrical Equipment of Machines which provides guidance on safety electrical installations within 'machinery' applications.

Depending on which of these standards is deemed to be applicable, this can result in differences in cable wiring and protection requirements.

To assess whether the containerised equipment is considered as 'fixed electrical installation' versus 'machinery', the Project team expended significant time to understand from the equipment suppliers the points of electrical connection and the extent to which each of the standards have been applied. The Project team provided this information to the State based electrical authority to establish which standard should apply.

Currently, there is a discrepancy between states regarding a determination on compliance. Clarity regarding the extent to which the Wiring Rules applies is critical to remove additional cost and time impact that will be felt across any hydrogen project. This would help drive an effective and nationally consistent gap analysis and compliance effort with overseas hydrogen equipment vendors.

3.2 Hazardous Areas and IECEx

The Wiring Rules also refer to compliance requirements with relevant Australian Standards for hazardous area management. During the design, challenges also arose with overseas equipment compliance and compatibility against AS/NZS 60079 Explosive Atmospheres, which set out the requirements for the design, selection and installation of electrical equipment in hazardous areas.

Based on these standards, Australia accepts the use of hazardous area electrical equipment holding an International Electrotechnical Commission Explosive (IECEx) certificate as opposed to Atmosphere Explosible (ATEX) certification, the latter of which is not accepted without an additional conformity assessment by a competent assessor. This is another layer of cost and time to achieving equipment compliance. ATEX is acceptable in countries outside of Australia, particularly throughout Europe. This presents a challenge for overseas vendors tailored to manufacturing ATEX certified equipment to also meet IECEx requirements, and introduces additional effort for local projects to review the suitability of selected components.

4.0 Cost Implications

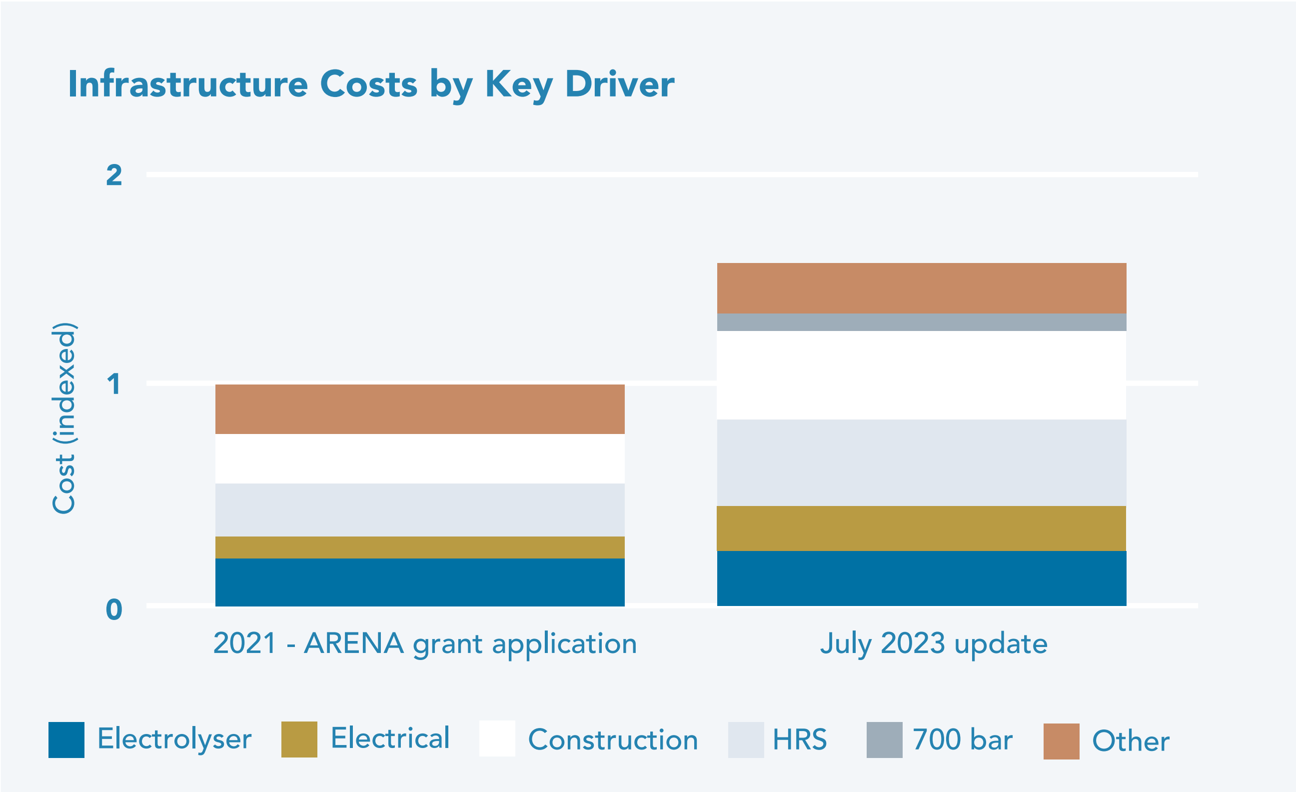
From the outset of the Project, it was known that significant capital outlay would be required to build a hydrogen service station capable of refuelling vehicles back to back, supported by a reliable generation source of hydrogen on site and, associated storage, compression and refuelling infrastructure.

It was only through the detailed design period that the gravity of the cost implications of achieving the full performance requirements of the hydrogen service station became evident. This was compounded by the new market nature and size of the Project's hydrogen infrastructure installation, which is an Australian first. As described in this Lessons Learnt Report, the Project team experienced a heavily iterative design process compared to other engineering projects. With additional clarity on vendor details and process safety requirements, size of the footprint of the station increased as the design evolved. The larger the footprint the more expensive the station is to build, noting that footprint size was not the only driver for higher than estimated costs.

Over the course of two years, the cost estimate of the Project increased considerably compared to the original budget from 2021. Key drivers of these cost increases are summarised in Table 3 on the following page.

Key Driver	Description
Electrolyser	At the time of vendor selection, there were limited vendors willing and able to deliver an Australian compliant electrolyser system at this scale. In addition, some vendors withdrew during the tender process. This resulted in a change from the original 2.0MW to a 2.5MW electrolyser system, increasing the size and costs for the associated cell stacks, power supply and cooling system.
Electrical	The large amount of electrical infrastructure required to support the hydrogen generation and refuelling equipment became apparent as the design matured, additional vendor data became available, and the Wiring Rules compliance requirements were clarified. This resulted in the switch room equipment and size doubling from initial specifications.
Hydrogen Refuelling	The refueller package for the Project was defined to be a 'fast fill' hydrogen refuelling package designed to refuel at least 10 trucks or buses consecutively, capable of dispensing 300 kg of hydrogen in under two hours. There are no standard, off the shelf solutions meeting these performance requirements as yet, meaning cost increases were seen across various elements of the package. Through detailed design, a larger footprint than had originally been envisaged was necessary in order to comply with hazardous areas and exclusion zones. This growth in overall size of the facility has impacted all construction costs.
Construction & market forces	Project delivery timelines coincided with a period of high general inflation and increased construction demand. As a result, the Project team has experienced cost increases of 20-30% for construction, standard materials, and hydrogen-related materials over the last 24 months. The Project has seen increases across almost every aspect of scope, including key materials such as concrete and steel. Additionally, at the time that equipment orders were placed, no local manufacturing capability existed for the electrolyser or refueller package, requiring all hydrogen equipment to be imported. With long lead times of over 18 months from order placement to equipment delivery, there has been an extended foreign exchange exposure for the Project.
Scope change to include 700 bar refuelling	The Project was designed around dispensing gaseous hydrogen at 350 bar for a fleet of back to base partner vehicles. As hydrogen refuelling technology continues to advance at pace, a number of vehicle OEMs have expressed commitments to produce 700 bar gaseous heavy FCEVs. This is a change from two years ago when the original scope was designed based on vehicles available then and demonstrates how the market continues to evolve. Based on this feedback, a variation to the Project scope to include 700 bar refuelling was included as an industry enabler.

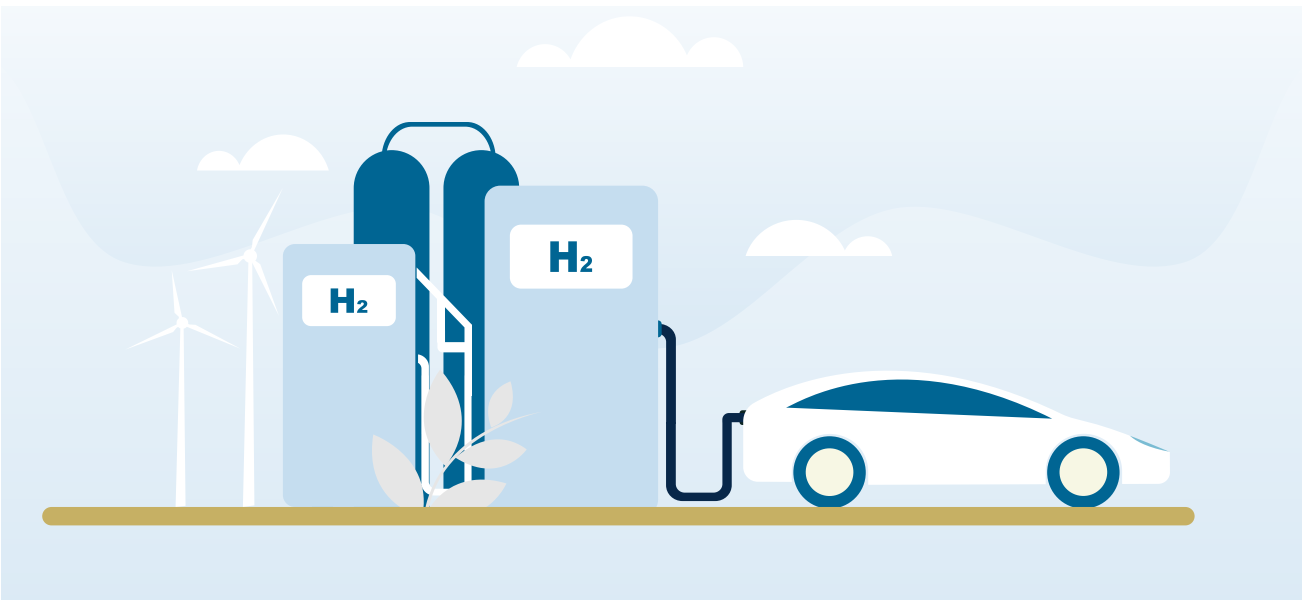
Table 3: Key drivers contributing to the Project's increased costs since the original 2021 budget



A graphical representation of a comparison of the relative increases in these key drivers

It should be noted that these infrastructure categories of cost expenditure also include balance of plant, safety, security and other real life useability features that are required for everyday operations. The packages of equipment alone are only a portion of the overall Project infrastructure costs.

The goal of building hydrogen refuelling infrastructure at scale within the Australian market is not without its challenges. Whether it be dealing with issues around standards and compliance, working with overseas vendors, or demonstrating the fast refuelling advantage of hydrogen, whilst in the current high inflationary environment all impact the infrastructure cost. Needless to say, the Viva Energy team along with its transport partners remains committed to delivering the New Energies Service Station Project that enables both supply and demand sides of the hydrogen equation together.



5.0 Hydrogen purity implications for HRS and open fleet heavy FCEVs

At Viva Energy, we are proud to help Australians reach their destination by delivering the energy that they need to get there. Our objective is to grow a sustainable business, which motivates us to address the challenge of climate change and be part of the solution. This is why we have partnered with our customers to demonstrate the important role that hydrogen can play in decarbonising hard-to-transition industries such as commercial road transport.

Our vision for the New Energy's Service Station is to look, feel and operate as per today's mechanisms for providing energy to a vehicle, as well as to a service level that the transport industry is accustomed to.

Traditional liquid fuel standards and regulation to ensure product quality

The Federal Department of Climate Change, Energy, the Environment and Water regulates the quality of petrol and diesel sold in Australia under the Fuel Quality Standards Act (2000) and the Fuel Quality Standards Regulations (2019). The Australian fuel industry and fuel suppliers must meet these legislative requirements. Moreover, there are individual Fuel Quality Standards Determinations for automotive Diesel, Biodiesel, Petrol, Autogas (LPG), Ethanol E10, and Ethanol E85. These documents set out the technical specification for each product as well as the standard test method for each parameter.

Having a Fuel Quality Standard for liquid fuels means that any vehicle owner can readily refuel their vehicle with petrol or diesel at any service station across Australia, and know that the quality of that fuel meets a minimum standard that will allow them to safely and reliably reach their destination, every time.

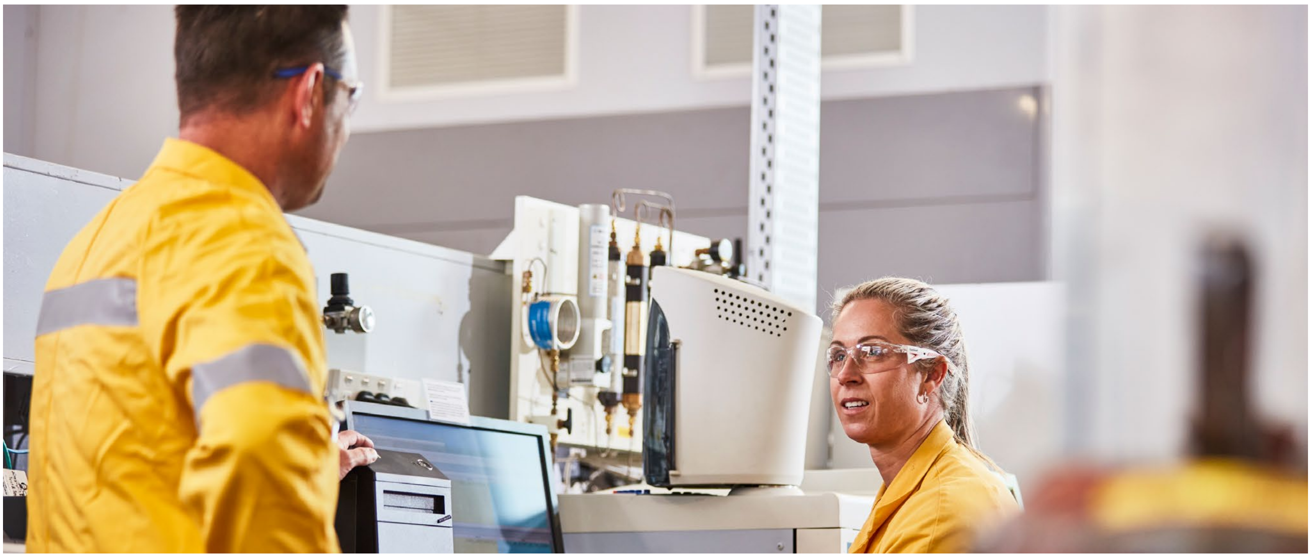
From a traditional fuel supplier's perspective, having prescriptive standards makes it clearer to comply with legislated requirements and ensures that industry performs to a minimum requirement.

What about hydrogen?

Currently for the sale of hydrogen gas as a fuel in Australia there is no equivalent legislated Fuel Quality Standards Act or Regulation. However, in the case of hydrogen mobility applications, given that the fuel cells in vehicles are highly susceptible to being impacted by contaminants, there are product quality parameters such as purity that need to be considered.

There are Australian Standards that do apply for the quality of hydrogen gas that is produced and dispensed at service stations. Given that hydrogen gas will be generated, compressed, stored and dispensed at the New Energies Service Station, the relevant AS standards that apply are AS ISO 19880.8:2021 Gaseous hydrogen – Fuelling stations, Part 8: Fuel quality control and AS ISO 14687:2020 Hydrogen fuel quality – Product specification.

Accordingly, AS ISO 14687 is the standard for fuel grade hydrogen gas that is being adopted for the New Energies Service Station, which specifies a minimum purity of 99.97% for gaseous hydrogen used for FCEVs.



Why is AS ISO 14687 relevant to the New Energies Service Station?

One of the key principles of the New Energies Service Station is that it is publicly accessible, where operators choose their own OEM; therefore the station needs to be vehicle make and model agnostic. This means that any owner of a hydrogen FCEV, regardless of make and model, will be able to refuel at the site.

Because the New Energies Service Station is vehicle agnostic, coupled with no current legislation or regulations on hydrogen fuel standards, Viva Energy took a proactive approach to survey the vehicle OEM landscape, to ensure that the hydrogen supplied from the site would meet the fuel quality requirements of vehicle OEMs active in the Australian market.

As a long time supplier of quality fuels, the Project team understands the importance of supplying quality hydrogen to customers and that off-specification fuel could adversely affect the performance of their FCEV, undermine their confidence in hydrogen or void the vehicle warranty.

Interpretation of AS ISO 14687 – is it 99.97% or 99.999%?

Encouragingly, industry is broadly aware of AS ISO 14687 as a hydrogen fuel standard. This means that in the absence of a legislated hydrogen fuel standard, unrelated parties have chosen to follow best practice in adopting Australian standards as the first port of call.

Interestingly a key observation was noted in that although AS ISO 14687 states a hydrogen purity of 99.97%, "five 9's" was often referenced, which points to a purity of 99.999%. The interpretation of AS ISO 14687 as 99.999% purity was unexpected and presented some questions internally within the Viva Energy team, namely:

- Is it 99.97% or 99.999%?
- How do we test to 99.999%?
- Is supply to 99.999% purity possible or necessary?

Further clarification from vehicle OEMs was sought and pragmatically, AS ISO 14687 was found to be acceptable. This process did however highlight that AS ISO 14687 may not be understood uniformly across industry, thus creating confusion for potential transport operators looking to invest in FCEVs. It also identified that we needed to better understand what local testing capability existed for fuel grade hydrogen to support compliance to AS ISO 14687 (refer to Section 5.4).

5.1 The importance of a Hydrogen Fuel Quality Standard

The challenge for our industry

To date we recognise two key challenges for industry:

1. The need for uniform understanding on minimum hydrogen quality requirements across both infrastructure providers and vehicle OEMs. Without this, it could stymie transport operator vehicle investment if warranties are deemed to be at risk on an already expensive asset.

2. The need for an industry-wide expectation on Hydrogen Fuel Quality Standards and refuelling practices. Without this, it may act as both a barrier to refuelling infrastructure investment and vehicle deployment if hydrogen quality guarantees and refuelling practices vary between refuelling service stations.

The impact on commercial terms and conditions

The commercial impact of varying hydrogen specification requirements across the transport industry can be far reaching; impacting transport operators, hydrogen suppliers and vehicle OEMs alike. Despite the source of hydrogen, renewable or otherwise, hydrogen suppliers servicing the road transport industry should supply a product to a standard set by Australian standards or a legislated Hydrogen Fuel Quality Standard. This will help enable basic supply contracts for hydrogen to be entered into, where specific terms and conditions may include:

- Quality guarantees, linked directly to the hydrogen specification;
- Provision to remedy instances where off-specification product is supplied;
- Warranties of hydrogen as a fuel product;
- Limitations of liability;
- Supply interruptions; and
- The process and timing to remedy supply interruptions, which could be a result of off-specification product detected in the system.

The impact on vehicle warranties

Hydrogen heavy FCEV warranties are limited in comparison to the warranties offered for Internal Combustion Engine (ICE) trucks and buses today, particularly for the fuel cell as an individual component. In most instances, fuel cells are warranted for a set number of years or the number of operating hours (of the fuel cell), whichever comes first.

For a prime mover that may be double shifted, the warranty period could expire in well under 2 years based on the fuel cell operating time. Compare this to some ICE warranties, which are guaranteed for 3 years and cover both parts and labour.

This highlights the criticality of establishing Hydrogen Fuel Quality Standards as transport operators that have invested in hydrogen vehicle technology will likely have exposure on their warranty terms sooner than what they would with current ICE counterparts. These limited FCEV warranties coupled with the uncertainty of after sales support and service of FCEVs not yet rigorously tested or deployed on Australian roads may also pose barriers to transport operators looking to adopt the technology.

Having an industry accepted Hydrogen Fuel Quality Standard helps eliminate confusion and gives passage to creating basic supply contracts for hydrogen (e.g. warranties and liabilities), following on from how the sale of traditional liquid fuels is governed today.

5.2 Fuel grade hydrogen testing capability in Australia

Hydrogen has been widely used across industry for many years, from food to industrial applications. As a result, there are established specifications, laboratories, test methods and processes to certify the quality of hydrogen used in those applications.

What is different about the hydrogen supplied by the New Energies Service Station however is the testing required to meet AS ISO 14687, where:

- The purity of fuel grade hydrogen (99.97%) is higher than required for food and industrial use;
- The large number of contaminants to be tested, which are included due to the risk of potential adverse impacts on vehicle fuel cells; and
- Those contaminants require testing to extremely low detection levels.

Local testing capability of hydrogen to meet AS ISO 14687 is currently limited as this area lags implementation, resulting in longer test turnaround timeframes, and higher costs.

Furthermore, whilst AS ISO 19980.8 is prescriptive around the quality of fuel grade hydrogen, the standard only offers general guidance around testing frequency and locations throughout a refuelling system or a service station.

This presents a supply chain challenge for a distributed supply model where infrastructure operators receiving and dispensing fuel grade hydrogen to customers need assurance on product quality, as is currently done with traditional liquid fuels. A consistent approach to testing would help to support infrastructure operators in implementing best practices, as well as give transport customers assurances around the minimum quality of hydrogen fuel regardless of HRS, as is currently done for customers with traditional liquid fuel deliveries.

The inclusion of fuel grade hydrogen under the Fuel Quality Standards Determinations, or similar, could help to establish both prescriptive specifications and test methods, which may provide some impetus to developing local testing resource and capability within Australia.

As more and more hydrogen projects are established and demand for fuel grade hydrogen increases (as supported by a Hydrogen Fuel Quality Standard), testing capability within Australia needs to grow to meet the market.

6.0 Conclusion

The New Energies Service Station's infrastructure and commercial elements have been designed to operate in tandem to deliver a hydrogen mobility project that generates both supply and demand side learnings in a commercial environment. The Project is underpinned by our ambition to construct a hydrogen refuelling station with the functionality and customer experience of today's traditional fuel stations and enable the longer term transition of larger fleet volumes to zero emission energies.

This publicly accessible commercial hydrogen refuelling station is very much a first in the Australian market, showcasing the decarbonisation potential of a broad range of heavy transport applications. Key takeaways from this report include:

1. Early engagement with regulators provided an opportunity to educate decision-making authorities and helped to define the approvals pathway and key areas of interest for approval and referral authorities.
2. Design of hydrogen refuelling stations to ensure the risks introduced by the facility are acceptable is an iterative process requiring detailed vendor data, for which projects should allow sufficient time.
3. Early review of imported equipment against Australian Standards, particularly the Australian Wiring Rules, is recommended to identify any compliance driven design changes which may impact time and cost. Opportunities remain in this space to clarify interpretation of Australian Standards for these new technologies.
4. A national Fuel Quality Standard and Regulation for hydrogen fuel, as supported by adequate testing capability within Australia, will give confidence and direction to industry to drive greater uptake and investment in the technology.

Projects should consider these learnings to help better inform their investment decision, highlight key areas that should be investigated early, and in the end, mitigate investment risk exposure. This should remove barriers for both infrastructure providers and some of the transport operators, as they consider investing in hydrogen for transport sector.

This project illustrates the benefits of industry and government working together to advance hydrogen as a future fuel, as we collectively move to decarbonise hard-to-transition industries such as commercial road transport.

Appendix A – Technical Addendum

Hydrogen Facility Layout

AS 19880.1 is the governing standard for hydrogen refuelling stations and requires that risk assessment be conducted to evaluate facility design. It is recommended that the risk assessment carried out for the hydrogen fuelling station should be quantitative or semi-quantitative. Therefore, while other guides exist offering prescriptive safety distances, modelling was required for this facility to determine the appropriate separation distances in the Australian context.

What about NFPA2?

Separation distances for hydrogen facilities are often discussed in the context of The United States' (US) Fire Protection Association Hydrogen Technologies Code 2 (NFPA 2). In the US, this code provides prescriptive guidance to calculating minimum separation distance based on gas pressures and piping sizes of the hydrogen equipment to be used on site. These general technical details of the hydrogen equipment is usually readily available from equipment vendors. Therefore, this approach to calculating minimum separation distances can be undertaken in early stages of design to inform initial layouts. There is some level of conservatism within NFPA 2, which also provides contingency for future changes in design.

Any other guidance for Australia?

Standards Australia Technical Specification SA TS 5359:2022 also provides prescriptive guidance to assist in specifying the minimum distance between nominated hydrogen equipment and people, structures or other fuel equipment that may be impacted. It should also be noted that while SA TS 5359 recognises that the operating conditions of the gas will impact level of risk, there is no differentiation between pressure levels in the typical minimum separation distances provided. While this technical specification offers a more prescriptive guide for the local context, it is clear that the AS/ISO 19880 series takes precedence over this specification for a gaseous hydrogen refuelling facility.

Risk Ratings for a Nascent Industry

Risk analysis tools require a risk rating to be determined through consideration of the consequence and likelihood of the identified risks. The early nature of the industry is such that availability of industry-specific data is limited and risk assessment tools are at varying levels of proficiency for use in high-pressure hydrogen mobility applications.

As one such example, the limited operating history for hydrogen mobility applications means that equipment reliability, frequency of release and consequence data is not well established relative to traditional fuels. It is expected that the methodology for determining consequence severity will evolve over time as more hydrogen projects are developed and operated.

Quantitative Risk Assessment (QRA)

Where prescriptive guidance on separation distances are applied, this allows for a facility layout to be quickly developed. A QRA is conducted for an existing layout, to assess it for acceptability.

Therefore the aforementioned NFPA2 and SA TS 5259 can be used to develop initial concept layouts as input to the QRA modelling. A QRA can validate whether the separation distances initially applied are acceptable based on the specific site and risk criteria applied and demonstrate that the mitigation measures employed are appropriate to achieve the desired level of risk of the station.

Where this methodology is applied, designers may wish to apply contingency to initial site footprint in early design to account for the differences in basis for leak size used by NFPA2 and the site specific QRA.

Key observations influencing the modelling were found to be:

- Larger hole sizes, both as a result of larger pipe diameters required for the equipment, as well as the nominated design leak sizes, resulted in larger risk contours.
- Higher levels of confinement or congestion at the point of release result in higher blast overpressure on delayed ignition events. Consensus has yet to be reached as to whether dispersion in outdoor installations is sufficient to consider these as unconfined releases, particularly for releases directed towards the ground where hydrogen can display 'ground-hugging' behaviour similar to that for heavier gases which can lead to confinement and delayed ignition.
- Designing the facility to limit potential for escalation or secondary release events (eg. due to flame impingement) had a marked influence on reducing risk contours.

As previously noted, limited industry data is available to support modelling assumptions used for risk assessments in this emerging industry. Ongoing work and industry knowledge sharing is required in this area to ensure a continued safe and reliable roll out of hydrogen refuelling infrastructure.