ARK ENERGY

MARKET & TECHNOLOGY REPORT

SEPTEMBER 2022

SunHQ Hydrogen Hub

Phase 1: Renewable Hydrogen Demonstration for Heavy Transport

ARENA Project 2021/ARP013

Submission to the Australian Renewable Energy Agency

Knowledge Sharing Exercise

CONTENTS

This Project received funding from ARENA as part of ARENA's Advancing Renewables Program.

1 BACKGROUND

SunHQ is a 1 MW PEM electrolyser project, which is to be owned and operated by Ark Energy Corporation. The project will be co-located within the Sun Metals Zinc Refinery precinct in a Behind-The-Meter (BTM) configuration with the 121 MW_{AC} Sun Metals Solar Farm. The use-case for the green hydrogen is five 140-tonne rated hydrogen Fuel Cell Electric Trucks (FCETs), which will transport zinc to the Port of Townsville on a 27 km round-trip. This will displace approximately 1,275 tonnes of CO_2 per annum that would be emitted by equivalent diesel-powered vehicles.

1.1 Group Overview

Ark Energy Corporation (**Ark Energy**) was established by Korea Zinc Company Ltd (**Korea Zinc**) in January 2021 with a mandate to decarbonise the Korea Zinc Group, beginning with our sister company Sun Metals Corporation (**SMC**). Korea Zinc is the largest producer of zinc, lead and silver in the world, and is listed on the Korean Stock Exchange (KOSPI) with a market capitalisation of approximately A$12 billion[1].

The Korea Zinc Group has joined to the RE100 initiative, which is representative of a commitment to power its global operations entirely from renewable energy by 2050. Given the Group's global presence, with 11 domestic and 9 foreign subsidiaries, decarbonisation is no small task.

To date, the Korea Zinc Group's renewable energy investments include:

- The 121 MW_{AC} Sun Metals Solar Farm, which was commissioned in May 2018 and co-located with the SMC Zinc Refinery. This is the largest integrated, BTM solar farm in Australia.
- A 30% equity share in the 923 MW MacIntyre Wind Farm located southwest of Warwick in Queensland, Australia, which will be the largest wind farm in the Southern Hemisphere.
- The SunHQ Hydrogen Hub.
- Korea Zinc installed a 25 MW / 150 MWh BESS at its Onsan Zinc Refinery in 2018, which was the largest industrial energy storage system in South Korea at the time.
- Acquired Epuron in December 2021, which is the leading independent renewable energy developer in Australia.

Figure 1 gives scope to the global presence of the Korea Zinc group and the locations of the Group's operations.

[1] As at 18/08/2022.

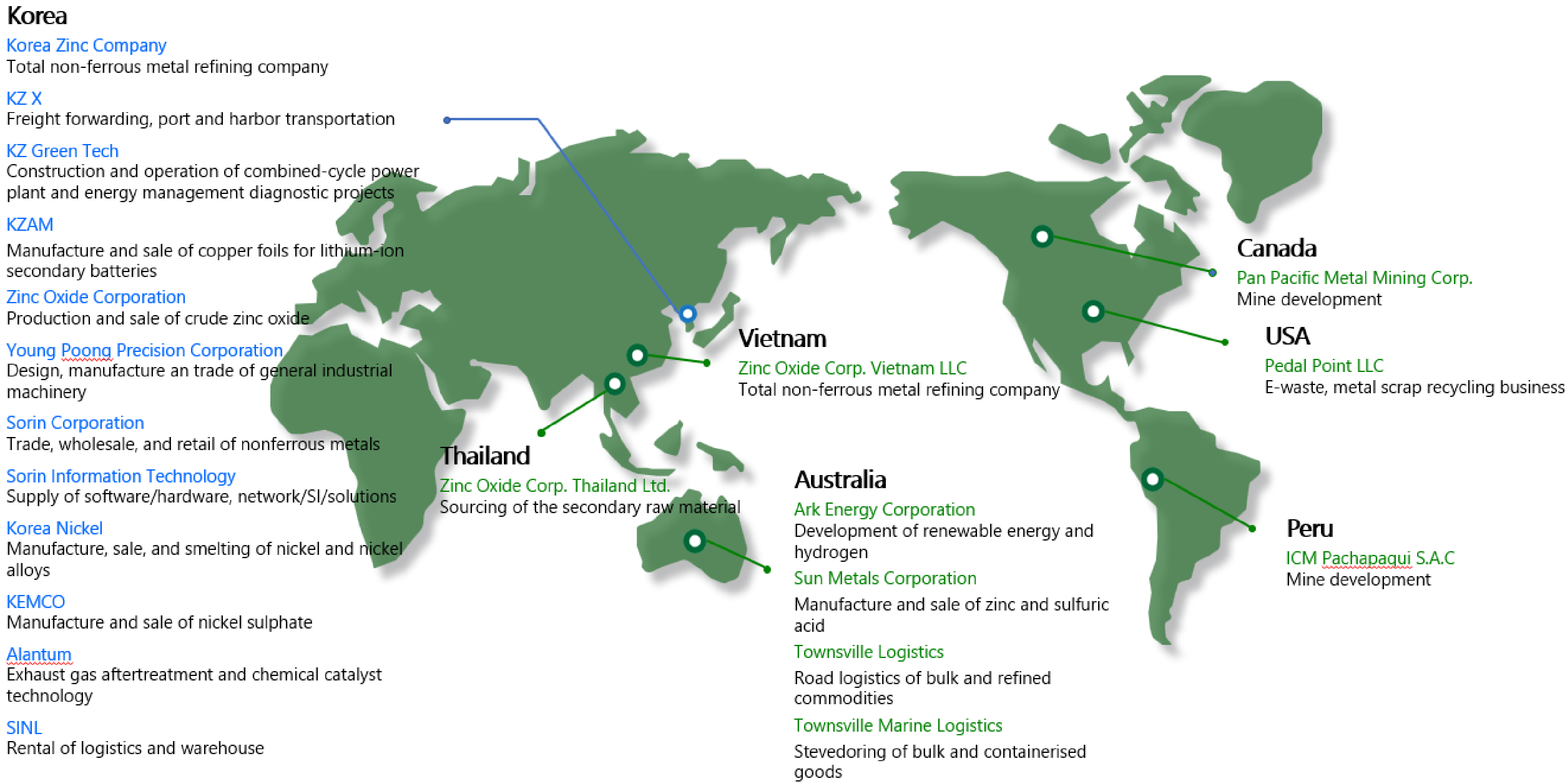

Figure 1 - Korea Zinc Group Companies

1.2 Project Overview

The 1 MW SunHQ project will produce green hydrogen as fuel for five 140-tonne rated hydrogen FCETs. Plug Power Inc. (**Plug Power**) has been engaged as the supplier of the PEM electrolyser and Compression, Storage and Dispenser (CSD) packages, and Hyzon Motors Inc. (**Hyzon**) has been selected as the supplier of the hydrogen FCETs. The Hyzon FCETs will displace five ultra-heavy diesel trucks in Townsville Logistics' (**TL**) fleet and transport zinc ingots and concentrates between the Port of Townsville and SMC's zinc refinery. Townsville Logistics, a sister company to Ark Energy, is a transport and logistics company that provides transport services to SMC and other companies. TL will operate and maintain the five 140-tonne rated FCETs. The trucks will complete a 27 km round-trip between SunHQ and the Port of Townsville, as detailed in Figure 2.

Figure 2 - Overview of SunHQ trucking route

The distinguishing attributes of the SunHQ project are summarised as follows:

- Green hydrogen electrolyser that will be integrated within a major industrial precinct and co-located with a 121 MW_{AC} solar farm;
- Deployment of hydrogen fuel cell heavy vehicles, bringing forward the decarbonisation of heavy transport in Australia by 5 to 8 years;
- Deployment of a hydrogen refuelling station that could be used by, and enable, other businesses in North Queensland to trial hydrogen vehicles in their fleet[2];
- Demonstration of the demand-response performance of a PEM electrolyser in response to SCADA data from the SMC solar farm and NEM wholesale electricity prices; and
- Developed by an extremely credible, well-financed and well-resourced company that plans to be a significant user of green hydrogen in the future.

[2] There is scope for green hydrogen offtake negotiations with third-party commercial and industrial customers.

1.3 Project Aim

The SunHQ project aims to achieve an array of objectives, and ultimately assist the broader industry in transitioning towards the use of hydrogen technologies. These objectives are described below.

Demonstrate feasibility of industrial hydrogen production and hydrogen heavy transport

SunHQ will demonstrate the feasibility of producing green hydrogen in an industrial precinct, while being integrated with renewable energy resources in a BTM configuration. The learnings that will be generated through constructing and operating SunHQ will be valuable to an array of industries related to manufacturing, refining and energy generation. SunHQ will also provide valuable learnings pertaining to the decarbonisation of heavy transport, which is traditionally a hard-to-abate sector. Ark Energy aims to demonstrate the techno-commercial viability of hydrogen as a competitive and sustainable fuel to the heavy transport industry.

Develop a domestic hydrogen supply chain

While Ark Energy has a mandate to decarbonise the global Korea Zinc Group, we have a particular focus on developing the domestic hydrogen economy first. Ark Energy is committed to expanding the footprint and capacity of SunHQ over time to support local third-party offtake.

Ark Energy is encouraged by the multiple hydrogen heavy transport initiatives that have been announced, both by the Government and the private sector. Third-parties have expressed interest in being future offtakers of green hydrogen from SunHQ. Ark Energy hopes to be supplying hydrogen to these parties by 2024.

Build local skills and share knowledge

Given the infancy of the industrial hydrogen industry, Ark Energy understands the paramount importance of ensuring the development of a skill base for the safe production, handling and use of hydrogen. We're committed to developing local skills in North Queensland such that the workforce is well positioned to take advantage of the developing hydrogen economy.

Enable the expansion of hydrogen production and use

A unique attribute of SunHQ is that it is not just de-risking hydrogen production and refuelling infrastructure, but also the demand for hydrogen. Ark Energy is taking the first steps in demonstrating how hydrogen heavy vehicles can be safely and effectively incorporated into a logistics supply chain. Through this, we envisage other transport companies will expedite plans for decarbonising their transport fleets using hydrogen.

1.4 Reference Projects

Where possible, Ark Energy has used the lessons learnt from previous hydrogen projects as a means of de-risking the procurement and construction of SunHQ. Ark Energy has engaged GPA Engineering Pty Ltd (**GPA**) to be the Owner's Engineer for SunHQ. GPA has experience across a diverse portfolio of hydrogen projects, including regulatory and technical reviews, feasibility studies and detailed design.

The key reference projects for SunHQ include:

- HyP SA – Hydrogen Park South Australia (*May, 2021*)
- Western Sydney Green Gas Project (*November, 2021*)
- Hydrogen Heavy Vehicles Value Chain Study – State Government of South Australia, Department for Energy & Mining (*February, 2022*)

1.5 Scaling Ambitions

Ark Energy has been deliberately modest in sizing the pilot stage of SunHQ, and will look to expand hydrogen production post-commissioning in line with the market as demand grows in the domestic hydrogen economy and ultimately in the global market. Table 1 provides an indicative growth profile for Ark Energy's hydrogen production capacity.

Table 1 - Ark Energy's hydrogen production scaling phases

Phase	Scope	Year	Electrolyser Capacity	H_2 Production
Phase 1	Pilot 'SunHQ'	2022	1 MW	91 tpa[3]
Phase 2	Domestic	2025	50 MW	20,000 tpa
Phase 3	Domestic & Korea Zinc	2030	900 MW	140,000 tpa
Phase 4	Domestic & Asia	2035 – 2040	3,500 MW+	500,000 tpa

2 PROJECT DESIGN PROCESS

2.1 Main Design Options

The main design options of SunHQ are related to the electrolyser technology type, the water supply and treatment, and the configuration and composition of the CSD package.

Electrolyser Technology Variants

There are a number of electrolyser technology variants at different stages of maturity. Examples of such technologies are:

- Alkaline electrolysers
- Anion Exchange Membrane (AEM) electrolysers
- Polymer Electrolyte Membrane or Proton Exchange Membrane (PEM) electrolysers
- Solid Oxide electrolysers

The two most developed and commercially available electrolyser technologies are PEM and alkaline. Figure 3 below shows the key differences between the ion flow of three of the listed technologies: alkaline, polymer electrolyte membrane and solid oxide electrolysers.

[3] Assuming a utilisation factor of 59%.

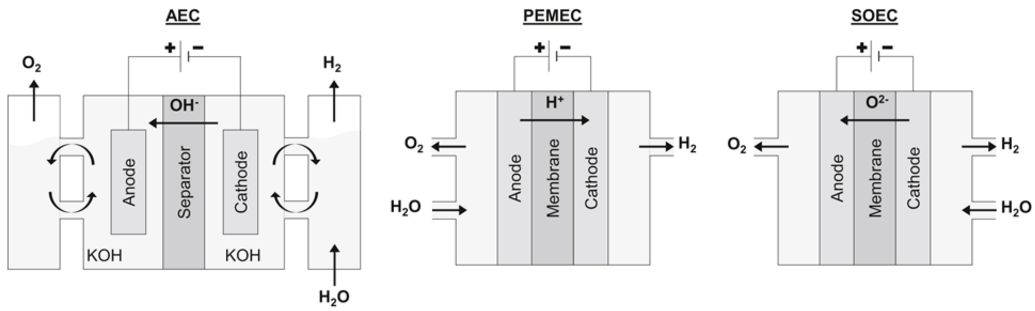

Figure 3 – Alkaline (AEC), PEM (PEMEC) and Solid Oxide (SOEC) Electrolyser Cell Comparison[4]

Table 2 provides an overview of the advantages, disadvantages and efficiencies of each electrolyser technology type.

Table 2 - Comparison of Electrolyser Technology Types[5]

Technology Type	Advantages	Disadvantages	Efficiency
Alkaline Electrolysis	• Well established technology • Low cost • Competitive energy efficiency • Commercially proven	• Degradation • Low purity • Low operational pressure • Low dynamic operation	70 – 80%
Solid Oxide Electrolysis	• High efficiency • High working pressure	• Laboratory stage • Low durability	90 – ~99%
PEM Electrolysis	• Compact design • Quick response • Greater H2 production rate • High purity • High energy efficiency • High dynamic operation	• New and partially established • High cost of components • Low durability	80 – 90%

Water Supply & Treatment Systems

Water is the feedstock to the electrolysis process. The amount of water required is contingent on two factors: the quality of feedstock water and the efficiency of the system's water purification unit.

Water supply for electrolysis is either provided via potable water supplied from municipal water mains systems or recycled water from waste-water treatment plants. The supplied water is generally further purified, often without the scope of the electrolyser package boundary, either within a containerised system or an adjacent purification facility.

[4] https://www.sciencedirect.com/science/article/pii/S0360319917339435

[5] Information sourced from "*Hydrogen Production by PEM Water Electrolysis – A Review*", *S.Shiva, V. Himabindu (15 March 2019)*

The water treatment facilities required in an electrolysis system are generally a combination of Reverse Osmosis (RO), mixed bed ion exchange resin system, particulate and active carbon filtrations, along with associated monitoring instrumentation.

These components are common technologies, widely used in multiple industries, and have a history of long-term performance with appropriate servicing and maintenance[6]. In other words, this is not a novel technology.

The electrolyser technology decision does not directly impact the amount of water required as feedstock for the electrolysis process. As discussed, the amount of water required is a function of the efficiency of the water purification unit and the purity of the feedstock water.

The SunHQ Project will source water from the mains town supply and the purification process will be conducted on-site. Approximately 9 L of water is required per kilogram of hydrogen produced. However, this amount assumes a perfectly pure water supply. Ark Energy anticipates that between 16 to 20 L of water will be required per kilogram of hydrogen produced due to the water purification process. Extrapolating this information, Ark Energy estimates that SunHQ will require approximately 1.6 – 1.8 ML of water per annum.

The water purification unit will create a stream of purified water, which is to be fed into the electrolyser, and there will also be a reject stream of water with a high concentration of minerals and salts. This reject stream will be transferred to the water treatment ponds on the SMC zinc refinery site to then be re-used in industrial processes within the refinery's operations. Therefore, the recycled water from the SunHQ site will be used as an offset to town-water consumption for the SMC refinery.

CSD Package Technology

The configuration of compression units within SunHQ is critical to meet the refuelling requirements of the Hyzon FCETs. Figure 4 provides an overview of the pressure of the hydrogen at different stages of the refuelling process.

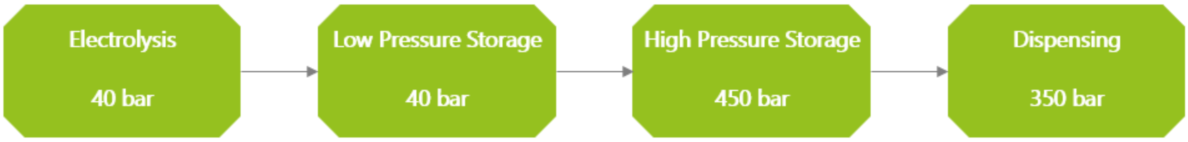

Figure 4 - Storage & Compression System Flow Diagram

The electrolyser supplies hydrogen at a pressure of 40 bar, which then enters low pressure buffer storage at 40 bar. The hydrogen is then transferred to a high-pressure storage tank, which stores the hydrogen at 450 bar. The storage tanks aboard the Hyzon FCETs are then filled at 350 bar. The 100 bar pressure differential between the high pressure storage and the Hyzon FCET storage tanks is required to ensure efficient flow of hydrogen into the vehicle.

The design process for SunHQ considered three common hydrogen compression techniques, including reciprocating, diaphragm and liquid compressors.

Reciprocating compressors for hydrogen service can be in a single stage, piston-cylinder configuration, as well as multistage configuration for higher pressure hydrogen service. Compared to other technologies, reciprocating compressors generally have more moving parts and are more difficult to maintain, which can reduce the overall life of the plant. Reciprocating compressors for hydrogen compression purposes are commercially available and have proven service and operating history, particularly for high pressure applications required for vehicle refuelling and bulk hydrogen loading facilities (i.e. filling tube trailers). Multiple international traditional compressor suppliers, as

[6] https://www.freedrinkingwater.com/water-education/quality-water-filtration-method-ed.html

well as companies that are focused on the hydrogen refuelling market, already provide commercial options for hydrogen refuelling services that meet SunHQ's requirements.

Diaphragm compressors can be cost effective due to their comparatively lower power consumption, lower cooling requirements and high throughput[7]. Despite the high volumetric efficiency, and therefore reduced power consumption, diaphragm compressors can suffer from diaphragm failure, especially at high flow rates. This technology excels at relatively low flowrates and smaller capacities.

Liquid compressors, or liquid ring compressors, are positive displacement machines that use liquids for directly compressing gas without mechanical sliding seals. Such technology can have a superior efficiency relative to other compression technologies due to the ability of the fluid to absorb heat generated by gas compression. Of the available liquid compressor technologies, ionic liquid compressors are considered superior given they were specifically designed to increase compression efficiency for hydrogen[8]. The ionic compressors use salts that are liquid at room temperature that have good chemical stability and thermal properties, good lubricating properties and low compressibility. This technology is also commercially proven. In comparison to reciprocating compressors, liquid compressors have a higher efficiency, longer service life, lower noise and vibration and low material costs. Such compressors are typically made using 316L stainless steel for improved resistance against corrosion and embrittlement.

SunHQ's compression and storage package has been designed such that three trucks can refuel consecutively with a 30-minute recovery period between each individual refuel. The fourth truck can then be refuelled 5 hours after the time at which the first truck commenced refuelling, and the fifth truck can commence refuelling after a 30-minute recovery period. A conceptual timetable is given in Table 3.

Table 3 - Refuelling schedule of Hyzon FCETs at SunHQ

Time	Activity
9:00am	First truck begins refuelling
9:15am	30 min recovery period of the HP storage
9:45am	Second vehicle begins refuelling
10:00am	30 min recovery period of the HP storage
10:30am	Third vehicle begins refuelling
10:45am	5hr break period from 1st vehicle refilling
2:00pm	Fourth vehicle begins refuelling
2:15pm	30 min recovery period of the HP storage
2:45pm	Fifth vehicle begins refuelling

The Hyzon FCETs are expected to have a range of approximately 200km when fully fuelled. Therefore, each truck will be able to complete 6 roundtrips per day from the SunHQ refuelling station, to the port, and back again.

Townsville Logistics currently has a fleet of 28 diesel triple-B trucks, which can be used for either short-haul trips to and from the Port of Townsville or long-haul trips to Mount Isa and beyond. At its

[7] https://www.pdcmachines.com/introduction-diaphragm-compressors/
[8] https://www.csiro.au/en/work-with-us/ip-commercialisation/hydrogen-technology-marketplace/compression-ionic-liquids

busiest, Townsville Logistics will generally run five trucks around the clock on the short-haul trip to the Port. Each truck typically does 10 trips per 12-hour shift, which implies 20 trips per day.

At the pilot stage of SunHQ, the Hyzon FCETs are not intended to entirely replace an equivalent diesel truck. Rather, the project aims to demonstrate that hydrogen powered, 140-tonne rated trucks are a feasible means of decarbonising the heavy road haulage industry. As SunHQ is expanded, the capacity for hydrogen FCETs to replace their diesel-powered equivalents will increase. Expansion of the facility will also contribute to decreasing vehicle refuelling wait times.

2.2 Final Design Reasoning

Plug Power, in collaboration with Ark Energy, has ultimately selected equipment that will be able to achieve the project's goals. Ark Energy specified a variety of details, such as the use of PEM electrolyser technology, volume of hydrogen required, schedule and budget, which Plug Power used to provide an appropriate design solution.

Ark Energy favoured the use of PEM electrolyser technology due to its superior ability to handle the intermittent nature of renewable energy supply. Alkaline electrolysers tend to favour continual and consistent operation, which did not suit this particular use case. In addition to being more suited to the intermittency of renewable energy, a PEM electrolyser will also be more suited to ramping down at short notice when the wholesale electricity price spikes.

Plug Power's design considerations also considered the system's suitability for local weather conditions (heat, humidity, and cyclonic wind loads), hydrogen service, and ease of use for operators (a PLC / SCADA system is already used at the Sun Metals zinc refinery).

3 TECHNOLOGY SELECTION

Ark Energy conducted a tender process in Q2 2021 for the selection of SunHQ's technology providers. A total of seven bids were received for the procurement of the electrolyser and CSD packages; three parties submitted proposals to supply both packages, one party submitted a proposal for the supply of the electrolyser package alone, and three parties offered to supply components of the CSD package. Plug Power was selected to supply both the electrolyser and CSD packages after reviewing and ranking each supplier from both a technical and economic perspective. Hyzon Motors was selected to be the provider of the ultra-heavy FCETs.

3.1 Electrolyser

Ark Energy selected Polymer Electrolyte Membrane (PEM) technology for the electrolyser package. This decision was primarily based on the PEM electrolyser's flexibility relative to alkaline electrolyser technologies; PEM electrolysers are more suited to the intermittent energy supply of renewable electricity generation and varying production based on the spot price of electricity.

From both a technical and economic perspective, Plug Power was the preferred tenderer and was selected to provide the electrolyser and CSD packages. The PEM electrolyser package includes:

- Inlet water treatment package
- Anode section

- Cathode section
- Electrolyser stack
- Hydrogen treatment (control of dewpoint and oxygen)

Figure 5 provides an overview of how each component of the PEM electrolyser package interacts.

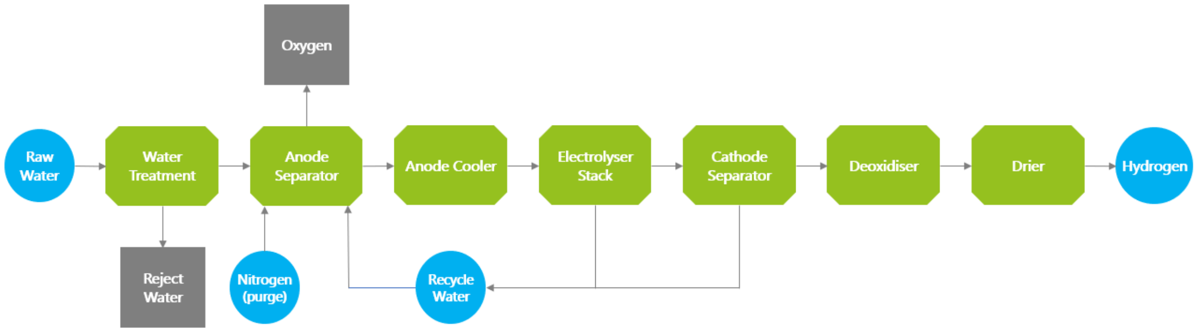

Figure 5 - Electrolyser Package System Block Diagram

3.2 Water treatment

Water treatment is a critical component of the hydrogen electrolysis process. Poor water quality may damage the electrolyser stack, which could decrease its operational life. Ark Energy is in the process of finalising the water purity requirements for SunHQ with Plug Power.

Plug Power's water treatment package will treat site potable water and a proportion of the anode fluids, which removes dissolved salts, gasses and impurities by reverse osmosis and continuous electro-deionisation. The generated pure water is fed to the anode system for use in electrolysis, and the reject water is discharged to waste.

As outlined above, Plug Power is responsible for providing the inlet water treatment package and all reject water will be captured and treated in the existing treatment ponds on the Sun Metals zinc refinery site and reused in the zinc refining process. This closed loop process ensures that the only water that leaves the site is via evaporation, creating a sustainable environmental footprint for the project.

3.3 Compression & Storage

Plug Power is responsible for providing the compression and storage units for SunHQ, which includes:

- Low pressure (LP) storage
- High pressure (HP) compressor with discharge cooler
- High pressure (HP) storage

The compressors selected for SunHQ are PDC Machines' diaphragm compressors. After reviewing and ranking compressor solutions, it was decided that PDC Machines' offering was well-suited to the operational protocol of the project. This decision was reached with consideration for safety, scalability, cost and suitability for hydrogen service.

Immediately after hydrogen is produced by the electrolyser stack, it is stored in LP storage at 40 bar. Three HP compressors, complete with discharge coolers, raise the pressure to 450 bar for HP storage. The HP storage will supply the hydrogen dispenser for the refuelling of the Hyzon FCETs. Further assessment shall be undertaken to determine whether separate storage and compression is required to meet third-party offtake demand.

When full, the LP storage will provide a 20-minute buffer between the electrolyser and HP compression.

The HP compressors will each have a capacity of 12 kg/hr and are configured as duty/assist with N+1 redundancy. The compressor package will include air coolers to achieve a delivery temperature to the HP storage of 30°C. The air coolers will be sized to meet the maximum cooling demand at the maximum ambient conditions.

3.4 Dispensing Systems

SunHQ requires dispensing systems to refuel the Hyzon FCETs. Two dispensers will be installed, each with a single refuelling hose complete with a breakaway coupling. A breakaway coupling is a “weak link” in a process flow that is designed to pull apart and close both ends of the flow path in the event of an issue (e.g., overpressure protection). A breakaway coupling can be easily put back together to resume operations; it primarily acts as a process safety device. A local panel will enable interaction with the driver and administers the refuelling protocol.

Upon connection of the refuelling nozzle to the vehicle, an initial pulse of hydrogen will be sent. The subsequent rise in pressure and temperature is used to inform the system of the initial quantity in the vehicle and the required refuelling rate. This step also enables a leak check to be performed.

The dispensed hydrogen is metered and cooled to a minimum of -20°C by a heat exchanger located within the dispenser. A dedicated refrigerant based chiller located within 20m of the dispenser provides chilled coolant supplied at -25°C. During refuelling, the temperature and pressure of the hydrogen are monitored to ensure that refuelling is completed safely.

A WEH TN1 High Flow refuelling nozzle was selected to be used by Hyzon Motors in consultation with Ark Energy and Plug Power to ensure it met the project’s requirements.

3.5 Safety Systems

Within the electrolyser package, Plug Power’s scope includes hydrogen leak detection. The dispenser has hydrogen gas leak detection, as well as line and tank leak detection which operate based on a sequence pressure test.

Hyzon Motors’ trucks include a variety of safety systems that apply to the various systems and components in the vehicle. The donor chassis themselves are Australian Design Rules (ADR) approved and are equipped with an array of safety technology that is incorporated into the Hyzon road train design. Hydrogen systems on the vehicle are integrated with several sensors, including hydrogen leak detection, pressure sensors, temperature sensors and flow meters that constantly monitor the operation of the fuel cell and ensure it stays within the safe working range. If the fuel cell deviates from the expected operational state, then these sensors can trigger a range of responses including warning alerts, gradual system shutdowns and emergency shutdowns.

Hydrogen leak detection is typically installed in multiple locations on the vehicle, particularly at points where the risk of hydrogen accumulation is the highest. The hydrogen storage system includes temperature-pressure relief devices on the end of each storage cylinder, and solenoid shutoff valves on each tank, as well as a shutoff valve on the main supply line to the fuel cell.

Ark Energy is also ensuring Safety in Design is a priority. Safety in Design is not a singular process, but a principle which requires the designer to demonstrate that risk is managed to as low as is reasonably practical (ALARP) across the lifecycle of the asset through to demolition.

At the outset of the project, the project team discipline engineers and project manager reviewed the hazards and risks associated with the project in a safety in design assessment review. This review identified high level risks. Subsequently, engineering assurance reviews are to be conducted on the high-level risks to ensure that safety in design is embedded within the process and asset lifecycle is adequately considered. The engineering assurance reviews can include, but are not limited to:

- Hazard Identification Risk Assessment (HIDRA)
- Risk Assessment
- Design Review
- Hazard and Operability Study (HAZOP)
- Safety Integrity Level (SIL) Assessment
- Layers of Protection Analysis (LOPA)
- Safety Management Study (SMS)
- Control Systems Hazard and Operability Study (CHAZOP)
- Constructability Review
- 3D Model Review
- Layout Review

3.6 Power Supply, Monitoring & Control Systems

Bulk site power for SunHQ will be fed by a new 33 kV power feed connected to the existing SMC 132 kV substation. The incoming 33 kV power feed to the hydrogen facility will be distributed through the facility via a 33 kV Switchroom.

From the Switchroom, there will be two 33 kV feeders. One feeder will connect to the facility's converter transformer, which will then supply power at 250 V_{DC} to the electrolyser stack. The other feeder will connect to a Balance of Plant Transformer, which will step the voltage down to 415 V. The Balance of Plant Transformer then feeds into the Low Voltage Balance of Plant Switchboard, which has two lines that provide power to the ancillary electrolyser equipment and the compressor package.

The configuration of the power supply system is summarised in Figure 6.

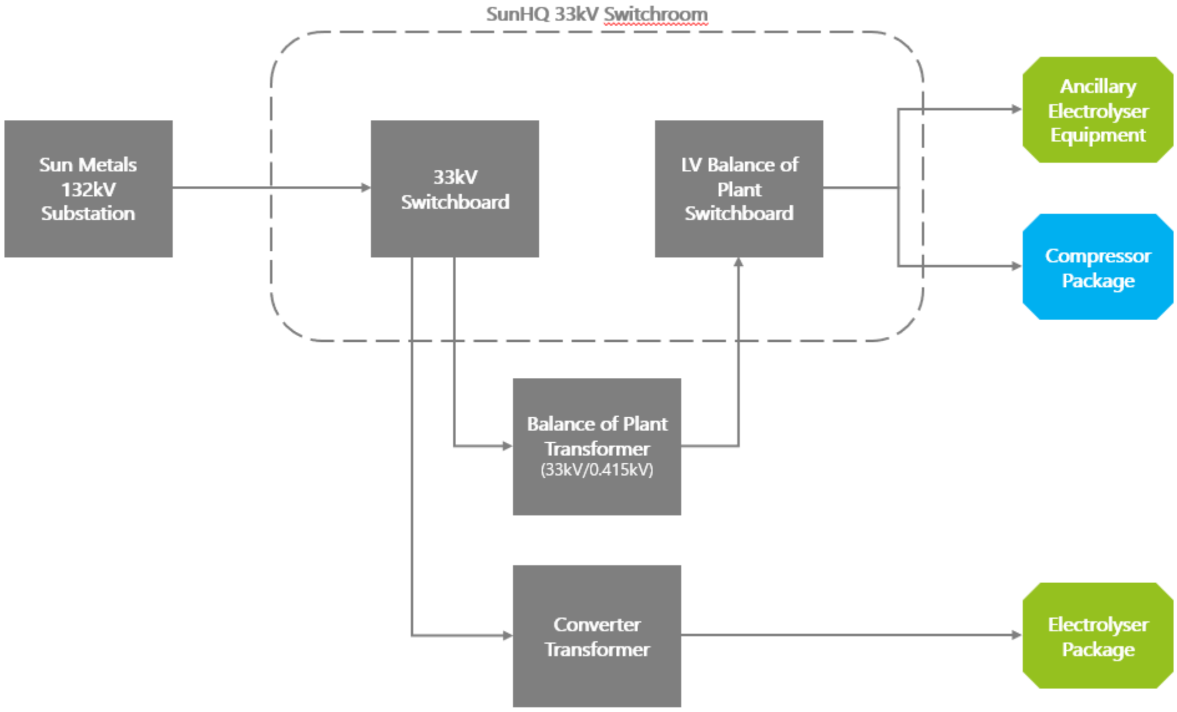

Figure 6 - Power Supply Configuration

A protection system, compatible with Powerlink's requirements, will be installed for the new HV Primary Switchgear. The required protection relays will be connected to current and voltage transformers within the existing SMC substation and to current and voltage transformers within the HV Switchgear. These protection relays will be installed within cubicles which will be located within the HV Switchroom.

Back-up power requirements and identification of critical drivers, such as building ventilation, will be considered in later stages of the design.

The supplier of relevant power supply monitoring and control systems is yet to be confirmed.

3.7 Vehicles

Ark Energy are purchasing five ultra-heavy, 140-tonne rated, hydrogen-powered prime movers that are suitable for haulage of triple-B trailers. These trucks, to be provided by Hyzon Motors, will be the first of their kind to operate. In the initial phase of SunHQ, these trucks will be capable of completing roughly 6 round trips per refuel between the Sun Metals zinc refinery and the Port of Townsville. The trucks have a target refuel time of 15 minutes.

3.8 Vehicle Monitoring & Telemetry

Hyzon expects to use a Bosch Rexroth telematics system on the five ultra-heavy FCETs. The vehicle monitoring system will provide a wireless interface for collecting and reading vehicle data for user analysis. As fuel cell electric vehicles (FCEVs) utilise an electric powertrain and are controlled by a series of digital controllers, a large amount of data is transmitted for user review. The vehicle monitoring system will allow Ark Energy, TL and Hyzon Motors to monitor and manage operations (fleet tracking, drive cycles, driver performance, refuelling cycles) and maintenance (tracking vehicle performance, rapid diagnostics and troubleshooting of issues using vehicle data).

The complete list of signals that will be available for user review will depend on the final configuration of the vehicle control systems. A summary of the information that Ark Energy expects will be available through implementing vehicle telemetry is given below.

High level vehicle information

High level information, which includes but is not limited to vehicle speed, hydrogen state of charge (SoC), battery SoC, vehicle range, gear, and tachometer, will be available for wireless access and analysis. This information is effectively that which is available to the operator of the vehicle on their dashboard.

Key fuel cell system data

The performance data of the hydrogen fuel cell will provide valuable insights into the operational capabilities of the Hyzon FCETs. Given these road-trains will be the first of their kind in commercial operation, data that details the performance of a hydrogen fuel cell will assist in the future development of the technology. Error diagnostic data will also be monitored for ease of maintenance if unforeseen problems arise.

Diagnostics data

The vehicle monitoring system will allow Hyzon to monitor the performance of the powertrain remotely and in detail. Ark Energy and Hyzon expect that the data collected by the vehicle monitoring system will assist Hyzon in:

- Supporting the vehicles and troubleshooting any issues that arise.
- Improving the software control and vehicle calibration.
- Monitoring the performance and durability of key components.
- Monitoring fuel cell degradation and improving control strategies.

4 PLANNED OPERATING PROTOCOLS

Ark Energy intends to integrate a control system that operates the electrolyser based on the electricity price. Put simply, SunHQ's hydrogen production will be ramped down when the electricity price is high and ramped up when the electricity price is low. In saying this, the operational protocols of SunHQ will be continually optimised to meet the shifting demands of Ark Energy's customers. This will require a user co-optimisation model between hydrogen dispatch and production.

The initial phase of SunHQ will have the capacity to refuel three trucks in the morning and two in the afternoon. A conceptual example of this refuelling schedule is provided in Section 3.3, Table 2. Increased demand will see this refuelling schedule optimised to accommodate additional offtake.

5 SOURCING OF MAIN COMPONENTS

SunHQ's main components have been sourced from an array of locations, which are summarised in Table 4. All components related to the electrolyser and CSD packages are being supplied by Plug Power or their sub-contractors, and the hydrogen trucks are being supplied by Hyzon Motors.

Table 4 - Summary of main component ex-works locations

Component	Pickup Location, ex-works
Electrolyser	Vietnam
Electrolyser Air Cooler	Vietnam
Compressors	United States of America
LP Buffer Tank	Australia
Bulk HP Storage Container	Germany
Chillers	Italy
Dispensers	United States of America
Hydrogen Trucks	Australia

6 COMPLIANCE AND CERTIFICATIONS

Compliance with Commonwealth and State legislation is mandatory for plant and equipment installed in Queensland. To ensure this, Ark Energy provided a comprehensive list of standards that Plug Power must comply with and this was included within the Master Supply Agreement (MSA). Failure to meet these standards may result in the inability to install and energise equipment.

While there are a vast number of standards that must be met by Plug Power under the MSA, *Wiring Rules AS NZS 3000:2018*[9] (referred to as AS3000) is a critical electrical standard to satisfy. Ark Energy has identified AS3000 compliance to be the greatest risk for project schedule and budget as the requirements are specific to Australia and equipment manufactured overseas often does not comply. Additionally, overseas manufacturers are not typically familiar with it and so implementing the necessary design changes is challenging.

Given SunHQ is located in Townsville, Queensland, *Registered Professional Engineer of Queensland* (RPEQ) sign-off is required on all engineering deliverables. This requirement is specific to Queensland and is not required for Hydrogen projects that are being constructed in other states or territories. Ark Energy has found it beneficial to raise this requirement early with suppliers to ensure RPEQ requirements and sign-off are properly administered during the design, fabrication and installation stages.

Finally, Ark Energy has introduced Hyzon Motors to Resources Safety & Health Queensland to assist in the development of a set of standards to govern the operation of hydrogen FCETs. Ark Energy and Hyzon Motors have each contributed to the draft hydrogen safety code of practice, which was

[9] https://www.standards.org.au/engagement-events/flagship-projects/wiring-rules#:~:text=AS%2FNZS%203000%3A2018%2C,consist%20of%20two%20separate%20parts.

recently published[10]. It is intended that this will lead to the delivery of a set of standards that promotes the safe operation of hydrogen FCETs in Australia.

7 OPERATOR TRAINING

Ark Energy recognises the importance of developing the skill-base of the local workforce in preparation for the growth of the Australian hydrogen industry. As such, we have taken steps to implement the correct training structures to ensure the safe production, handling and use of hydrogen. In particular, Ark Energy has signed a MOU with TAFE Queensland (**TAFE**) and is working in partnership with them to design, develop and deliver training (both accredited and non-accredited) focussed on the upskilling and re-skilling of the workforce.

Scope for Hydrogen Safety at Production Facilities package

TAFE's educational/certification package will address general hydrogen hazards and safety protocols. It will also provide detailed information as to the functions of key infrastructure within a hydrogen plant. Participants will learn the fundamental safety risks, standards and mitigating technologies and processes involved in a facility that produces hydrogen.

Scope for Hydrogen Fuel Cell Electric Truck package

TAFE will use operating manuals and instructional material provided by Hyzon Motors to develop an accredited educational package for the safe maintenance and operation of Hyzon's FCETs. Completion of the training programs will ensure participants are aware of the Hyzon FCET's operating and monitoring systems.

Operating procedures of the SunHQ facility

Ark Energy's Operations and Maintenance team will be responsible for SunHQ on a day-to-day basis. It is not anticipated that SunHQ will represent a full-time commitment for any individuals within the Operations and Maintenance team at this stage. A full-time individual may become necessary. This will be decided well before commissioning and as the facility is expanded.

8 INSURANCES

Ark Energy has begun discussions with insurance providers as to the appropriate approach to insuring a hydrogen production facility and refuelling depot in North Queensland. Given SunHQ is co-located within the Sun Metals Zinc Refinery precinct, which is designated as a high-impact industrial zone, insurance providers have shown a willingness to wrap SunHQ under the same packages that are already in place for SMC. However, as SunHQ is expanded, it may become necessary for Ark Energy to directly engage insurers to provide a package separate to SMC's insurances.

Ark Energy entity insurance policies

As a group, the Ark Energy entities have an array of insurance packages, which cover:

- Industrial special risks

[10] https://www.business.qld.gov.au/industries/mining-energy-water/resources/safety-health/petroleum-gas/safety-news-education/hydrogen#:~:text=Proposed%20hydrogen%20safety%20code%20of%20practice&text=The%20code%20of%20practice%20is,existing%20requirements%20are%20not%20practicable

- D&O liability
- Commercial motor
- Marine cargo
- Public and products liability

Plug Power insurance policies

Plug Power must effect and maintain insurance that is sufficient to cover its liabilities in relation to design and suitable use of their equipment. The requirements are embedded in the purchase contract.

Hyzon Motors insurance policies

Similarly, Hyzon Motors must effect and maintain insurance that is sufficient to cover its liabilities in connection with the purchase contract.

9 SUPPLY CHAIN OBSERVATIONS

There are currently no Australian manufacturers or suppliers of electrolysers, and the risk of equipment non-compliance with AS3000 and other design standards needs to be carefully managed

The procurement process for SunHQ has indicated that the hydrogen equipment supply industry is more developed in Europe and the US relative to Australia. Foreign vendors now have standard designs for their equipment that they can duplicate and deploy rapidly. However, Ark Energy has found that the standard designs of foreign companies are typically not compliant with Australian design standards. The need to re-design equipment to meet Australian standards is time consuming. Technical learnings from SunHQ will increase our vendors' understanding of Australian compliance expectations.

In the long term there will be an opportunity to further review AS3000 and harmonise it with the International Organisation for Standardisation (ISO) and International Electrotechnical Commission (IEC). The harmonisation review would have the objective of assisting potential Australian manufacturers to have access to global hydrogen equipment markets and create greater choice and competition in selecting imported equipment.

The hydrogen supply chain is facing logistical challenges related to COVID-19 and the conflict between Russia and Ukraine

COVID-19 and the Russia/Ukraine conflict pose significant threats to the hydrogen supply chain. The manufacturing and procurement processes of both Hyzon Motors and Plug Power have been impacted by these macroeconomic factors. Both industries have multinational supply chains, which leave them vulnerable to such adverse circumstances.

10 PROFESSIONAL SERVICES OBSERVATIONS

The depth of professional services specific to the hydrogen industry is available but limited in Australia

Ark Energy engaged an Owner's Engineer to supplement engineering experience within Ark Energy and Sun Metals. When looking to engage an Owner's Engineer, Ark Energy was able to find one that had recent and relevant experience in Australia and was able to compliment the Ark Energy and Sun Metals engineering capabilities. In saying this, there were only a handful of candidates with practical experience delivering hydrogen production and refuelling facilities in the Australian market.