VIVA EnergyAustralia

Viva Energy Australia
Market and Technology Report Edition 1 - Infrastructure

New Energies Service Station Project

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Acknowledgments

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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.

Viva Energy acknowledges and pays respect to the Wadawurrung People, the traditional custodians of the land that the New Energies Service Station Project is being developed.

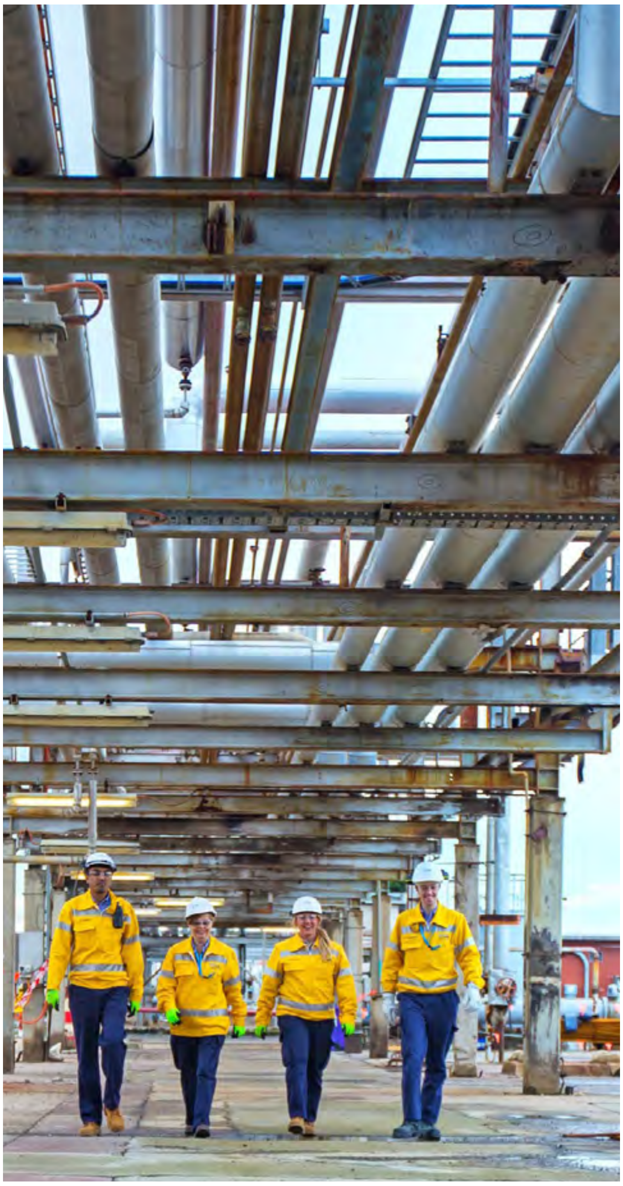
Contents

1. Background

a) Overview of Viva Energy

Viva Energy is a leading retail, industrial and energy business with more than a 120 years of operations in Australia. While the traditional liquid fuels we manufacture and supply will continue to play a critical role in supporting the economy, as the energy system transitions to a lower-carbon future, we have a range of initiatives underway to supply low and zero carbon options to the market.

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



b) Rationale and aims of 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, and a 'fast fill' hydrogen refuelling package designed to refuel at least 10 trucks or buses consecutively.

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

- The regulatory and approval pathways for public hydrogen refuelling service stations;
- The commercial and technical readiness of hydrogen refuelling infrastructure and FCEVs;
- Demonstrating the safety of hydrogen vehicles and refuelling to build confidence for infrastructure and fleet owners and operators; and
- The performance of various FCEVs across different industries.

Viva Energy, Toll Group, Comfort DelGro Corporation (CDC), Cleanaway and Barwon Water are the founding partners in the Project, with up to seven hydrogen fuel cell trucks and buses committed across these heavy transport operators. Furthermore, Viva Energy is progressing discussions with other transport operators with a presence in the local Geelong market and it is expected that up to eight more FCEVs will be added to the Project.

c) Reference projects

Where possible, the New Energies Service Station has drawn on learnings from previous hydrogen generation and mobility projects, including:

- Toyota Ecopark Hydrogen Demonstration (Altona, VIC);
- Jemena Power to Gas Demonstration (Sydney, NSW);
- ActewAGL Hydrogen Refuelling Station (Fyshwick, A.C.T); and
- Port Kembla Hydrogen Refuelling Facility (Port Kembla, NSW).

Key insights from these projects related to the extended lead times for hydrogen generation and refuelling packages, Australian Standards compliance challenges for imported equipment, and customer refuelling constraints arising from limited storage and compression capability and capacity.

Drawing on these lessons learnt, the Project team focused on defining the system requirements including vehicle refuelling patterns and hydrogen regeneration times early in the engineering design process. The main equipment packages were tendered before a final investment decision was taken to allow for the extended delivery lead time. Compliance with Australian Standards and allowances for the review of vendor equipment designs was also considered in the specification and lead times for these packages.

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.
AC	Alternating Current	Alternating current is the way electric power is transmitted from generating facilities to end users including to businesses and residences, and is the form of electrical energy that consumers typically use when they plug appliances into a wall socket. The electrolyser requires Direct Current power and AC power is converted using a rectifier for supply into the electrolyser.
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.
BOP	Balance of Plant	A term used to reference the equipment and supporting systems used for the New Energies Service Station.
CSD	Compression, Storage and Dispensing	A term used to reference the compression, storage and dispensing of hydrogen post-electrolyser, needed to make the hydrogen generated usable for mobility applications.
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.
DC	Direct Current	Direct current is typically used in electronic devices with a battery for a power source. The electrolyser requires Direct Current power and AC power is converted using a rectifier for supply into the electrolyser.
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.

List of Acronyms (continued)

Acronym	Full Name	Brief Description
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.
FSS	Fire Safety Study	The fire safety study ensures that the proposed fire prevention, detection, protection and fighting measures are suitable for to meet the risks presented by the potential fire scenarios at the facility.
HAZOP	Hazard and Operability Analysis	The in-depth analysis is undertaken in collaboration with a multidisciplinary team of employees to identify potential hazard operability issues with the Project and to propose preventing actions.
HAZID	Hazard Identification	A systematic and structured analysis undertaken to identify potential hazards and assess risks associated with a system or process early in the design phase of the Project.
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.
ISO	International Organisation for Standardisation	ISO is a worldwide federation of national standards bodies (ISO member bodies), responsible for creating and maintaining international standards.
LCOH	Levelised Cost of Hydrogen	The capital and operating costs of producing 1kg hydrogen at the point of the electrolyser of the process.
MHF	Major Hazard Facility	Major hazard facilities (MHF) 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.
O&M	Operations and Maintenance	The undertaking of daily activities required to maintain the optimal performance of the Project's equipment and site facilities.
OEM	Original Equipment Manufacturer	A company who manufactures and sells products to customers or end-users. For the Project, this refers to the supply of FCEV vehicles by OEMs to transport operators.

List of Acronyms (continued)

Acronym	Full Name	Brief Description
OPEX	Operating Expenses	The costs incurred by the Project to generate, compress, store and dispense hydrogen.
OPT	Outdoor Payment Terminal	An outdoor payment platform for the authorisation and electronic payment of fuel transactions at the site.
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.
PLC	Programmable Logic Controller	A type of computer that controls the site's functions using the internal logic programmed into it to automate processes.
QRA	Quantitative Risk Assessment	A formal and systematic approach to estimating the likelihood and consequences of hazardous events, and expressing the results quantitatively as risk to people, the environment and the site.
RO/EDI	Reverse osmosis / electro deionisation	A purification process used to achieve high water purity prior to feeding into the electrolyser. Following reverse osmosis, water is still saturated with salts and oxygen. Electro deionisation uses electricity to remove these impurities prior to feeding into electrolyser.
RMU	Ring Main Unit	A medium voltage switchgear to support the electrolyser by providing continuous power with the ability to switch power sources in the event that repair works or an unexpected disruption occurs.
SCADA	Supervisory Control and Data Acquisition	Is a hardware and software application which is used to control the hydrogen generation, storage, compression and dispensing by collecting, analysing and visualising data in real time.
SIL	Safety Integrity Level	The measurement of performance of a safety system under all the stated conditions within a stated period of time.
SMS	Safety Management Study	A comprehensive and structured process defined in Australian Standards to examine the potential risks posed to a high pressure pipeline when surrounding land uses change.

2. Project design process and Technology Selection

The aim of the New Energies Service Station is primarily to provide refuelling facilities for heavy FCEVs. Due to the early nature of the hydrogen mobility market, on-site generation was determined to be required to offer a consistent and reliable supply of fuel-grade gaseous, renewable hydrogen. There was no alternative source of supply we could rely on when developing the Project in 2021.

2.1 Hydrogen Generation Design

The key factors when selecting the electrolyser were reliability, maturity in hydrogen generation technology and vendor support in Australia. Renewable hydrogen production can be via Proton Exchange Membrane (PEM) or Alkaline electrolysis technology.

While alkaline electrolysis is well established, PEM solutions are also significantly progressed in their technology and commercial readiness. Both technologies were considered for this Project, with no option but to source internationally.

To ensure a consistent quality of hydrogen dispensed at the New Energies Service Station, it was determined that the electrolyser output should meet AS ISO 14687 Hydrogen Fuel Quality – Product Specification as a minimum fuel quality standard dispensed into customer FCEVs.

AS ISO 14687 is a published and internationally recognised standard for hydrogen fuel quality and meeting these requirements should provide confidence in Viva Energy's hydrogen refuelling facility for both transport operators and their vehicle suppliers.

From an electrolyser selection perspective, in order to meet AS ISO 14687, this necessitates drying and purification of the hydrogen stream regardless of PEM or Alkaline technology.

Catalytic deoxygenation and adsorption dryer has been included in the electrolyser package to ensure that the purity specifications can be met.

Just as the cell stacks in vehicles are sensitive to the hydrogen fuel used, the cell stacks in electrolysers are sensitive to the purity of the water used for generation of hydrogen.

Impurities in the water can impact cell stack efficiency and longevity, and it was found that many electrolyser Original Equipment Manufacturers (OEMs) supply an integrated water treatment system as part of the package.

This is also the case with the electrolyser selected, which has an integrated Reverse osmosis/electro deionisation (RO/EDI) water treatment system. Electrolysis requires approximately 9L of purified water to produce 1kg of hydrogen.

Accounting for impurities in the feed to the RO/EDI system, it is expected that around 15L of water will be required per 1kg of hydrogen generated. The station is located within 1km of a waste-water treatment plant, offering the opportunity to utilise recycled water for the electrolysis process.

The station will have recycled and potable water supply, with the potable water supply included to ensure continuity of supply (and hydrogen generation) in the scenario of a recycled water outage.

Electricity is the other major input for electrolysis with the cell stacks often requiring a Direct Current (DC) power supply. Nel offered a power supply system with their package, consisting of a converter, transformer, rectifier, medium voltage switching compartment and DC busbar to transfer the power from this system to the cell stacks. These technologies are not novel, however to ensure technical integration, this solution was nominated.

2.2 Hydrogen Refuelling Design

The optimal design of a Hydrogen Refuelling Station (HRS) is dependent on meeting the needs of the end users. Key decisions informing the infrastructure design were the design of the different vehicle type/s, refuelling pressures, refuelling profiles and commercial supply provisions.

A key principle for the New Energies Service Station was to develop renewable hydrogen refuelling infrastructure for heavy vehicles that allows customers to operate FCEVs in a manner as similar as possible to their incumbent diesel vehicles. Ultimately the design balanced infrastructure deployment costs with a fast refuelling system that delivers the best possible customer experience.

Commercial-sized heavy vehicle refuelling requires high investment in storage, compression and chilling equipment of a magnitude substantially larger than those for light vehicles due to the volumes involved. Refuelling infrastructure for closed fleets (such as those in depots) will also not require the same size considerations because the vehicles can be scheduled more flexibly. On road refuelling demands are more difficult to manage due to the "peaky" nature of refuelling patterns over a given 24-hour period. This is because commercial heavy vehicles such as buses, waste vehicles and prime movers that form part of the Project design basis, refuel with higher volumes of 20 – 80kg per fill, and as per business as usual deployment, undertake specific and scheduled transport tasks that mostly refill at the start or the end of a shift.

There are limited 350bar vehicle options across multiple trucking asset classes and a variety of transport operations such as prime movers, heavy-rigid waste trucks and buses. The New Energies Service Station was designed to cater to a broad fleet of back to base, 350bar heavy vehicles as an enabler for many different customer market segments with waste management, road freight and commuter buses all currently represented on the Project.

Vehicle range limitations and the lack of hydrogen refuelling infrastructure means that each vehicle operating as part of the Project will likely need to refuel at Viva Energy's facility at least once a day - hence the "back to base" nature of the project.

The station was designed to be able to refuel 10 trucks or buses consecutively, with a notional refuelling time of around 15 minutes for the average fill. This fill speed will theoretically enable a vehicle to move through the service station within a 20 minute window.

The filling has been designed to follow internationally recognised refuelling protocol SAEJ 2601-1 Fuelling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles. This includes the vehicle driving in, connecting to the dispenser, refuelling, disconnecting from the dispenser, paying and driving away.

Depending on the vehicle type and transport task, it is anticipated that the average fill will provide a range of between 200-450km.

The station will feature two 350bar dispensers that each will have one high-flow nozzle. Supporting this offer is a third hydrogen dispenser with two nozzles, one for standard-flow 350bar refuelling and one standard-flow nozzle catering to 700bar vehicles. All nozzles will be equipped with infrared communications that will enable the maximum safe refuelling quantities and therefore vehicle range, provided infrared communications are reciprocated by the vehicles.

Gaseous fuelling is fundamentally different to traditional liquid (diesel) refuelling. Flow rates do not remain constant in all situations as is the case for liquids. Liquid fuels are pumped from a storage tank at a consistent rate based on the pump capacity, regardless of the volume of fluid in the storage and vehicle tanks. For hydrogen gas, pressure differences in both the refuelling system storage vessels (ie: the dispensing system), and the receiving tank/s (ie: the vehicle) affects the flow rate of the gas. As a result, the vehicle refuelling patterns and refuelling speeds are directly impacted by the volume of storage available, storage pressures and compression capacity of the facility.

For this facility, compressors have been selected to meet the design refuelling profile for the site, with a n+1 redundancy design basis with a focus on a reliable refuelling offer and positive customer experience.

During vehicle refuelling, the hydrogen gas dispensed from the compression and storage system into the vehicle tank will expand. Due to the unique properties of hydrogen gas, and the negative Joule Thomson cooling effect, it heats up on expansion. Depending on ambient temperature, fuel delivery temperature and target pressure in the vehicle tank, this requires the hydrogen to be cooled prior to dispensing to ensure the vehicle fuel tanks remain within their design temperature limits.

The vehicle tanks typically have an upper limit of 85°C based on the composite liner of the tanks themselves. To maintain this temperature range, there are two chillers at the station to support pre-cooling of the hydrogen gas to the dispensers. Additional factors influencing the final design have been commercial supply considerations where volume cover for a number of days is stored to maintain supply to vehicles, keeping spares of key equipment, as well as process safety risk assessments.

2.3 Safety Systems

In existing Major Hazard Facilities (MHF) and Major industries, process safety risk assessments feature heavily to ensure safe and reliable operation of plant and equipment.

Viva Energy has followed similar principles as part of the risk assessment process for the Project. These assurance reviews have been undertaken by either established industry risk specialists, the Project team, or a combination of both, and included:

- Hazard Identification (HAZID) study;
- Hazard and Operability (HAZOP) study;
- Safety Integrity Level (SIL) determination;
- Quantitative Risk Assessment (QRA);
- Fire Safety Study (FSS); and
- Safety Management Study (SMS).

As a result of these studies, key safety features and controls were implemented in the design of the electrolyser container and refueller packages, as well as in the Balance of Plant (BOP).

In the case of the containerised electrolyser, some of the key safety features include flame detection, smoke detection, gas detection for hydrogen in the oxygen stream, and gas detection of hydrogen within the container.

Detectors are widely used to provide real-time monitoring of a range of parameters that may indicate whether equipment is operating within expected and safe operating windows, or there is a leak or fire. These detectors let the system know that there is an error in the process (a system trip) and trigger a system shutdown as a precaution.

There are a number of other operating conditions that can also trigger a system trip if it exceeds the design operating window.

The compression, storage and refuelling equipment is also equipped with safety systems to ensure that operations are maintained within safe design limits, and that the system safely shuts down on detection of unexpected conditions. An example of this are the safety systems that are designed to prevent over-pressurisation of equipment.

They are based on the principles of shutting off the source of the high pressure before the design pressure of the system is exceeded, thus preventing loss of containment through rupture.

Hydrogen gas detection and flame detection also feature throughout this portion of the site and are concentrated in areas where there are more fittings and therefore risk of a leak. As part of the SAEJ 2601-1 refuelling protocol, the dispenser will check for leaks in the connection between the dispenser and the vehicle tank prior to and during the refuelling event.

This is done by the system sending a pulse of hydrogen gas from the dispenser to the vehicle and checking that there is no drop in pressure. The dispensers are also equipped with a breakaway coupling for each hose.

A breakaway coupling is designed to disconnect automatically and stop the flow of gas through the hose if an unexpected force is applied.

This safety system is in place as a response to the potential (although unlikely) for vehicles to drive away while still connected to the dispenser. This is a standard, liquid fuels safety practice for refuelling on public service station forecourts.

The use of a fire barrier between the hydrogen area and forecourt aims to minimise risk to the public access area.

Fire barriers are deployed such that in the event of a fire in any one area, the impact is contained and the fire does not spread to affect the remaining plant and equipment.

2.4 Power Supply, Monitoring and Control Systems

Power will be provided to the site from the local PowerCor 22kV distribution network. The site will incorporate 22kV switchgear, which will connect to the incoming feed, and distribute power to the site equipment.

The electrolyser container will have a dedicated power supply unit inclusive of a transformer and rectifier connected by a DC busbar. The transformer will step-down the voltage from 22kV to the appropriate low voltage level specific to the electrolyser container rectifier, which will then convert the power supply from an Alternating Current (AC) into DC power to feed into the electrolyser stacks. Power to the balance of the site will be provided via a dedicated distribution transformer and low-voltage distribution switchboard. The main switchboard, control and communications equipment will be housed in a dedicated switchroom within the facility.

The electrolyser and refuelling packages are both equipped with independent Programmable Logic Controllers (PLC). These systems receive information from the electrolyser and refueller packages via connected instrumentation and provide control outputs based on the pre-programmed functions. This includes control of key process metrics such as cell stack current for hydrogen production, hydrogen flowrate to the dispenser, pressures throughout the system, and safety shutdowns.

An overarching PLC will manage integration between the packages. This overarching PLC will also receive or initiate signals to/from the BOP, including items such as manual emergency stop signals. A Supervisory Control and Data Acquisition (SCADA) system will also be used to monitor all systems on the site both locally and remotely.

The payment system selected for the site is a standalone Outdoor Payment Terminal (OPT), as is already used with traditional unmanned truck stops. This will allow customers to pay for the hydrogen fuel at the station.

3. Planned Operating Protocols

The planned operating protocol for the facility is designed to be based on the principles that: hydrogen fuel should be available for customers as and when they need it, the fuel should be generated as efficiently as possible, and equipment should be maintained within safe operating limits.

Compression, storage and dispensing will be driven by customer refuelling demand. In order to ensure that hydrogen is ready and can be dispensed at fast-fill speeds for the next vehicle that arrives to refuel, the station will preference keeping the higher-pressure storage vessels full.

On the generation side, the aim is to efficiently generate hydrogen from the electrolyser.

During years where station utilisation is lower, this creates flexibility to reduce the electrolyser generation rate when power prices are high and prioritise generation during periods where power prices are lower.

The operating protocol will be continuously revised and updated to meet changing volume demands and the learnings gained on commercial operations of FCEVs.

4. Sourcing of Main Components

A competitive tender process was undertaken for the key hydrogen packages being the electrolyser, storage, compression and dispensing systems. Tenderers were invited to bid for one or more of these systems.

All electrolyser vendors offered packages of standardised stack sizing. Quoted lead times for standard packages ranged from 12 – 18 months from order placement to readiness for shipment. At the point of vendor selection, OEMs were still in the early stages of developing an "off the shelf" product for the Australian market.

With electrolyser cell stack sizes rapidly changing, there were limited vendors willing and able to deliver an Australian compliant electrolyser system at this scale. Without previous exposure to the Australian market, vendor responses were either unsure of the time required for an Australian compliant solution, or overconfident that their product was developed enough to meet the necessary standards. Generally, the Project noted an additional 6 months required to deliver to Australia.

This is to allow time for a gap analysis to be completed and increased overall lead times to 18 – 24 months.

In addition, the COVID-19 pandemic, and subsequent geo-political events arising from Russia's invasion of Ukraine impacted the availability of small-scale electrolyser supply to the Australian market, with some vendors withdrawing their bids mid-process.

Viva Energy found that it was common for suppliers to offer the compression, storage and dispensing as a single, integrated refuelling package. There was a larger variety in technology types and configurations offered for the refueller as compared with the electrolyser package. These nuances between the vendor packages were assessed against a commercial scale demand profile as the area of greatest variance.

While there are a lot of vendors offering a base package, none of these are as yet "off the shelf". Customisation of each package is required to suit the client's refuelling requirements or specifications and to meet domestic standards.

The vendor data required for detailed design of auxiliary systems and BOP is also not readily available, and this has a material impact on engineering time and cost.

These data sheets are generally completed once or during the customisation process. At the time of writing this report, we believe that no system can yet claim to be an "off the shelf" product for supply to the Australian market.

The BOP electrical packages were also subsequently competitively tendered once the hydrogen equipment package details were sufficiently defined to specify these items. The main equipment required to support the station were a high-voltage switchgear, a low-voltage transformer, a switchroom and a control system to integrate packages. Supply chain delays also experienced for these items, with lead times increasing by 20 – 50% relative to past experience. Delays to signing off final details on these packages also occurred as a result of delays or changes in hydrogen equipment vendor data.

Other critical items procured for the Project include high-pressure stainless-steel tubing and hydrogen flame detectors, both of which were also considered long-lead items with lead times of over six months across a range of suppliers.

4.1 Supply Chain Observations

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.

As outlined in the previous section, extended lead times, delays and lack of compliance with Australian Standards have been challenges with this specialised equipment. Lead times are not only a concern on initial order placement but also in the event that issues are identified throughout the fabrication and testing process which requires replacement of parts.

Further, Viva Energy sought to leverage an engineering consultancy with hydrogen technical expertise, previous domestic hydrogen experience, liquid fuels retailing experience, strong safety and risk management, and alignment with Viva Energy's safety culture and ways of working.

At the start of the Project, it was found that there were limited professional services firms with experience in designing and delivering hydrogen generation and especially, refuelling projects. However, there are a number of consultancies with relevant and transferable experience from related industries such as oil and gas, high-voltage electrical, and industrial gases. With the increasing number of projects under development, there is an increasing number of professional services firms gaining hydrogen specific experience.

Developing the skillset and knowledge base of the both professional services businesses and the relevant trades that touch the burgeoning hydrogen industry should remain a focus for the domestic market to continue to develop.

5. Compliance and Certification

Projects installed in Australia should comply with relevant Australian standards. The ME-93 Hydrogen Technologies committee was formed in 2019 and has since adopted a number of standards relating to hydrogen generation and refuelling, with some of the key standards relating to this Project as follows:

AS 22734:2020 Hydrogen generators using water electrolysis
Industrial, commercial, and residential applications

AS 19880.1:2023 Gaseous hydrogen
Fuelling stations, Part 1: General requirements

AS ISO 19880.8:2021 Gaseous hydrogen
Fuelling stations, Part 8: Fuel quality control

AS ISO 14687:2020 Hydrogen fuel quality
Product specification

This is not an exhaustive list of standards with which hydrogen equipment and infrastructure needs to comply with; there are relevant Australian standards relating to pressure containing equipment, foundation design and electrical wiring to name a few. In Viva Energy's experience, these peripheral standards can introduce a challenge for overseas vendors to review, understand and most importantly comply with.

Of particular note is AS/NZS 3000:2018 Electrical Installations (AS/NZS 3000), or more commonly known as the 'Wiring Rules'. Unlike many other Australian standards for equipment design, AS/NZS 3000 is not adopted from an international standard, such as IEC or ISO.

This creates a challenge for overseas suppliers as there will often be limited pre-existing background understanding of the requirements under this standard, including the number of embedded standards which may be relevant, such as AS/NZS 60079 Explosive Atmospheres Series for electrical equipment in hazardous areas and AS/NZS 61439 Low-voltage switchgear Series.

We have provided considerations for compliance with Australian Standards by overseas vendors in our New Energies Service Station Lessons Learnt Report December 2023.

AS/NZS 3000 is unique in that it is applied on a mandatory basis in accordance with state based legislations. Under this framework in Victoria, electrical sign off is required for prescribed electrical work, which includes hazardous area installations and high-voltage installations.

Stronger alignment and cohesion with state based legislation requirements would provide clearer messaging to vendors regarding Australian compliance that will result in acceptance across every state and territory.

Other equipment certification that is required in Victoria is for pressure vessels. Pressure vessel registration is required with Worksafe Victoria to ensure that they are designed safely and to appropriate standards. Any components which are third-party sourced to vendors supplying larger hydrogen equipment packages may require additional time for vendors to obtain all the required information to obtain verification. Project teams should factor time in for both data collation and the registration process itself.

6. Operator Training

As the New Energies Service Station will be a public site, Viva Energy wants drivers of passenger and heavy FCEVs to be able to readily refuel on-site and without the need for onerous training.

That being said, the Project team recognises that guidance will need to be provided, in order to help ensure first time users of the site can refuel safely.

This is because refuelling with gaseous hydrogen is different to traditional liquid fuels, driven by the properties of both energy types.

Some key differences include:

- Hydrogen is dispensed at colder temperatures to enable safe refuelling, given that it heats up during filling. As a result, drivers will notice the dispensing nozzle frost up during filling, which is not observed with traditional liquid fuels;
- The hydrogen dispensing nozzle is heavier compared to a petrol or diesel fuel pump;
- Hydrogen dispensing nozzles are more costly to replace, so need to be handled with care; and
- The station's nozzle will need to be compatible with the receptacle on the vehicle, similar to that of the plug and socket for Battery Electric Vehicles.

Given the above, we envisage that the following design considerations will be implemented such that FCEV drivers can easily and safely dispense hydrogen into their vehicles:

- Clear signage and demarcation directing vehicles to the relevant 350bar and 700bar dispensing bays, and towards the site exit;
- Clear signage on the dual dispenser indicating which nozzles are 350bar and 700bar;
- Clear instructions on the safe handling and operation of the dispenser, located at each dispenser and nozzle;
- Onsite Emergency notification system for drivers;
- Driver training via both a training manual and short video; and
- User assistance via the OPT for any issues with payment.

In conjunction with support from our HRS equipment vendor, collaboration with operators of other hydrogen refuelling sites within Australia to seek their input and guidance on best practice refuelling would also benefit the Project and industry.

7. Financial Summary

From the outset of the Project, it was known that the capital cost of building a hydrogen service station capable of replicating today's diesel refuelling practices would be high given the early-market nature of the hydrogen industry.

Reliable generation source of hydrogen on location and the associated storage, compression and refuelling infrastructure are key cost drivers in the capital expenditure build for the Project.

These costs were only fully understood during the detailed design process where, over the course of two years, the cost estimate of the Project markedly increased compared to the Project's 2021 budget estimate at the time of Viva Energy's ARENA application.

Some of the key drivers of these cost increases include:

- Changing the electrolyser size from the original 2.0MW to 2.5MW;
- The increased amount of electrical infrastructure required to support the hydrogen generation and dispensing equipment, as well as clarifying the Wiring Rules compliance requirements;
- The complexity of the refuelling package and unidentified add-ons;
- The increased footprint required to comply with the hazardous areas and exclusion zones necessary for the refuelling package;
- The prevailing high inflationary environment impacting construction costs; and
- Varying the Project scope to include 700bar refuelling as an industry enabler.

Further details on cost implications can be found in the Viva Energy Lessons Learnt Report December 2023.

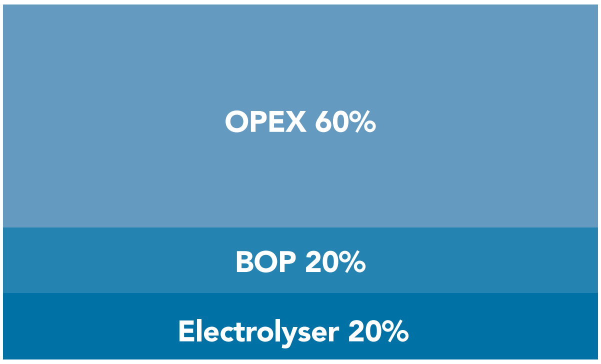
8. Project Levelised Cost of Hydrogen

For the purposes of this report and with regards to the cost assessment of the Viva Energy Project, the Levelised Cost of Hydrogen (LCOH) is;

the cost to produce 1kg of renewable hydrogen post electrolyser, pre-compression, pre-storage at around 30bar.

It is important to clarify this noting there are other LCOH definitions beginning to appear in industry.

Components of LCOH



LCOH

Broadly, the components of LCOH can be split into three different categories; Operating Expenses (OPEX), BOP and the capital cost of the electrolyser. The inputs used to determine LCOH include:

- Electrolyser capacity;
- Utilisation of the electrolyser;
- Years of producing / project life cycle;
- Renewable electricity costs;
- Electricity usage; and
- Water costs and water usage.

OPEX is the largest cost component of LCOH contributing approximately 60 percent of the Project's LCOH. OPEX is comprised of renewable electricity, Operations & Maintenance (O&M) and water costs. Of these three components, the cost of renewable electricity has the greatest contribution to OPEX.

Access to low-cost electricity will play a key role to reducing LCOH, and may include:

- **Prioritising generation during periods where power prices are lower**, typically during the day when renewable solar and wind energy is most abundant and outside of the morning and evening peak demand periods; and
- **Minimising retailer network charges** by limiting hydrogen generation during peak summer demand windows by leveraging the flexibility of hydrogen generation through the electrolyser.

It should be noted that these OPEX tradeoffs then impact capex, as lower utilisation will likely drive a larger sized generation unit, and higher storage requirements.

The **BOP**, needed for the stable and efficient operation of the electrolyser represents around 20 percent of LCOH. This includes items such as the:

- Electrical infrastructure required to support hydrogen generation, which includes the HV (high voltage) switchroom, Ring Main Unit (RMU) (or similar) and electrical connections;
- Infrastructure for potable and recycled water connections, to either feed the electrolyser or remove water;
- Civil infrastructure needed for the footprint to locate the hydrogen equipment; and
- Other costs such as freight and import duties, given that all the hydrogen equipment is imported and these have a cumulative impact on costs.

BOP costs will vary according to the station's design basis and dispensing capability, the site footprint and layout. These BOP costs are more pronounced when referring to the dispensed cost of hydrogen (referred to as BOP_{CSD} in the next section) and whether the Project is a greenfield or brownfield site.

The **capital cost of the electrolyser** package is similar to that of the BOP costs, again contributing around 20 percent to the Project's LCOH.

Levelised Cost of Hydrogen vs Dispensed Cost of Hydrogen

When referring to LCOH, it is important to note that this only reflects the generation cost of hydrogen post-electrolyser, and does not factor in the Compression, Storage or Dispensing (CSD) needed to make the hydrogen generated useable for mobility applications.

The hydrogen generated post-electrolyser is at a low pressure (i.e. 30 bar), which is not suitable for refuelling vehicles. In order to make this hydrogen usable for vehicles operating at either 350bar or 700bar, the hydrogen needs to be compressed to higher pressures and then stored in pressure vessels. To enable a vehicle to then be refuelled, dispensing equipment is then required. The components of CSD for the Project includes:

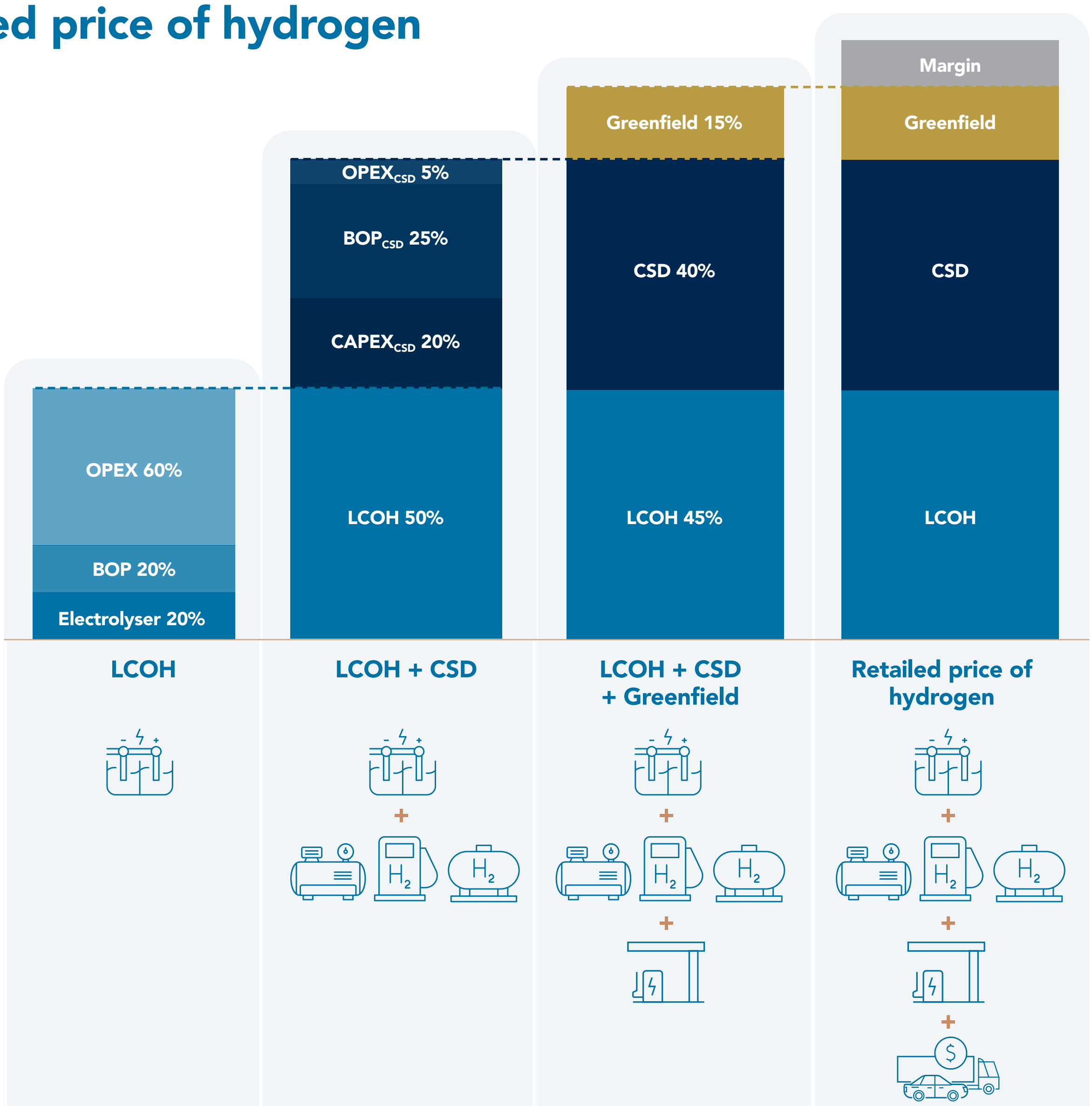
- The capital cost of the equipment required for CSD, i.e. refuelling package ($CAPEX_{CSD}$);
- The BOP required for the stable and efficient operation of the refuelling package (BOP_{CSD}); and
- OPEX which is comprised of O&M and electricity ($OPEX_{CSD}$).

Combined, LCOH plus CSD derives the **dispensed cost** (at cost, with no margin or capital cost recovery), which is effectively double that of LCOH.

The New Energies Service Station Project is a greenfield development, meaning an entirely new facility is being constructed. Therefore, the civil works required on this project are higher than what would be expected if an electrolyser and hydrogen refueller was built on an existing service station in the network of Viva Energy retail sites. Site entry and exit, and the footprint required to allow for the turning circles and safe movement of heavy vehicles (much greater than that for passenger vehicles) have been considered, along with the provision of basic amenities such as a toilet block.

These greenfield costs alone are assessed as contributing almost 15 percent of the Project's dispensed cost.

Cost breakdown of the retailed price of hydrogen



Cost component	LCOH (hydrogen generation) +	Compression, Storage and Dispensing (CSD) +	Greenfield - includes service station facilities and heavy vehicle arterials =	Retailed price – includes capital cost recovery and margin
Hydrogen CAPEX	Electrolyser package	Refuelling package	No additional infrastructure required	No additional infrastructure required
BOP CAPEX	› Infrastructure – electrical, recycled water, minor civil and mechanical › Engineering and commissioning › Freight and duties	› Infrastructure – major mechanical, minor electrical and civil › Alarms › Hydrant › Fire and gas detection › Engineering and Commissioning	› Infrastructure – major civil, electrical › Amenities block › Payment and IT › Lighting and signs etc.	No additional infrastructure required
Hydrogen pressure	30bar	350bar	350bar	350bar
Hydrogen usability	Un-usable	Un-usable	Usable for vehicles with service station facilities	Usable for vehicles with service station facilities

LCOH, CSD and greenfield development costs are genuine costs associated with delivering a fast and reliable HRS tailored for heavy vehicles.

These cost elements are often overlooked or misunderstood when discussing the cost of hydrogen in the nascent stage of the market. LCOH can be misleading as an indicator for the market price for hydrogen given that the product is not usable post-electrolyser at a pressure of 30 bar and requires further processing before it can be dispensed into vehicles or used in other applications.

It should be noted that LCOH, CSD and greenfield development costs price stacks shown here only reflect the dispensed cost of hydrogen, and does not reflect the dispensed price (or otherwise retailed price). This is because the dispensed cost does not include necessary pricing elements such as capital cost recovery or margin needed to drive an investment case. Differentiating between the dispensed cost and dispensed or retailed price is important to help clarify what price the customer actually pays at the dispenser. Given this, Viva Energy recommends that the term "retailed price" should be used in public discourse when referring to hydrogen pricing for light or heavy vehicles at public service stations or retail sites.

9. Insurances

The New Energies Service Station Project has not encountered difficulties with regards to insurance for the construction phase of the Project. We have requested that our appointed contractors provide insurances for the construction of the Project irrespective of their scope of works.

In line with Viva Energy's Standard Construction Contract, our Contractors are requested to obtain or hold the following insurances:

- Public & Product Liability;
- Professional Indemnity;
- Work Cover;
- Motor Vehicle; and
- Construction Works.

No special considerations have been needed so far for the Project in relation to Construction Insurance.

Our Standard Construction Risk Insurance requires that the Contractor must effect a policy of insurance covering loss or damage in relation to the work under the Contract for an amount not less than the total of the Contract Sum, plus 30%, and the value of materials provided by Viva Energy, temporary work under the Contract and materials, constructional plant and other things brought onto the Site by or on behalf of the Contractor.

Insurance to cover the facility will be finalised closer to when the site is opened and operational. The new market nature of renewable hydrogen projects and assets in Australia means that off the shelf insurance programs are not readily available.

Given that Viva Energy is a large energy company with an existing insurance program that also covers the Geelong Refinery (a Major Hazard Facility), it is anticipated that the New Energies Service Station will be covered as part of Viva Energy's overall insurance program.

10. Local Government Development Approvals

In Victoria, the overarching legislation to gain planning approvals, is the *Planning and Environment Act 1987* which is part of the Planning framework. As the Project is within the Geelong municipality, this meant that the City of Greater Geelong Council was the approving authority.

It is important to note that since we commenced the approvals process, key changes to the Planning Provisions in Victoria occurred in August 2023, which recognised the role and importance of large hydrogen generation Projects like ours. Although this change occurred after we commenced the approvals process for our Project, there are two key changes:

- For future hydrogen generation projects over 1MW, the Minister for Planning is now the approving authority as opposed to local Councils, and this would help streamline approvals; and
- Hydrogen generation of this magnitude is clearly defined in the planning scheme, in terms of land use. This is particularly important as we had encountered some ambiguity from authorities in this space as it was not defined previously.

Even though this change has occurred and is a positive step towards streamlining approvals, future Projects will still be required to be assessed under the provisions within the Victorian Planning Framework and existing processes.

It is also important to first map out the approvals pathway for a Project to ensure that the roles of the appropriate regulators or authorities are understood. We found that, in some cases, the roles of regulators or authorities varied depending on the type of approval being sought. For example, the Victoria EPA was a referral authority (providing input) on the Development Application to Council within the Planning Framework under the *Planning and Environment Act 1987*, and a determining authority under the *Environment Protection Regulations 2021*.

Another example was how the Project would meet the requirements under the *Dangerous Goods Storage and Handling Regulations 2022* which WorkSafe Victoria regulate but separately, WorkSafe Victoria was also a referral authority under the Planning Framework.

We have provided additional insights on how we approached and gained Planning Permit approval for the Project in our publicly available Lessons Learnt Report December 2023.