# Jemena Gas Networks (NSW) Ltd

## Pre-startup Compliance Report

Western Sydney Green Gas Project

Jemena
bringing energy to life

**An appropriate citation for this paper is:**

Pre-startup Compliance Report - Western Sydney Green Gas Project



**Authorisation**

| Name | Job Title | Date | Signature |
|---|---|---|---|
| Reviewed by: | | | |
| Jarrod Irving | Project Manager | 30 September 2021 | |
| Approved by: | | | |
| Mark Turner | General Manager Gas Projects | 5 October 2021 | |

**History**

| Rev No | Date | Description of changes | Author |
|---|---|---|---|
| A | 05/07/2021 | First Draft | M Moroney |
| 0 | 30/09/2021 | Revised and updated | J Irving |
| | | | |

**Owning Functional Area**

| | |
|---|---|
| Business Function Owner: | Gas Distribution |

# Table of contents

**Acronyms** ..... **iv**
**1. Compliance Report Declaration Form** ..... **1**
**2. Introduction** ..... **2**
2.1 Purpose ..... 2
2.2 Objective ..... 2
2.3 Project Approvals ..... 3
2.4 Timing and Project Phases ..... 3
**3. Project Description** ..... **4**
3.1 Location ..... 4
3.2 Key Features ..... 6
3.3 Construction Activities ..... 6
3.4 Commissioning Activities ..... 8
3.5 Operational Activities ..... 9
**4. General Compliance Information** ..... **12**
4.1 Previous Compliance Report Actions ..... 12
4.2 Non compliances ..... 12
4.3 Incidents ..... 12
4.4 Complaints ..... 14
**5. Pre-Construction Compliance Documentation** ..... **16**
5.1 Construction and Commissioning Safety Studies (CSS) ..... 16
5.2 Hazard and Operability Study (HAZOP) ..... 17
5.3 Final Hazard Analysis (FHA) ..... 17
5.4 Fire Safety Study ..... 18
**6. References** ..... **22**
6.1 Internal ..... 22
6.2 External ..... 22

# Acronyms

| Acronym | Definition |
|---|---|
| AS/NZS | Australian Standard / New Zealand Standard |
| ACS | Asset Class Strategy |
| BOP | Balance of Plant |
| CEMP | Construction Environmental Management Plan |
| CLM | Community Liaison Manager |
| CSS | Construction Safety Study |
| DBYD | Dial Before You Dig |
| DPIE | Department of Planning, Industry and Environment |
| EGP | Eastern Gas Pipeline |
| EIS | Environmental Impact Statement |
| ESD | Emergency Shutdown |
| FHA | Final Hazard Analysis |
| FOMS | Field Operation and Maintenance Specification |
| FSS | Fire Safety Study |
| HAZID | Hazard Identification |
| HAZOP | Hazard and Operability Study |
| HSE | Health, Safety and Environment |
| HSMP | Health and Safety Management Plan |
| HV | High Voltage |
| JGN | Jemena Gas Networks (NSW) Ltd |
| LV | Low Voltage |
| NDT | Non Destructive Testing |
| NSW | New South Wales |
| OEMP | JGN NSW Distribution Network Operational Environmental Management Plan (OEMP) |
| PCR | Pre Startup Compliance Report |
| PHA | Preliminary Hazard Analysis |
| PLC | Programmable Logic Controller |
| SAOP | Jemena Safety and Operating Plan |
| SCADA | Supervisory Control and Data Acquisition |
| SDS | Safety Data Sheet |
| SMS | Safety Management Study |
| SSD | State Significant Development |
| SWMS | Safe Work Method Statement(s) |
| TRS | Horsley Park Trunk Receiving Station |
| WSGG | Western Sydney Green Gas (the Facility) |

# 1. Compliance Report Declaration Form

| Compliance Report Declaration Form | |
|---|---|
| **Project name** | Western Sydney Green Gas Project |
| **Project Application Number** | SSD 10313 |
| **Description of Project** | Trialling Power-to-Gas (P2G) technology by converting purchased green energy from the electricity mains network into hydrogen gas and injecting it into its secondary gas distribution network over a 5-year period. |
| **Project Address** | 202-214 Chandos Road, Horsley Park (Lot 1, DP 499001) |
| **Proponent** | Jemena Gas Networks (NSW) Limited (Jemena) |
| **Title of Compliance Report** | Pre-Start Compliance Report |
| **Date** | 30 September 2021 |

I declare that I have reviewed relevant evidence and prepared the contents of the attached Compliance Report and to the best of my knowledge:

- The Compliance Report has been prepared in accordance with all relevant conditions of consent.
- The Compliance Report has been prepared in accordance with the Compliance Reporting Post Approval Requirements.
- The findings of the Compliance Report are reported truthfully, accurately and completely.
- Due diligence and professional judgement have been exercised in preparing the Compliance Report.
- The Compliance Report is an accurate summary of the compliance status of the development.

Notes:

- Under section 10.6 of the Environmental Planning and Assessment Act 1979 a person must not include false or misleading information (or provide information for inclusion in) a report of monitoring data or an audit report produced to the Minister in connection with an audit if the person knows that the information is false or misleading in a material respect. The proponent of an approved project must not fail to include information in (or provide information for inclusion in) a report of monitoring data or an audit report produced to the Minister in connection with an audit if the person knows that the information is materially relevant to the monitoring or audit. The maximum penalty is, in the case of a corporation, $1 million and for an individual, $250,000.
- The Crimes Act 1900 contains other offences relating to false and misleading information: section 307B (giving false or misleading information – maximum penalty 2 years' imprisonment or 200 penalty units, or both).

| | |
|---|---|
| **Name of authorised reporting officer** | Mark Turner |
| **Title** | General Manager – Gas Projects |
| **Signature** |  |
| **Qualification** | Bachelor of Engineering – Instrumentation and Control |
| **Company** | Jemena Gas Networks (NSW) Limited |
| **Company Address** | Level 15, 567 Collins Street MELBOURNE VIC 3000 |

# 2. Introduction

Jemena Gas Networks (NSW) Limited (Jemena) is undertaking the Western Sydney Green Gas Project (WSGGP) (the Project), which involves trialling Power-to-Gas (P2G) technology by converting purchased green energy from the electricity mains network into hydrogen gas and injecting it into its secondary gas distribution network over a 5-year period. The Project would potentially facilitate ongoing development of commercially viable P2G systems in Jemena's NSW gas network.

The Project is located at the existing Jemena high pressure gas facility in Horsley Park (Horsley Park Facility), located in Western Sydney. The P2G facility will use renewable electricity to generate hydrogen, which can be injected into the natural gas network or used to generate electricity back to the grid by means of a hydrogen-powered micro-turbine.

The Project is subject to an environmental assessment and approval process under the *Environmental Planning and Assessment Act 1979* (EP&A Act) and is classified as State Significant Development (SSD).

The delegate for the Minister for Planning and Public Spaces granted development consent on the 10 August 2020, requiring that the Project be carried out in general accordance with:

- Western Sydney Green Gas Project – Environmental Impact Statement (EIS), dated December 2019;
- Western Sydney Green Gas Project – Response to Submissions, dated May 2020;
- Additional information in a letter from Jemena dated 16 June 2020;
- Western Sydney Green Gas Project Instrument of Consent (Application no. SSD 10313), dated 10 August 2020;

Jemena has engaged their delivery partner Zinfra for commissioning, operation and ongoing maintenance of the Western Sydney Green Gas Hydrogen Facility (Facility).

## 2.1 Purpose

The purpose of this PCR is to demonstrate the development is compliant with Schedule 3, Conditions B4 and B1 of the Development Consent.

The PCR has also been documented to cover the requirements of the NSW Government Requirement 1, Compliance Reporting Post Approval Requirements, May 2020, Department Planning, Industry and Environment (DPIE).

## 2.2 Objective

The objective of this PCR is to ensure compliance with the actions proposed or recommended from documentation required under Schedule 3, Condition 1 of the Development Consent. This documentation included the following:

- Construction Safety Study (*Jemena Western Sydney Green Gas Project, Construction Safety Study Report, Rev 0*, dated 8 October 2020 and approved by DPIE on 16 November 2020)
- Commissioning Safety Study (Jemena Gas Networks (NSW) Ltd, Commissioning Safety Study Report, Western Sydney Green Gas Project, Rev 0, dated 5 May 2021 and approved by DPIE on 3 May 2021)
- Hazard and Operability Study (*Western Sydney Green Gas Trial HAZOP Report Rev 1*, dated 17 August 2020 and approved by DPIE on 19 November 2020)
- Final Hazard Analysis (Final Hazard Analysis (FHA) Jemena - Detailed Design for Hydrogen Generation (Western Sydney Green Gas Project), Rev A, dated 3 September 2020 and approved by DPIE on 19 November 2020); and

- Fire Safety Study (Fire Safety Study (FSS), Jemena - Detailed Design for Hydrogen Generation (Western Sydney Green Gas Project) Jemena Ltd, Rev A, dated 14 September 2020 and approved by DPIE on 27 November 2020)

## 2.3 Project Approvals

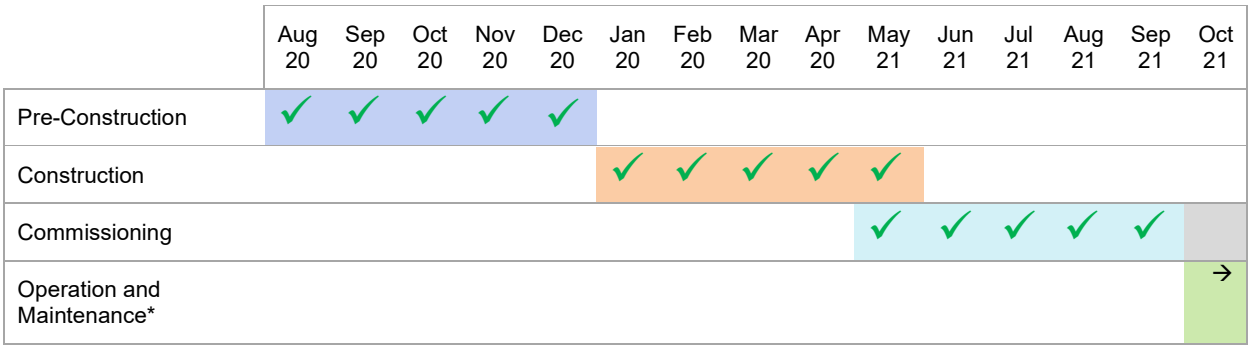
This PCR has been developed specifically to address the requirements of Condition B4 of the Development Consent. The requirements of Condition B4 are:

> *The Applicant must prepare a Pre-startup Compliance Report for the development to the satisfaction of the Secretary. This report must be submitted to the Secretary for approval at least one month prior to carrying out any operations under this consent, and detail the development's compliance with the documents required under **condition 1** of **schedule 3** of this consent, including:*
>
> *(a) date of document preparation;*
> *(b) date that construction and commissioning commenced; and*
> *(c) actions proposed and/or taken in order to implement the recommendations made in the documents.*

## 2.4 Timing and Project Phases

The Project has been split into four specific phases of works consisting of construction, commissioning, operation and decommissioning. The current indicative project timeline is presented in Figure 2–1. As shown in this figure, construction works commenced in 3 January 2021 and Commissioning commenced 23 May 2021, following approval of the required management plans.

**Figure 2–1: Indicative Project timing**




**Notes**

* 5 year operation in accordance with condition of approval Condition of Approval (CoA) A8
Grey – Potential carryover

Decommissioning has not been included in the schedule as this will occur approximately five years from the commencement of operations.

# 3. Project Description

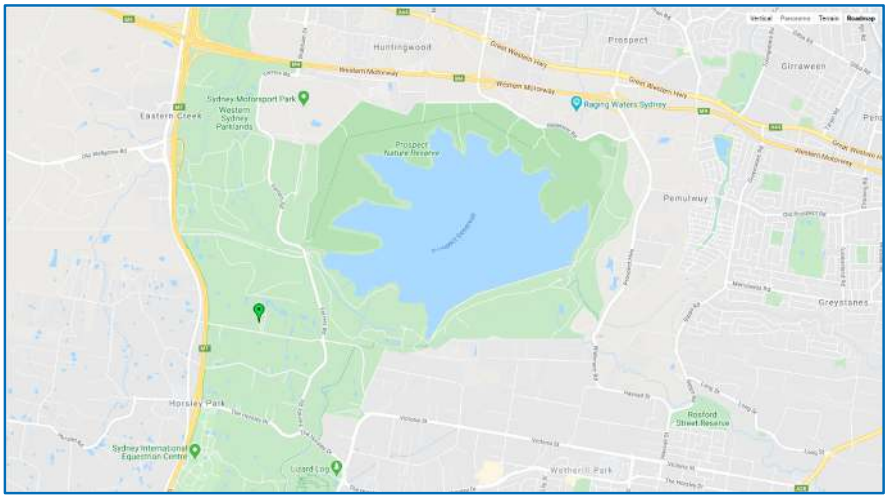
The Project involves the construction, commissioning and operations of a P2G hydrogen facility at the existing Horsley Park Trunk Receiving Station (the Horsley Park Facility), located in Western Sydney. The trial will be one of the most comprehensive hydrogen trials in Australia and will use renewable electricity for the production capacity 100 Nm³/h of hydrogen gas with a 500 kW Proton Exchange Membrane (PEM) electrolyser. Produced hydrogen gas will be injected into the existing natural gas distribution network at up to 2% by volume via a dedicated injection control panel.

The Project also includes a gas-fuelled generator package (microturbine) that once approved for operation will be initially operated on compressed natural gas to generate power for export to the grid and then be converted to operate using 100% hydrogen as the fuel source in early 2022.

## 3.1 Location

The Horsley Park Facility is located at 194 – 202 Chandos Road, Horsley Park (Lot 1 DP 499001 and Lot 3 DP 1002746) in Western Sydney, NSW (refer to Figure 3–1).

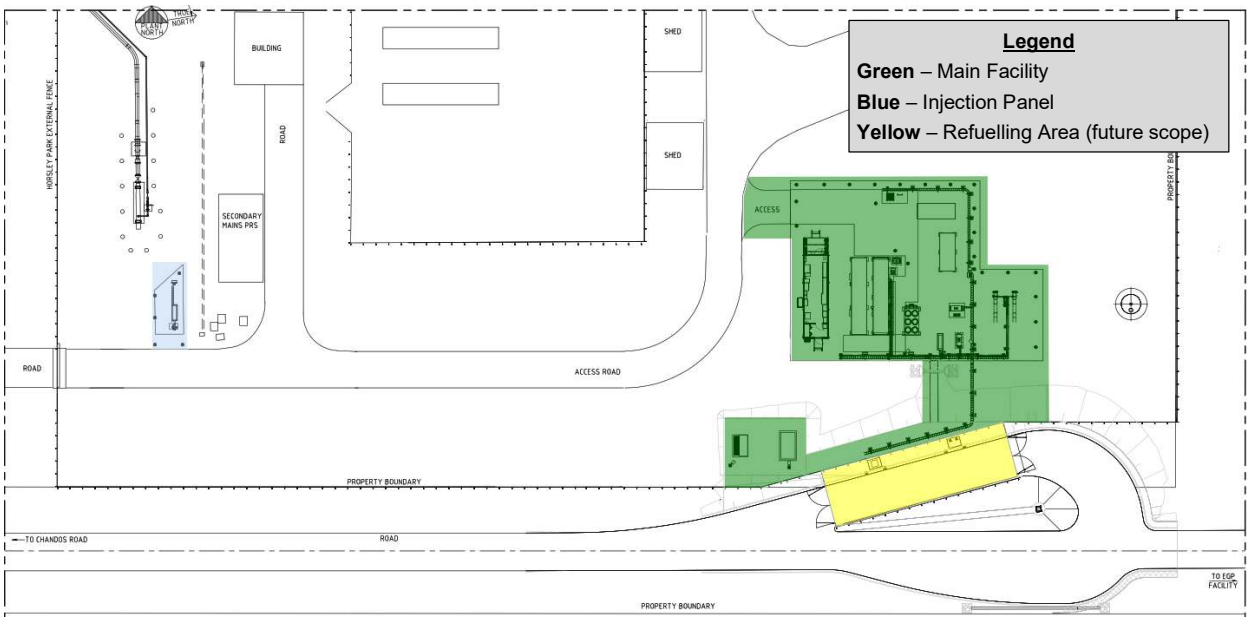
**Figure 3–1: Site Location**




The general layout of the site is shown in Figure 3–2 below and the WSGG Facility layout presented in Figure 3–**3** below.

**Figure 3–2: General Layout of Development**


**Figure 3–3: WSGG Facility**



## 3.2 Key Features

The facility will perform the following key functions:

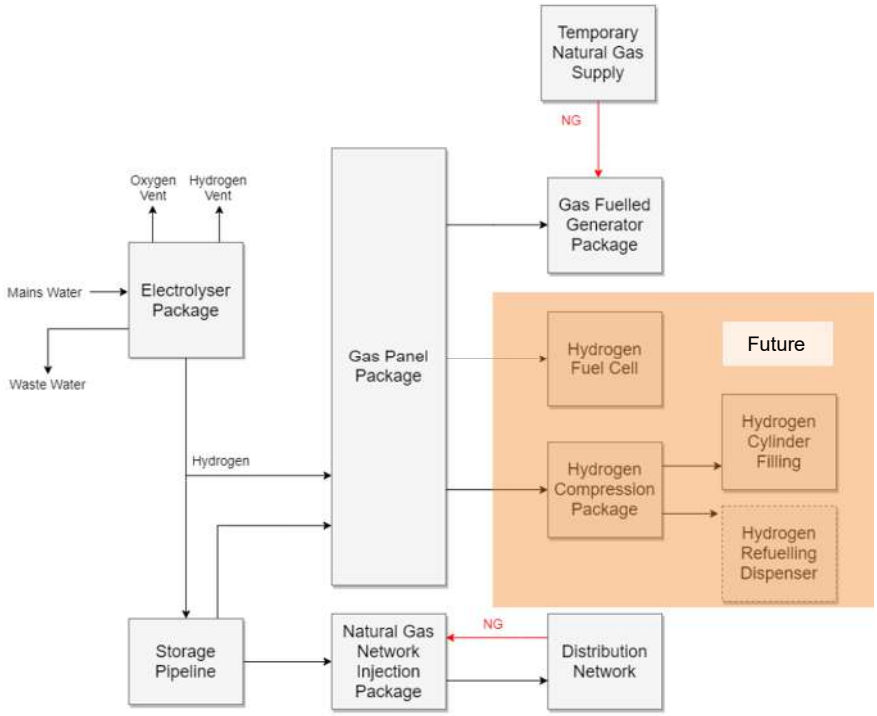
- convert mains water into hydrogen gas using grid (renewable) electricity through electrolysis;
- store hydrogen gas in a buried on-site carbon steel pipeline (this will be used for buffering the various produced hydrogen gas usage options);
- control and safely manage hydrogen gas pressures, temperatures and flow rates for injection into Jemena's Secondary Mains gas pipeline and downstream medium and low pressure network; and

Additional future proposed key functions include:

- utilising a hydrogen microturbine generator to convert stored hydrogen into electrical energy for supply to the grid.
- providing a hydrogen fuel cell, to convert stored hydrogen into electrical energy for supply to the grid; and
- providing hydrogen dispensing facilities to allow the filling of transportable hydrogen cylinders.

A general flow diagram of the facility operation is provided in Figure 3–4 below.

**Figure 3–4: Flow Diagram and General Facility**




## 3.3 Construction Activities

Construction activities for the Project were undertaken over an approximate six-month period. The construction activities undertaken as part of the facility construction are summarised in Table 3–1.

**Table 3–1: Summary of Construction Activities**

| Construction Stage | Details |
|---|---|
| Preliminaries | • Long lead item procurement;<br>• Construction planning;<br>• Construction documentation;<br>• Post approval documentation submissions;<br>• Workshop fabrication;<br>• Weld and weld qualifications;<br>• Procurement of contractor-supplied equipment and sub-contractors. |
| Mobilisation and Site Establishment | • Mobilisation to site;<br>• Construction and HSE signage installation;<br>• Establishment of lay-down area, fencing and facilities;<br>• Site Security establishment;<br>• Housekeeping and set up of disposal/removal of waste facilities;<br>• Relocation of services, where required;<br>• Removal of fencing;<br>• Demarcation of construction area;<br>• Set up of environmental controls. |
| Site Civil Construction | • Topsoil removal and stockpiling;<br>• Access road and truck wash facilities;<br>• Piling installation;<br>• Material importation/re-use of material for facility areas;<br>• Pipe and cable installation and trenching;<br>• Hardstand construction;<br>• Spoil and waste management;<br>• Ongoing site restoration (as required). |
| Hydrogen Buffer Storage Pipeline | • Excavation of pipeline trench and tie-in bell-holes;<br>• Transport, stockpiling and backfilling;<br>• Welding of pipeline strings;<br>• NDT and field-joint coating of welds;<br>• Lowering in of pipeline;<br>• Backfill of pipeline trench;<br>• Cleaning, hydro-testing and drying of pipeline. |
| Major Equipment Packages | • Receipt of equipment, off-loading and storage (as required);<br>• Installation of packages including:<br>– Electrolyser Package (process and electrical containers and separate cooler system),<br>– Microturbine Package,<br>– Gas Panel Packages,<br>– Gas Injection Panel Package,<br>– Electrical Equipment Room,<br>– High Voltage Switchgear and Kiosk Transformer (HV substation),<br>– Waste water tank & irrigation system.<br>• Trenching between packages;<br>• Electrical and instrumentation wiring of packages and connections. |

| Construction Stage | Details |
|---|---|
| Electrical Works | • Trenching all electrical inter-connections;<br>• HV electrical cable installation up to and including termination on to the Utility Switching Station;<br>• Installation of all Electrical (HV and LV), Control and Instrumentation cables with the required labelling, including terminations;<br>• Inspections and testing;<br>• Installation of lightning and cathodic protection systems;<br>• Installation of facility safety signage and electrical labelling as required. |
| Mechanical and Structural Works | • Installation, connection and testing of:<br>– Facility tubing and valves,<br>– Water piping system,<br>– Nitrogen cylinders and network.<br>• Installation of facility safety signage and applicable labelling as required. |

The works noted above will be completed in a manner consistent with relevant laws, policies and guidelines.

## 3.4 Commissioning Activities

For testing and commissioning activities, the facility was separated into isolatable sub-sections to allow for a staged commissioning approach. Commissioning was completed at different stages for each sub-section. The separation of the facility into isolatable sub-systems was done to:

- allow a progressive transition from the construction to commissioning phase;
- allow for the earliest possible commencement of commissioning for critical path systems;
- allow for the manageable, efficient and safe execution of the commissioning phase by having smaller, simpler, isolatable sub-systems for the commissioning team to focus on one at a time; and
- allow for clear and transparent commissioning progress reporting to the Project Manager and other key project stakeholders.

The sub-sections and associated systems completed as part of the commissioning are listed in Table 3–2 below.

**Table 3–2: Commissioning System Breakdown**

| # | System title | Primary function | Main equipment |
|---|---|---|---|
| 1 | Power | Provides power to the facility via the electrical equipment room. | High voltage (HV) switchgear;<br>HV Transformer;<br>Motor Control Centre. |
| 2 | Instrument air | Instrument air distribution to the blowout preventer (BOP) for valve actuation, external to the electrolyser (Instrument air for BOP is supplied from the electrolyser. | Instrument air compression (Within electrolyser). |
| 3 | Control system | Provides control of all the facilities on site. | Facility PLC and SCADA systems |

| | | | |
|---|---|---|---|
| 4 | Water | Provides water to the electrolyser water treatment system. Provide waste water from the electrolyser for irrigation. | Water storage tank;<br>Irrigation pump. |
| 5 | Nitrogen | Provides nitrogen from bottle storage to the electrolyser for purging. | Nitrogen bottle storage;<br>Nitrogen filtration, regulation and isolation skid. |
| 6 | Hydrogen production | Production of hydrogen from mains water and power. | Electrolyser Power and Process container including the:<br>• demineralised water system;<br>• gas generation system;<br>• hydrogen purification system;<br>• reverse osmosis system;<br>• closed loop cooling systems; and<br>• Dry Cooler. |
| 7 | Hydrogen Storage | Bulk hydrogen storage. | Pipeline buffer storage;<br>Pipeline isolation valves;<br>Pipeline blowdown vent. |
| 8 | Hydrogen Injection | Controls the injection of hydrogen into the secondary mains. | Secondary mains injection panel;<br>Secondary main hot taps. |
| 9 | Hydrogen distribution | Regulates and controls the flow of hydrogen from the buffer store pipeline to various users on site. | The Gas Panel. |

### 3.4.1 Commissioning Sequence

The commissioning sequence generally followed the order listed in Table 3–2 above. The commissioning sequence was altered at the discretion of the Commissioning Team, which was subject to timing of construction completion of each system, availability of materials and resources, timing of relevant approvals are, provided the alternate sequence can be executed safely and efficiently.

### 3.4.2 Commissioning Documentation

The commissioning works were completed in accordance with the following pre-commissioning deliverables, including the following:

- Emergency Response Plan;
- Jemena Safety and Operating Plan (SAOP) (GAS-999-PA-HSE-002);
- Traffic Management Plan; and
- Environmental Management Strategy, Rev 3.

## 3.5 Operational Activities

The operation of the P2G Plant will be undertaken by remote telemetry to observe and monitor performance of the plant 24 hours a day by a Control Room. The site will be rarely staffed and if required operators may attend during normal working hours (7:00 am – 6:00 pm Monday to Friday), and in the event of equipment failure the system is designed to automatically isolate, and not impact upon the existing natural gas facilities.

The remote telemetry system will provide data via Supervisory Control and Data Acquisition (SCADA), which in turn will alert the control room staff of the condition of the site prompting a response in line with the response sheet for the site.

The Project facility will incorporate both manual (local) and automatic (both local and remote) features that will allow plant and equipment to be operated safely and efficiently.

The primary objective of the control system during operation will be to provide control over processing functions, protect plant, equipment and personnel, and enable simple and reliable plant shutdown, depressurisation, and isolation of equipment. The Project facility will be occasionally manned, with minimal operator involvement required, including for start-up, shutdown, and restart. The systems shall therefore monitor and control the facilities on a continuous basis under all operating and environmental conditions.

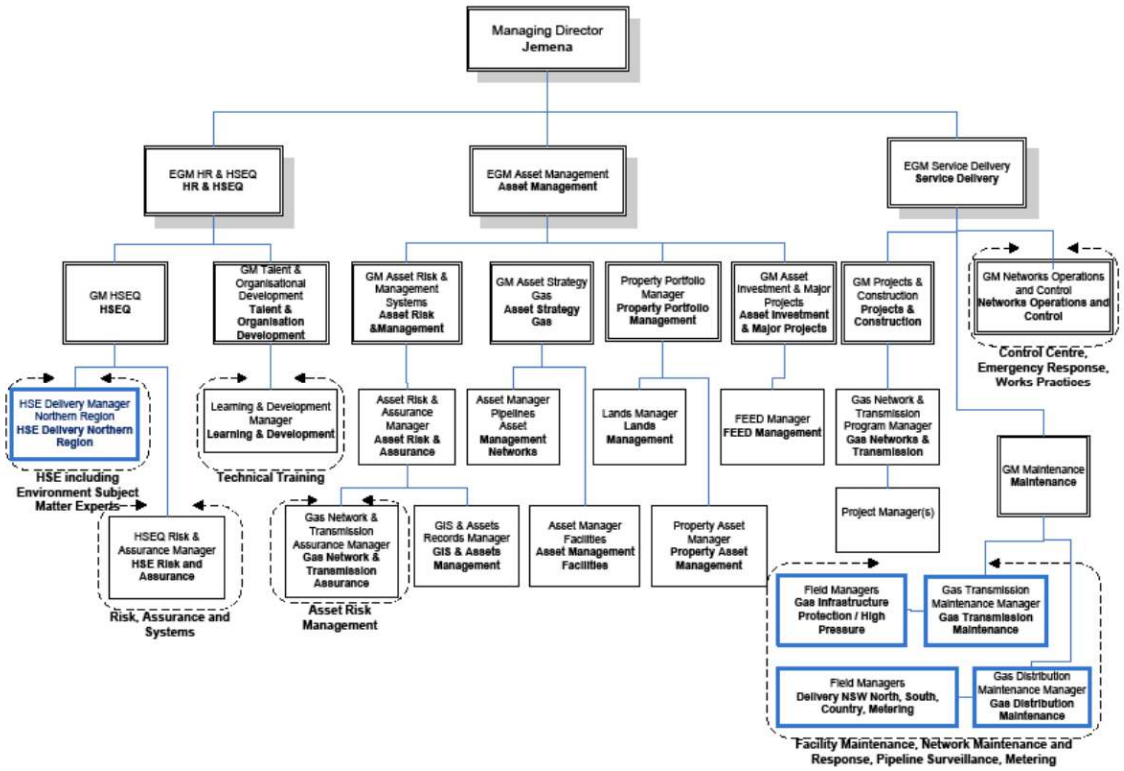
The Project facility will be provided with a local Programmable Logic Controller designed to control all major process functions, and a safety instrumented system (SIS) that will shut down (trip) a range of equipment and equipment packages, and close major isolation valves during emergency events or process trips. Hydrogen gas quality will be measured by a gas analyser, with data visible to the facility SCADA to enable plant adjustments to be made, if necessary.

### 3.5.1 Roles and Responsibilities

In accordance with the JGN NSW Distribution Network Operational Environmental Management Plan (OEMP) (Rev 6) relevant groups with environmental responsibilities within Jemena which cover the Network and this Facility are detailed in Figure 3–5. All Jemena personnel, regardless of position are responsible for the environmental performance of their activities, for reporting of environmental incidents and implementation of requirements of the Environmental Management Strategy and the JGN OEMP.

For additional information about the Jemena Organisational Structure and Responsibilities in operating and maintaining the pipeline, refer to the JGN Network Safety and Operating Plan (SAOP).

**Figure 3–5: Roles and Responsibilities (from JGN Network OEMP, Rev 6)**



### 3.5.2 Contractor Responsibilities

Contractors engaged to perform works on behalf of Jemena, shall operate in accordance with all applicable legislation, Jemena Procedures and the JGN Network OEMP. Jemena may request that subcontractors provide a Construction Environmental Management Plan (CEMP) or a Safe Work Method Statement(s) (SWMS) should their work activity present a risk to the environment. Subcontractors are required to report all incidents to their Jemena Supervisor immediately and the Control Room.

### 3.5.3 Operational Documentation

Key operational documentation that apply to the Facility include the following

1. Jemena Safety and Operating Plan (SaOP); and
2. GAS-1499-PA-EV-001 – JGN NSW Distribution Network OEMP.

# 4. General Compliance Information

This section of the PCR has been documented to meet general reporting compliance requirements as detailed in the NSW Government Requirement 1, Compliance Reporting Post Approval Requirements, May 2020, DPIE, such as previous actions, non-compliances, incidents and complaints.

## 4.1 Previous Compliance Report Actions

As per Schedule 4 Condition C9, an Independent Audit is required to be performed 12 months after commencement of operations then 3 yearly. Operations have not commenced and this is the first compliance report completed. There are no previous actions to report on.

## 4.2 Non compliances

A summary of non-compliances to Development Consent conditions up to the completion of this PCR are detailed in Table 4–1 below.

**Table 4–1: Development Consent non-compliances**

| Condition | Compliance requirement | Non-Compliance Reason | Further Information / Improvement Measures |
|---|---|---|---|
| N/A | Nil | Nil | Nil |
| | | | |

## 4.3 Incidents

A summary of historical incidents leading up to the PCR are detailed in Table 4–2.

**Table 4–2: WSGGP incidents**

| Date | Reporting pathway | Summary | Response | Status |
|---|---|---|---|---|
| 25/11/2020 | Internal* | Pad foot (mat) used to spread load of the cranes outrigger damaged the access road surface as the crane took the containers load. | Larger mats to be used. Access road surface to be addressed as part of final works (i.e. spray seal). | Closed |
| 02/12/2020 | Internal* | Trench excavation crew along the JGN/EGP boundary contacted buried 1/2" electrical conduit (2mm cable within the conduit broken). Not on DBYD, no maker tape installed above conduit and no surface markers in the area. | Additional requests for information to be sought for future trenching works in the area. | Closed |
| 28/01/2021 | Internal* | Power outage at JGN TRS facility as a result of cable strike due to construction of temporary pad (Note: Stand-by officer in place, cables exposed, timber skids used as protection). | Damaged cable section repaired. Steel road plates to be used in future and stop works to be initiated to re-assess risks should methodology required to be altered. | Closed |

| | | | | |
|---|---|---|---|---|
| 03/02/2021 | Internal* | Bottom split on plastic jerry can causing a diesel spill (20L). | Area cleaned up with spill kit and defective jerry can replaced. | Closed |
| 24/02/2021 | Internal* | Bell hole being pumping out (due to wet weather) resulting in slight trench collapse dislodging a CP cable which was then hit by 8T excavator bucket. | CP cable repaired. Toolbox held about wet weather and implications of trenches / bell holes shifting and any cables in these areas. | Closed |
| 05/03/2021 | Internal* | EGP NBN cable damaged during cable relocation activities due to excessive folding of the cable. | Works stopped. Optus repaired the cable. Toolbox held. | Closed |
| 24/03/2021 | Internal* | Near miss – Gust of wind below electrolyser door open as it was not secured / latched. Door caught by worker. | Door latches installed. | Closed |
| 31/03/2021 | Internal* | Telstra cable struck during excavation of stormwater pit. Subcontracted permit officer in place did not identify. | Cable repaired. Subcontracted permit officer removed from site. Principal Contractor personnel to be designated spotter for all future excavation permits / works. | Closed |

* Internal report only. The threshold for incident reporting did not meet the definition as detailed in Development Consent Definitions.

## 4.4 Complaints

A summary of complaints recorded during the reporting period are detailed in Table 4–3 below.

**Table 4–3: Project Complaints Received**

| Category | Via | Date | Summary | Actions/Mitigation | Status |
|---|---|---|---|---|---|
| **December 2020 -** No complaints received. | | | | | |
| **January 2021 –** No complaints received. | | | | | |
| February 2021 | | | | | |
| Noise | Jemena Customer Service | 09/02/2021 | Resident called to advise the Site Alarm system was going off in the early mornings (past 3 days). The Resident also said that there had been a few truck movements in the early hours of the morning which had woken them. | The Community Liaison Manager (CLM) called the Resident at 12.30pm – and apologized for the Project impacts – advising the alarm had been reset. The CLM offered to advise in advance of any future outside of work hours truck movements (including a couple occurring the next day around 5am). The Resident was reasonable and grateful of the return call and opportunity to connect with the CLM. | Closed |
| March 2021 | | | | | |
| Noise | 1800 No. | 11/03/2021 | Resident called to advise that large trucks had arrived on site at 11.30pm and 6.15am. They were noisy and create dirt & dust and resident said this was unpleasant. | The CLM apologized for the impacts and agreed to advise in advance of any future large truck movements outside normal work hours. Resident was pleasant and appreciative of the offer. | Closed. |
| April 2021 | | | | | |
| Noise | 1800 No. | 12/04/2021 | Resident called to advise the alarm had tripped over the weekend and created unnecessary noise. CLM immediately apologized and explained she had just been about to call to proactively say sorry – as she had heard this news a few minutes prior. Resident was grateful we were aware and | CLM apologized and advised we were reducing the sound level on the alarm, as well as checking the procedure to ensure alarm doesn't stay 'on' for any longer than absolutely necessary. | Closed. |

| | | | | | |
|---|---|---|---|---|---|
| | | | had planned to take action, including lowing the sound on the alarm system. | | |
| **May 2021 –** No Complaints received. | | | | | |
| June 2021 | | | | | |
| Noise | 1800 No. | 5/06/2021 | Resident hear a noise all through the night – sounded like a valve being released, and wanted to know if this was the 'new norm' ? | CLM investigated and advised the resident (by return text on Sunday 5pm) that it was due to an equipment failure at an adjacent site and not the WSGGP. Zinfra technicians were on-site to rectify the issue. | Closed |
| **July 2021 –** No Complaints received. | | | | | |
| **August 2021 –** No Complaints received. | | | | | |
| **September 2021 –** No Complaints received. | | | | | |

# 5. Pre-Construction Compliance Documentation

This section of the PCR specifically addresses Schedule 3, Condition B1 requirements with regards to the implementation of recommendations within the Construction Safety Study (CSS), Commissioning Safety Study, Hazard and Operability Study (HAZOP), Final Hazard Analysis (FHA) and the Fire Safety Study (FSS) in accordance with Schedule 3, Condition B4.

## 5.1 Construction and Commissioning Safety Studies (CSS)

The *Jemena Western Sydney Green Gas Project, Construction Safety Study Report*, *Rev 0*, dated 8 October 2020 (P2G-2099-PA-HS-005) was approved by DPIE on 16 November 2020. The report summarises key hazardous events and proposes control measures. These measures have been summarised in Table 5–1, inclusive of actions implemented. Note that construction activities were completed on site on 22 May 2021.

**Table 5–1: Key findings, controls and measures implemented**

| Key Finding Area | Recommendation | Actions Implemented |
|---|---|---|
| Site Security | Where security fencing removed, temporary high security fences to be used. | The WSGGP Health and Safety Management Plan (HSMP), Rev 2 (P2G-2099-PA-EV-003 WSGGP), documented HSE requirements during the construction phase. Fencing requirements are specified in Section 12.2 of this plan in addition to Section 30.2 for Site Security and Public Safety. Requirements of plan implemented during the construction phase. |
| Existing Services | Service locators.<br>Positive identification of buried services.<br>Non Destructive Digging<br>Permit to Work System. | HSMP, Section 12.2 details the existing services procedures which were undertaken during the construction phase for the project. As detailed in Table 6, a number of service location incidents occurred due to unknown / undetected services, changing conditions and not following the permit to work process. Incidents investigations were undertaken for each issue, with the final issue resulting in Principal Contractor staff being present and responsible for excavation works in the vicinity of underground services. |
| Traffic Management | Traffic Management Plan.<br>Signage at site entrance. | Jemena Western Sydney Green Gas Project Traffic Management Plan, Rev 3, 20/11/2020 submitted to DPIE on 17/11/2020 and approved on 27/11/2020. Section 7.1.2 specifies site signage requirements for the entry and exit. Requirements of the plan implemented during the construction phase. |

The CSS has been superseded by the Commissioning Safety Study to reflect the projects transition from construction phase to commissioning. This has been documented in *Jemena Gas Networks (NSW) Ltd, Commissioning Safety Study Report, Western Sydney Green Gas Project*, *Rev 0*, dated 5 May 2021, approved by DPIE on 3 May 2021. It details the procedures and processes that will be implemented during the commissioning phase of the project.

As part of that documentation a commissioning hazard identification (HAZID) was conducted on the commissioning works. All outstanding actions and close-out comments relating to the works have been detailed in Table 5–2, inclusive of close-out comments. It is noted that commissioning activities have been successfully completed at the site.

**Table 5–2: Commissioning HAZID Actions and Close-Out Comments.**

| Line # | HAZID Comments / Actions | Required Close Out Action | Close-Out Comments |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 3.02 | Operational: Concerns on non-qualified persons accessing HV transformer including LV side | • Specific HV locks<br>• Note to be included in work instructions not to access HV Transformer LV side | • HV locks procured<br>• Warning signs added to transformer<br>• Site induction covers transformer risks and included in work instructions |
| 3.03 | Operational: Clarity required on what start/stop capability control room will have during maintenance | Investigate what remote start/stop capability's control room have | • Detailed in site induction and training packs<br>• Control room training package<br>• Detailed in maintenance work instructions |
| 3.12 | Commissioning: New technology to Jemena portfolio, leverage of vendor to better understand risk and risk controls | Commissioning procedures and package risk assessment to be supplied from electrolyser vendor. | Commissioning procedures provided by Vendor and reviewed by Jemena |

## 5.2 Hazard and Operability Study (HAZOP)

Two HAZOP study workshops were conducted on 25-26 July 2019 and 4 and 12 August 2020. The outcome of the workshop was documented in the report Western Sydney Green Gas Trial HAZOP Report, Rev 1, dated 17 August 2020 (P2G-2099-RP-HZ-002) approved by DPIE on 19 November 2020. The report provides an Overview of Key Actions, summarised from the formal study minutes, covering the themes of:

- Leak prevention and management;
- Leak detection;
- Oxygen;
- Ignition control;
- Production specification;
- Overpressure;
- Maintenance;
- Waste water;
- Commissioning.

All remaining HAZOP close-out actions, with the exception of design elements associated with cylinder filling have been closed. The HAZOP table has been provided in **Appendix A – HAZOP Close-Out Register**.

## 5.3 Final Hazard Analysis (FHA)

The Final Hazard Analysis (FHA) Jemena - Detailed Design for Hydrogen Generation (Western Sydney Green Gas Project), Rev A, 3/09/2020 (P2G-2099-RP-HZ-005) was approved by DPIE on 19 November 2020. The objectives of the study and the report were to determine the risk of a major incident at the WSGGP facility affecting offsite land users and to compare this with established tolerable risk criteria. The conclusion of the study and report was:

> "There are no potentially fatal offsite individual risks presented by the design of the Western Sydney Green Gas Project in this report. Any risk of potential injury beyond the boundary is well below the tolerable risk target for the surrounding land use."

Section 10 of the report has the following recommendations:

> "In conjunction with design safeguards listed in this report, Jemena will develop an integrity management plan involving inspection and maintenance of critical equipment as well as upgrading and implementing their safety management system for the site. This will be reflected in an update to the Safety Case GAS-999-PA-HSE-002 and the Asset Management System Manual, JEM-AM-MA-001."

The amended Safety Case (GAS-999-PA-HSE-002), Jemena Asset Management Pty Ltd, Safety Case Pipeline Management Plan Jemena Gas Pipelines 1, 2, 3, 7, 8 Jemena Colongra Lateral Pipelines 33, Rev 5, dated 25 September 2020 was approved by DPIE on 11 November 2020. Section 5.3 of this plan states:

> "Integrity and Maintenance Plans are developed for each asset based on the specific requirements for each asset…."

The Jemena Gas Networks (NSW) Ltd Asset Class Strategy : Facilities 2021-2027, Rev 3, 27 April 2021 (GAS-999-PA-FA-001) includes the requirements of the WSGG Facility (Section 4.3). The *WSGGP Operations and Maintenance Specification, Rev 0*, dated 31/03/2021 provides an overview of equipment at the site and provides details on the work codes for inspections and maintenance of equipment. All 34 Work Instructions for maintenance and operations for the WSGG asset have been uploaded to the Jemena scheduling system in SAP.

The Executive Summary of the FHA report also states the following:

> "There is potential for additional future scope items to be added consisting of:
> - Vehicle refuelling facilities and associated hydrogen high pressure storage (as described in the PHA)
> - Hydrogen cylinder filling facilities.
>
> If these scope items are going to proceed, this FHA will be amended to include them and re-submitted."

Vehicle refuelling facilities will not be pursued for this project at this stage. Note that the FHA already considered the inclusion of the fuel cell, cylinder filling station and change in fuel supply to the microturbine. An amendment to the FHA dated 2 July 2021 (P2G-2099-RP-HZ-005-r1) was created to support the development consent modification for the hydrogen fuelled fuel cell, cylinder filling station and change in fuel source for the Microturbine. This development consent modification, including the revised FHA, was submitted 02 July 2021.

## 5.4 Fire Safety Study

The *Fire Safety Study (FSS), Jemena - Detailed Design for Hydrogen Generation (Western Sydney Green Gas Project) Jemena Ltd, Rev A*, dated 14 September 2020 (P2G-2099-RP-RM-006) was approved by DPIE on 27 November 2020. The executive summary of the report, Table 1 details a number of recommendations, details of these recommendations and the Projects implementation are detailed in Table 5–3 below.

**Table 5–3: FSS Recommendations and Status**

| No | Recommendation | Action Taken | Status |
|---|---|---|---|
| 1 | The FSS shall be reviewed whenever a change has been made to the design, or new equipment has been added to the | None required at this stage. | Closed |

| | | | |
|---|---|---|---|
| | WSGGP and updated as required. | | |
| 2 | Complete close out of actions for all HAZOP actions and documented in a HAZOP closed out action report. | Western Sydney Green Gas Trial HAZOP Report Rev 1, 17/08/2020 (P2G-2099-RP-HZ-002). Refer to Section 4.2 above for further details. | Closed |
| 3 | Confirm close out of all SMS actions. | All actions from the SMS have been closed in the latest revision of the SMS report: P2G-2099-RP-RM-001_0 - Safety Management Study Report - Buffer Store Pipeline | Closed |
| 4 | Confirm storage quantity and location of spare Ion Exchange Resin. | Approximately 150 kg currently stored on-site within the storage shed. SDS located on site and within the Emergency Response Plan. | Closed |
| 5 | Confirm measures (e.g. bollards, signage) are implemented during construction to control the risk of an excavator strike on the buried buffer store pipeline. | Standard pipeline industry practice for installation was followed – no strikes of the pipeline occurred (signage, barriers, stringing pipeline, qualified dogman, qualified operators, survey location of buried pipe, marking tape, depth of burial, positive identification prior to other excavations, sequencing of excavations) | Closed |
| 6 | Add WSGGP to the existing integrity management system of procedure prior to the completion of the project. | To comply with AS 2885 requirements, the Jemena Integrity Management System is known as an Asset Class Strategy (ACS) Document which references the Field Operation and Maintenance Specification (FOMS) document.<br>The Jemena Gas Networks (NSW) Ltd Asset Class Strategy : Facilities 2021-2027, Rev 3, 27 April 2021 (GAS-999-PA-FA-001) includes the requirements of the WSGG Facility (Section 4.3). The WSGGP Operations and Maintenance Specification, Rev 0, 31/03/2021 provides an overview of equipment at the site and provides details on the work codes for inspections and maintenance of equipment. All 34 Work Instructions for maintenance and operations for the WSGG asset have been uploaded to the Jemena scheduling system in SAP.<br>The Jemena Gas Network Safety and Operating Plan GAS-999-PA-HSE-002 Rev 5, Appendix A section 3.7 includes a description of the assets managed under the network Safety and Operating Plan | Closed |
| 7 | Verify completion of Hazardous Areas Verification Dossier in accordance with AS/NZS 60079.14:2009 Clause 4.2 is completed for the WSGGP. | A Hazardous Areas Verification Dossier has been completed for Western Sydney Green Gas in accordance with AS/NZS 60079.14:2009.<br>*Western Sydney Green Gas Hazardous Area Dossier, Rev 0, dated 9 August 2021* (P2G-2099-RC-HA-001) | Closed |
| 8 | Develop procedures for WSGGP which reference the existing safe work system manual prior to completion of the project. | Jemena Gas Network (NSW) Ltd Safety Management System Western Sydney Green Gas Project, Rev 0, 19/03/2021 was approved by DPIE on 03/05/2021. The SMS details all HSE requirements including the use of SWMS and permits. The following specific Jemena SWMS were developed and have been in use during the commissioning phase:<br>• Electrolyser Commissioning<br>• Electrical System Commissioning<br>• Nitrogen Commissioning<br>• Microturbine Commissioning | Closed |

| | | | |
|---|---|---|---|
| | | • Instrument Air Commissioning<br>• Gas Panel Commissioning<br>• Buffer Store Pipeline Commissioning | |
| 9 | Develop relevant procedures and policies to control portable ignition sources at the WSGGP. | The Jemena Gas Transmission – Permit to Work Form Rev 2 (GAS-999-FM-HSE-026), has been amended to incorporate a Hydrogen Specific Permit (Authority). The Jemena Safe Work System Manual (GAS-999-OM-HSE-002) provides information on Training and Competency Requirements associated with the Hydrogen Permit, inclusive of a Hydrogen Induction.<br>The Jemena Permit to Work Procedure (GAS-999-PR-HSE-006) and the associated Hot Work Permit details requirements for works in Hazardous Areas (i.e. areas where an explosive atmosphere is present). | Closed |
| 10 | Site emergency procedures should document actions to be taken by the operator during emergency situations. | Jemena Gas Networks (NSW) Ltd, Emergency Response and Management Plan, Western Sydney Green Gas Facility Rev 1, 28/03/2021. Section 3.2 details Roles and Responsibilities during emergency situations. | Closed |
| 11 | Update the Balance of Plant (BOP) cause and effects matrix to show communication between BOP and the package. | The BoP has been updated and completed provided in cause and effects matrix within P2G-2099-RG-PS-001 | Closed |
| 12 | Confirm XV-03008 will be closed during an Emergency Shutdown (ESD). | In the event of an ESD all actuated valves on the site will close, including XV-03008. Tested and confirmed. Documented on cause and effects matrix P2G-2099-RG-PS-001 | Closed |
| 13 | Confirm ESD communications to and from the Hydrogen Compression Package. | Future scope | Open |
| 14 | Confirm ESD signal from the fuel generator Programmable Logic Controller (PLC) is sent to the BOP PLC. | Future scope | Open |
| 15 | Develop a drawing (Fire Services Layout) showing the location of the ESD push buttons, gas detectors, visual flashing beacon/s and audible alarms. | Jemena Gas Networks (NSW) Ltd, Emergency Response and Management Plan, Western Sydney Green Gas Facility Rev 1, 28/03/2021. Appendix B has the Evacuation Diagram for the project, which includes ESD and alarm locations. | Closed |
| 16 | Develop Emergency Response Plan. | Jemena Gas Networks (NSW) Ltd, Emergency Response and Management Plan, Western Sydney Green Gas Facility Rev 1, 28/03/2021 | Closed |
| 17 | Ensure locations of main and alternative Emergency Services access to the site are shown on the Fire Services Layout. | Jemena Gas Networks (NSW) Ltd, Emergency Response and Management Plan, Western Sydney Green Gas Facility Rev 1, 28/03/2021. Appendix B has the Evacuation Diagram for the project, which includes primary and secondary emergency access routes. | Closed |
| 18 | Include evacuation routes on the site. | Jemena Gas Networks (NSW) Ltd, Emergency Response and Management Plan, Western Sydney Green Gas Facility Rev 1, 28/03/2021. Appendix B has the Evacuation Diagram for the project, which includes the evacuation route. | Closed |

| | | | |
|---|---|---|---|
| 19 | Include locations of emergency assembly points on the (Fire Services Layout) and in the Emergency Response Plan. | Jemena Gas Networks (NSW) Ltd, Emergency Response and Management Plan, Western Sydney Green Gas Facility Rev 1, 28/03/2021. Appendix B has the Evacuation Diagram for the project, which includes assembly points. | Closed |

# 6. References

## 6.1 Internal

Final Hazard Analysis Jemena - Detailed Design for Hydrogen Generation (Western Sydney Green Gas Project), Rev A, 3/09/2020 (P2G-2099-RP-HZ-005)

Jemena Asset Management Pty Ltd, Safety Case Pipeline Management Plan Jemena Gas Pipelines 1, 2, 3, 7, 8 Jemena Colongra Lateral Pipelines 33, Rev 5, dated 25 September 2020

Jemena Gas Networks (NSW) Ltd Asset Class Strategy : Facilities 2021-2027, Rev 3, 27 April 2021 (GAS-999-PA-FA-001)

Jemena Gas Networks (NSW) Ltd, Commissioning Safety Study Report, Western Sydney Green Gas Project, Rev 0, 5 May 2021

Jemena Gas Networks (NSW) Ltd, Emergency Response and Management Plan, Western Sydney Green Gas Facility Rev 1, 28/03/2021

Jemena Gas Networks (NSW) Ltd Asset Class Strategy : Facilities 2021-2027, Rev 3, 27 April 2021 (GAS-999-PA-FA-001)

Jemena Gas Network (NSW) Ltd Safety Management System Western Sydney Green Gas Project, Rev 0, 19/03/2021

Jemena Gas Transmission - Permit to Work Form Rev 2 (GAS-999-FM-HSE-026)

Jemena Permit to Work Procedure (GAS-999-PR-HSE-006)

Jemena Safe Work System Manual (GAS-999-OM-HSE-002)

Jemena Western Sydney Green Gas Project, Construction Safety Study Report, Rev 0, 08/10/2020 (P2G-2099-PA-HS-005).

Jemena Western Sydney Green Gas Project Traffic Management Plan, Rev 3, 20/11/2020

Western Sydney Green Gas Trial HAZOP Report Rev 1, 17/08/2020 (P2G-2099-RP-HZ-002).

WSGGP Health and Safety Management Plan (HSMP), Rev 2 (P2G-2099-PA-EV-003 WSGGP)

WSGGP Operations and Maintenance Specification, Rev 0, 31/03/2021

## 6.2 External

NSW Government Requirement 1, Compliance Reporting Post Approval Requirements, May 2020, DPIE

# Appendix A – HAZOP Close-Out Register

ACTIONS:

GPA
JEMENA
ANT
BALLARD
COREGAS
OPTIMAL

| Client | Jemena | | | Document Title | Document Subtitle | Document No. |
|---|---|---|---|---|---|---|
| Client | P2G-2099 | GPA | 18667 | HAZOP Minutes | Overview | P2G-2099-MM-HZ-001 |
| Project | Western Sydney Green Gas Project | | | | | |

**HAZOP Minutes - Overview**

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Session | Guideword | Cause | Consequence | Existing safeguard | Action required | Priority | Responsible | Complete Yes/No | Close-out Comments and References |
| O-1 | S1 | TOXICITY | Nitrogen leak within electrolyser enclosure. | Nitrogen is an asphyxiant. There is potential to create low oxygen atmosphere. | Continuous ventilation of the enclosure. Ventilation flow meter will stop unit if the ventilation is not working.<br>Nitrogen bottles are located outside the container.<br>Personnel use of low-oxygen gas detectors. | Develop procedures for entering enclosure when the system is shut-down.<br><br>Consider use of low-oxygen alarm on atmosphere in the electrolyser container. | 1<br><br>1 | AW<br><br>AW | YES | Closed, Procedures (Work Instructions, SWMS, training) either developed or well in progress, are being developed for electrolyser maintenance, include isolation procedure and O2 monitoring on personnel monitors, no further action required |
| O-2 | S1 | SERVICES REQUIRED | Low light inside enclosure on power failure. | Slip, trip or fall. | Night work not required. | Egress lighting from enclosure supplied from UPS to be provided. | 1 | AP<br><br>JD | | Electrical Equipment Room specified to include emergency exit lighting - refer P2G-2099-SP-EL-004.<br><br>Electrolyser containers proposed to include points for battery-backup Exit lighting as per ANT Variation Request JEM-002A. Exit lighting to be installed by construction contractor.<br><br>Internal lighting included within EER and electrolyser power and process containers |
| O-3 | S1 | SERVICES REQUIRED | Only instrument air users in current balance of plant scope are two small actuated shutoff valves. | Including a balance of plant air compressor may be an unnecessary expense | | Facility instrument air to tie into electrolyser instrument air system. | 1 | AP / SH | YES | Refer P&ID DW-PD-005. Note that air consumption has not been confirmed, so supplementary compression may be required in future, but instrument air tie-in to electrolyser has been provided. |
| O-4 | S1 | MATERIALS OF CONSTRUCTION | Underground pipeline is CS pipe, which is susceptible to hydrogen embrittlement. | Loss of containment. | Carbon steel pipeline designed with low design factor and relatively low-strength grade (X52) material to ensure low stress conditions protecting against rupture due to H2 embrittlement.<br><br>Facility piping is stainless steel, which is less susceptible than carbon steel to H2 embrittlement, and is also operating under low stress conditions which will prevent a rupture. | Review requirements relating to hydrogen-assisted fatigue crack growth (HA-FCG), relating to defect inspection, weld defect tolerances, and monitoring etc. | 1 | NK | YES | Refer safety management study report, P2G-2099-RP-RM-001, and fatigue crack growth modelling calculation, P2G-2099-CA-PL-001, which utilised the ASME model for HA-FCG. |
| O-5 | S1 | MATERIALS OF CONSTRUCTION | Buried piping. | | Use of coating and cathodic protection | Determine requirements for cathodic protection (sacrificial anode or cross-bonding to existing lines, TBC) | 1 | NK | YES | The pipeline will be protected using sacrificial anode cathodic protection. Refer also the Safety Management Study, P2G-2099-RP-RM-001, which provides detail of corrosion control. |
| O-6 | S1 | MATERIALS OF CONSTRUCTION | Degradation of soft materials e.g. Swagelok fittings, gaskets, instrumentation from exposure to hydrogen. | Loss of containment. | | Confirm compatibility of soft components in hydrogen service (hot-tap O-rings, insulation joints, instrument seals etc.) | 1 | NK / SD | YES | All tubing components are confirmed by supplier as suitable for hydrogen service. The requirement that soft components be compatible with hydrogen has been included in the project construction SOW and IFT datasheets. |

**HAZOP Minutes - Overview**

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **O-7** | **S1** | COMMISSIONING | Contaminated pipeline. | Unable to achieve specified hydrogen purity (particularly for future scope items - fuel cells - where high purity is required). | Initial lower-spec hydrogen can be directed into the natural gas network (due to lower purity requirement). | Prepare commissioning plan for quality, with focus on pipeline cleanliness and dryness. | 1 | NK / ML | | Construction SOW P2G-2099-SW-CN-001(1) Section 2.13.1 outlines the pre-commissioning requirements for the facility and pipeline. The Contractor is required to clean the pipeline and test the purity of the hydrogen at the outlet of the buffer store to achieve ISO 14687:20919 - Fuel quality for PEM fuel cell applications. The nominated Construction Contractor has outlined their proposed cleaning method to Jemena and GPA which has been reviewed and accepted. Commissioning plan P2G-2099-PA-CS-001 and associated procedures provide further detail on the cleaning and testing procedures. Hydrogen quality in the pipeline tested and confirmed suitable for network injection. |
| **O-8** | **S1** | BREAKDOWN | Loss of power. | Site communications turn off and cannot identify the condition / status of the station.<br><br>Note that hydrogen supply is not critical; interruption to hydrogen supply is not a contractual loss of supply problem. Demonstration plant only. | 0.5 hour uninterruptible power supply (UPS) used in electrolyser for control/communications and will return instruments to a safe condition so that monitoring of parameters can continue while site is shut down. | Install UPS for balance of plant with 2 to 3 h backup time.<br><br>Include backup power supply to lighting of exit signs in enclosures. | 1<br><br>1 | SD<br><br>AP | YES | UPS with minimum 2hr battery backup specified - Refer P2G-2099-DS-EL-005.<br><br>Battery-backup exit lighting to be installed. |
| **O-9** | **S1** | STARTUP / SHUTDOWN | Start-up and shutdown are critical. One of the critical concerns is purging of piping; managing potential for air ingress during maintenance. | Explosion in piping/equipment. | | Create competency based training for operators/maintainers and include risks of air ingress during start-up/shutdown.<br><br>Create start-up and shutdown procedures and include air freeing/nitrogen purging of equipment prior to start-up. | 3 | AW | YES | Closed, Training packages complete and delivered noting hazards and unique hydrogen properties to be managed. Work Instructions developed that include the purging of equipment, no further action required |
| **O-10** | **S1** | EFFLUENT | Effluent includes Reject water from water treatment plant, Hydrogen and oxygen gasses. | Environmental pollution | Environmental approval plan required to be submitted and approved for the operation. | HAZOP action 3.1: design pre-filtration system to reduce waste water production rate from RO system from 30% to target 1%<br><br>Sizing basis for on-site water inventory is 5m3 currently. Preferred sizing basis is the duration between load-out and size of load-out truck (e.g. 18 m3). Finalise sizing requirements for input into Environmental Impact Statement. Look at options to reduce water consumption and waste; on-site use optional. | 1 | SH | YES | Water options study concluded that pre-filtration is not required and waste water generated can be used onsite for irrigation. On-site storage capacity is based on irrigation usage rather than load-out. Refer water options report, P2G-2099-RP-EV-002. |
| **O-11** | **S1** | NOISE / VIBRATION | Pumps, vents etc. | Neighbourhood disturbances. | Noise study planned for the site. | | | | | |

**HAZOP Minutes - Overview**

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **O-12** | **S1** | FIRE / EXPLOSION | Hydrogen, oxygen, bushfire, and knock-on effects from adjacent facilities (this plant is within radiation contour of adjacent facilities). | Hydrogen facility potentially harmed if a pipeline incident occurs, but will not cause escalation beyond the existing risk. | Consequence modelling and risk assessment to be completed.<br><br>Note: no gas or fire detection currently provided in the facility.<br>HAZOP action | Determine if fire detection is required for the site e.g. fusible loops as a result of risk assessment. | 1 | SH | YES | Fusible loops are not effective for detecting jet fires, which are directional, and so have not been used. Fire detection will not be provided at the facility. |
| **O-13** | **S1** | FIRE / EXPLOSION | Loss of containment within electrolyser enclosure. | Fire within enclosure. | Hydrogen detector in the electrolyser enclosure, with control functionality to increase the fan speed for ventilation on low levels of H2 and shutdown on high levels. | Shutdown balance of plant when electrolyser shuts down on safety function (e.g. high hydrogen).<br><br>Determine if fire detection is required within the electrolyser enclosure. | 1<br><br>1 | SD<br><br>AP | | Closed - Electrolyser initiated ESD shutdown is reflected on P2G-2099-RG-PS-001.<br><br>Fire & gas detection has been included in the electrolyer enclosure. Refer to Electrolyser instrument list. |
| **O-14** | **S1** | SAFETY EQUIPMENT | Loss of containment. | Operator approaches plant without knowing there's a leak, potentially introducing an ignition source. | Hydrogen detectors installed in the electrolyser building and planned for the BOP gas panel.<br><br>Operators to wear personal hydrogen detectors.<br><br>Control of ignition sources on the site though Jemena's existing management procedures such as hot work permits, antistatic clothing etc.<br><br>Competency based training for operators. | Install an alarm/beacon at the site entrance gate to alarm on hydrogen detection so that operators do not approach faulted equipment.<br><br>Determine if any modifications to Jemena's ignition control management procedures are required such as hot work permit system, antistatic clothing requirements, non-sparking tooling. | 1<br><br>2 | SD<br><br>AW | YES | Beacons and Sirens are provided at three locations 1) Hydrogen Injection 2) EER area main access, 3) Southern access path from vehicle turnaround. Items are reflected in IO list P2G-2099-LS-JJ-002 and instrument list P2G-2099-LS-JJ-001.<br><br>Closed, Jemena has developed a Hydrogen Authority which requires operators to open a hot work permit prior to commencing work, only operators with the HA and Hot Works PTW may work on the plant. In addition to the Hot Work, Jemena is removing all potential sources of ignition that may otherwise be considered acceptable under a Hot Permit for Natural Gas applications, such as mobile phones, etc, within the hazardous area. |
| **O-15** | **S1** | QUALITY AND CONSISTENCY | *Leak due to material defect or human error during construction or maintenance.* | Loss of containment. | Jemena's Existing test and tag systems.<br><br>Commissioning procedures | | | | | |
| **O-16** | **S1** | OUTPUT – RELIABILITY AND BOTTLENECKS | *Demonstration plant only.*<br>*Provision for future rate increase is included.* | | | | | | | |
| **O-17** | **S1** | EFFICIENCY | *No Causes identified.* | | | | | | | |
| **O-18** | **S1** | SIMPLICITY | *No Causes identified.* | | | | | | | |
| **O-19** | **S1** | MOBILE EQUIPMENT / PLANT MOVEMENT | Buried services supplying Eastern Gas Pipeline (EGP) site are located in the area of the vehicle turnaround. | Access to buried equipment restricted by new development. | | Review layout against buried services. Determine optimum locations for vehicle access to the site. Jemena to provide buried services drawing.<br><br>Provide vehicle turnaround access for water storage tank load-out.<br><br>Provide for laydown requirements for construction in development of layout. | 1<br><br>1<br><br>1 | AW / NK<br><br>NK<br><br>NK | YES | Vehicle turn-around has been designed with consideration of existing buried services. Vehicle route will cross existing services, but new foundations will be clear of existing services. Refer plot plan P2G-2099-DW-CV-001.<br><br>Water storage load-out is no longer required.<br><br>Laydown areas are available at rear of facility; construction contractor to finalise layout and construction sequence. Refer construction specification P2G-2099-SW-CN-001. |

**HAZOP Minutes - Overview**

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **O-20** | **S1** | MOBILE EQUIPMENT / PLANT MOVEMENT | construction traffic | Compromise to existing operations | Construction phase - access to the EGP site required to be maintained during construction. | Include in commissioning plan access plans, laydown areas etc. so as not to disrupt access to existing facilities. | 2 | JI | YES | Closed - Construction Mangement Plan and Comissioning safet study (Commissioning HAZID) covered these issues |
| **O-21** | **S1** | PROCESS PLANT NORMAL / ABNORMAL MAINTENANCE | Presence of oxygen causes high flammability of materials. | Unexpected ignition/fire | Specific oxygen-service grease provided by Hydrogenics. | Competency-based training to be reviewed for operators for equipment in oxygen service.<br><br>Jemena to create management plan for consumables and critical spares - in oxygen and hydrogen service. | 1<br><br>1 | AW<br><br>AW | YES | Closed, Jemena has included Oxygen specific training as well as management of spare and consumables for both hydrogen and oxygen. Jemena has undertaken an operational risk workshop on the 19th of May to assess the suitability of new procedures and controls from an operational perspective, no further action required. |
| **O-22** | **S1** | PROCESS PLANT PROCESS FUNCTIONALITY | | Value in keeping spares separate to natural gas equipment. | | Determine suitable location for spares. Review potential to store spares in site control hut, or existing facility sheds - separate room? | 1 | AW | YES | Closed, Critical spares and equipment unique to WSGG will be stored on site in dedicated 20ft shipping container. Generic equipment common to other facilities will be stored at the Greystanes depot. No further action |
| **O-23** | **S1** | ERGONOMICS | Electrolyser has a number of filter packages and nitrogen bottles that need to be changed out routinely. | | | Ensure ease of access and manual handling requirements are accommodated. | 1 | NK | YES | Ease of access and manual handling has been considered at each design review. Refer minutes of 90% design review, P2G-2099-MM-PM-053. |
| **O-24** | **S1** | GUARDING | | | | Demarcate boundary of hazardous area for pipeline flanges (e.g. with Bollards). | 1 | NK | YES | Hazardous area boundary is 3m from flanges, refer HA classification report: P2G-2099-CA-HA-001. Area demarcated with chin-linked bollards: P2G-2099-CA-HA-001. |
| **O-25** | **S1** | WARNINGS | *Unauthorised access to site* | introduction of ignition sources. | Fencing and signage will be provided. | | | | | |
| **O-26** | **S1** | VULNERABILITY | *Unauthorised access to site*<br>*Demonstration plant has government & media interest.* | introduction of ignition sources. | Access to be managed through permit system. | | | | | |
| **O-27** | **S1** | 3RD PARTY INTERFERENCE | *Unauthorised access to site*<br>*Demonstration plant has government & media interest.* | Theft, plant damage, introduction of ignition sources. | Site security includes line of sight detectors, gate alarms, CCTV (recently upgraded) etc. A separate security assessment will be completed for the site. | Complete site security review | 2 | AW | YES | Closed, A full site security upgrade, including the WSGG facility was complete (as a separate project) immediately after construction of WSGG. Upgrade includes high security fence and 24/7 surveillance. No further action. |
| **O-28** | **S1** | GUARDING | ELECTRICAL: Electrical supply. Electrical equipment is high current. | Jemena technicians for the site are not familiar with electrolyser electrical equipment.<br><br>Is there potential that stray currents will compromise CP function? | | Confirm electrical maintenance requirements w. Hydrogenics/ANT.<br><br>Determine if additional training is required for electricians.<br><br>Confirm potential for stray currents to compromise CP system. | 1<br><br>2<br><br>1 | AP<br><br>AW<br><br>NK | YES | Closed, Jemema and Zinfra have agreed with ANT what maintenance activities will be conducted by Zinfra, these have been developed into work instructions and vendor training has been delivered to the technicians to cover off specific requirements. Any high voltage work will be undertaken by a specific HV contractor. No further action.<br><br>Safety management study (P2G-2099-RP-RM-001) considered fault current and other CP electrical effects. No sources of CP interference have been identified. |

HAZOP Minutes - Overview

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Session | Guideword | Cause | Consequence | Existing safeguard | Action required | Priority | Responsible | Complete Yes/No | Close-out Comments and References |
| O-29 | S1 | NATURAL EVENTS | Heavy rains | flooding | Site located at high point.<br>There is a stormwater gully between facility and fence. | | | | | |
| O-30 | S1 | NATURAL EVENTS | Bushfire | Plant damage | A bushfire assessment will be completed for the Environmental Impact Statement EIS | | | | | |
| O-31 | S1 | NATURAL EVENTS | Wind | Debris, hail, branches coming down… | | Operators to monitor trees to control risk of branches falling off. | 3 | AW | YES | Closed, The monthly maintenance work instruction for condition monitoring includes vegetation management for the site. No further action. |
| O-32 | S1 | NATURAL EVENTS | Lightning | Plant damage | | Lightning review in accordance with AS 1768.<br><br>Hydrogenics to advise of any lightning protection requirements | 1<br><br>1 | SD<br><br>AP | YES | Lightning risk assessment P2G-2099-RP-EL-003 completed and issued.<br><br>The process container vents are earthed lightning rods installed. |
| O-33 | S2 | TOXICITY | No new issues identified. | | | | | | | |
| O-34 | S2 | SERVICES REQUIRED | No new issues identified. | | | | | | | |
| O-35 | S2 | MATERIALS OF CONSTRUCTION | No new issues identified. | | | | | | | |
| O-36 | S2 | COMMISSIONING | A number of different packages and equipment need to be commissioned by different parties. | Lack of coordination could lead to delays, incidents and accidents. | | Integrated coordination procedure for start up of various packages required. | 3 | AW | YES | Closed, The commissioning plan document has now been produced and signed off by GPA and Jemena. No further action. |
| O-37 | S2 | BREAKDOWN | No new issues identified. | | | | | | | |
| O-38 | S2 | STARTUP / SHUTDOWN | No new issues identified. | | | | | | | |
| O-39 | S2 | EFFLUENT | Potential pooling of water locally around the fuel cell bund if the drain from the exhaust is not plumbed to the facility drainage line. | Water pooling in bund or on hardstand around the fuel cell. | Design is not finalised so no safeguards in place. | Confirm expected flow rate quantity from fuel cell and determine whether the waste water line for the fuel cell needs to be connected to the facility vent. If yes, then assess impact to HAZOP. | 1 | ML | YES | Optimal have clarified: “Expect to be 1 or 2 litres of water/condensate on cold start up, normal operation water is discharge via exhaust. We suggest this could be discharged to a gravel area.”<br>Reference email: 18667-S11306 |
| O-40 | S2 | NOISE / VIBRATION | Pulsation from compressor leading to failure of tubing. | Loss of containment. | No safeguards identified. | Confirm with vendor what pulsation control/resonance frequencies of the compressor are present and confirm whether a pulsation study/vibration analysis is required on the BOP pipework | 1 | ML | NO | COREGAS ACTION<br>FUTURE<br>Vendor to confirm if pulsation study is required. This TQ was issued to Coregas 24/08/2020 with no response received to date. |
| O-41 | S2 | FIRE / EXPLOSION | Fire at injection panel - unable to isolate instrument gas supply at injection panel. | Fire continues to be fuelled by the natural gas network. | Manual isolation valves at pipeline riser - although may not be accessible in the event of a fire. | A design change request and risk assessment to address the inability to safely isolate the secondary mains is required. | 1 | TR | YES | A risk assessment was carried out for a potential fire scenario at the secondary mains injection panel.<br><br>The risk assessment concluded that the likelihood of a fire for the scenarios assessed was rare and the consequence of the fire was severe, leading to an overall risk categorisation as Moderate.<br><br>Based on the Jemena Risk Management Manual risk appetite guidelines no further risk mitigation actions or controls were deemed to be necessary.<br><br>Reference email: 18667-S11205 |

**HAZOP Minutes - Overview**

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **O-42** | **S2** | SAFETY EQUIPMENT | Fire at new packages. | Damage to equipment/injury to operations personnel. | It is unknwon what fire safety equipment will be supplied with the new pacakges or if the vendors believe they will be required. | Confirm what safety equipment is required for the new equipment packages (e.g., fire extinguishers). | 1 | ML | YES | Refer WSGGP Fire Services Layout drawing prepared by Jemena |
| **O-43** | **S2** | QUALITY AND CONSISTENCY | No new issues identified. | | | | | | | |
| **O-44** | **S2** | OUTPUT – RELIABILITY AND BOTTLENECKS | No new issues identified. | | | | | | | |
| **O-45** | **S2** | EFFICIENCY | No new issues identified. | | | | | | | |
| **O-46** | **S2** | SIMPLICITY | Control complexity as a result of adding fuel cell, microturbine (and potentially) solar array. | Electrical fault as multiple generators are not working together properly.<br><br>Decouple site from grid due to generation on site resulting in shutdown. | Automatic isolation from grid in the event of unstable generation is included in the design and the safe state. | Microgrid control philosphy to be drafted.<br><br>Microgrid controller to be incorporated. | 1 | CR | YES | Hybrid controller is supplied by Optimal to manage fuel cell and microturbine in conjuction with the balance of plant. Refer to P2G-2099-GL-DN-001. SEL 751 protection relay between the generation and load side of the MCC protects facility from unstable generation on site. Invertors on fuel cell are 4777 certified. Microturbine self manages sychrnoisation with the grid. Solar array not installed. All documented in facility FD P2G-2099-SP-JJ-001 and OHC FD P2G-2099-GL-DN-001 |
| **O-47** | **S2** | MOBILE EQUIPMENT / PLANT MOVEMENT | Insufficient access for forklift to drive to cylinder cage. | Cylinders cannot be replaced due to insufficient access. | Space for cylinder cage and subsequent access has been allowed for (but may be insufficient). | Review the footprint of the cylinder cage and compressor pacakges once they are included in the 3D model to confirm adequate space has been allowed for forklifts. | 1 | ML | YES | Nitrogen cylinder manifold pack has been moved in 3D model P2G-2099-DW-PI-015 (prior to 22/09/2020) to the Plant North side of the electrolyser process container on the hardstand. This revised location provides sufficient space for forklift access to be able to replace the nitrogen manifold packs when empty. |
| **O-48** | **S2** | PROCESS PLANT NORMAL / ABNORMAL MAINTENANCE | No new issues identified. | | | | | | | |
| **O-49** | **S2** | PROCESS PLANT PROCESS FUNCTIONALITY | No new issues identified. | | | | | | | |
| **O-50** | **S2** | ERGONOMICS | No new issues identified. | | | | | | | |
| **O-51** | **S2** | GUARDING | No new issues identified. | | | | | | | |
| **O-52** | **S2** | WARNINGS | Inadequate warning signs shown on new package items. | Hazards unknown to operators (e.g. high voltage residual electricty in DC fuel cell bus after shutdown). | No safeguards identified. | Confirm what warning signs will be provided with new packages and which signs are to be added (if not provided, but also in addition to provided signs). | 2 | ML | YES | HSE review of the site following construction has determined signage requirements for all systems |
| **O-53** | **S2** | VULNERABILITY | No new issues identified. | | | | | | | |

**HAZOP Minutes - Overview**

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **O-54** | **S2** | 3RD PARTY INTERFERENCE | Additional packages will involve additional vehicles requiring access. Vehicles colliding with plant. | Damage to vehicles and plant. | Some traffic bollards have been provided throughout the facility. | Review additional bollard protection/ other traffic management protection requirements with the new pacakges. | 1 | ML | YES | Final site layout has been complete with traffic bollards provided to protect sensitive equipment from vehicle impact. The entrance into the facility has chained-linked, removable traffic bollards to prevent unauthorised access. Inside the facility, bollards have been added to the design around the nitrogen manifold pack and NG tie in point and electrolyser IBC container to protect which are the only items considered to be at risk of vehicle impact. |
| **O-55** | **S2** | NATURAL EVENTS | No new issues identified. | | | | | | | |

GPA ENGINEERING

ACTIONS:

GPA
JEMENA
ANT
BALLARD
COREGAS
OPTIMAL

| Client | Jemena | | | Document Title | Document Subtitle | Document No. |
|---|---|---|---|---|---|---|
| Client | P2G-2099 | GPA | 18667 | HAZOP Minutes | Nodes | P2G-2099-MM-HZ-001 |
| Project | Western Sydney Green Gas Project | | | | | |

**HAZOP Minutes - Nodes**

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Session | Guideword | Cause | Consequence | Existing safeguard | Action required | Priority | Responsible | Complete Yes/No | Close-out Comments and References |
| 1-1 | S1 | HIGH FLOW / LEVEL | High amperage into the electrolyser package. | Design sized for maximum hydrogen production. | Current control and current meters which trigger shut-down of the electrolyser. Stack cannot physically generate more than 200 Nm3/h. | | | | | |
| 1-2 | S1 | HIGH FLOW / LEVEL | Downstream rupture / leak occurs. | Loss of containment of H2 and production continues to atmosphere. Gas pressure decreases as the buffer store inventory depletes. | Back-pressure regulator on electrolyser stack prevents low discharge pressure. | Add trip to PALL-06015 to shut down the electrolyser in the event of rupture (consider pressure rate-of-change trip).<br><br>Confirm back-pressure regulator on electrolyser stack prevents low discharge pressure. | 1<br><br>1 | SD | YES | Pipeline low-pressure and rate of change trip have been added. Refer P2G-2099-DW-PD-008, tag number PIT-02001 (new).<br><br>The outlet of the HPS includes a back pressure regulator set at 26 barg. In case of a loss of pressure downstream of the electrolyser this regulator will prevent pressure dropping lower than this setting. |
| 1-3 | S1 | LOW FLOW / LEVEL | Closed or partially closed manual valve (such as H03003 or other downstream valves). | Loss of production. High pressure in the electrolyser and continuous hydrogen venting from the vent stack. | Electrolyser controls current in response to discharge pressure. High downstream pressure would reduce electrolyser settings to minimum turn-down, manual vent will relieve pressure, and finally an electrolyser PSV will relieve hydrogen to protect the | | | | | |
| 1-4 | S1 | NO FLOW / EMPTY | See low flow | | | | | | | |
| 1-5 | S1 | NO FLOW / EMPTY | Downstream end of pipeline is not flowing in some operating conditions, such as if the valve line-up on the gas panel means that the buffer storage is bypassed | The downstream end of the pipeline will be a "dead leg". | Pipeline is dry and clean and hence internal corrosion risk is not expected even in zero flow conditions. | | | | | |
| 1-6 | S1 | REVERSE FLOW | Backflow from secondary mains during empty/low pressure conditions of the buffer store. | Natural gas contamination into the hydrogen piping. Hydrogen purity is compromised, which will do damage to any customers using fuel cells or other sensitive technology. | PALL-06015 to XSV-06001 will inhibit injection system from opening if the pressure is less than 1,050 kPag (the MAOP of the secondary mains).<br>Check valve on natural gas injection line. | Jemena's preference is for anti-feedback of NG into H2 is a primary method plus two additional layers of protection. Primary Protection in this case would be from PALL-06015 which closes XSV-06001. Check valve is a layer of protection. Consider second check valve (different type) or closing FV-06003 on PALL-06015 (although not independent to closing XSV-06001) as a second layer of protection. Specify soft seats check valves with zero leak. | 1 | NK | YES | PIT-02001 now also closes the flow valve, FV-06003. Refer P&ID P2G-2099-DW-PD-004. |
| 1-7 | S1 | REVERSE FLOW | Rupture / leak or venting of the electrolyser package. | The buffer store is emptied via the electrolyser package. | | Add a check valve adjacent H03003. | 1 | SH | YES | Check valve added on electrolyser outlet, refer drg. P2G-2099-DW-PD-005, (grid reference D8). |
| 1-8 | S1 | HIGH PRESSURE | Locked in gas warms up after being shut in. | The pressure increases, ultimately exceeding the pressure design conditions. | The pipeline will not reach more than 3,500 kPag due to high pressure electrolyser shut-down trips. The piping is designed for 3,800 kPag and hence can handle any thermal pressure increase during shut-in conditions. Pipeline is buried, and hence not subject to short-term heating. | Increase pipeline design pressure from 3,800 kPag to full class 300, and hydrotest to that pressure.<br><br>DRAFTING NOTE: Correct set-points on PIT-06015 | 1 | NK | YES | The pipeline hydrotest pressure was increased to maximum for class 300 (1.5 x 5.1MPag). However, the design pressure of the pipeline remains at 3,800 kPag. Refer safety management study, P2G-2099-RP-RM-001, and the construction specification, P2G-2099-SW-CN-001. |
| 1-9 | S1 | LOW PRESSURE | Consumption of gas in the buffer store depletes the inventory, e.g. because multiple users take the gas simultaneously. | The buffer store pressure reduces below the minimum pressure for the gas turbine, which is 540 kPag. This will initiate a trip for the gas turbine. | PALL-03016 interlocked to XSV-03001 will prevent use of gas turbine if the inlet pressure to the turbine is below 540 kPag. | | | | | |

**HAZOP Minutes - Nodes** OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **1-10** | **S1** | HIGH TEMPERATURE | Electrolyser supplies high temperature hydrogen at discharge due to incorrect operation of the dryer in its recharge cycle. | The pipeline downstream is designed to a maximum of 65°C; potential damage to coatings of other soft components if the temperature is exceeded. Also harm to personnel if they contact piping at high temperatures. | Electrolyser high temperature alarm on each dryer, trip on discharge vessels. TTZ 1160 is a temperature switch set at 80°C, the gas sent to the vent stack will never exceed this temperature, not even during regeneration, this is because heat exchanger X-1156 is present.<br><br>Length of buried pipeline will allow for | Determine maximum allowable temperature for the piping. Set electrolyser's high temperature trip to shut down the electrolyser if temperatures exceed maximum allowable for downstream piping. | 1 | NK / AP | YES | Piping downstream of the electrolyser is designed to SH3D pipe specification which has a maximum design temperature of 100 DegC which is above the set point of the electrolyser temperature trip. The pipeline has a maximum design temperature of 65 DegC however as per Design Basis P2G-2099-DG-DN-001, the pipeline material selected can accommodate infrequent incursions above this temperature up to 80°C without de-rating of the design pressure. The electrolyser high temperature set point is at 65DegC. |
| **1-11** | **S1** | LOW TEMPERATURE | Low temperatures may occur after rapid depressurisation of the system. The minimum temperature would occur after depressurisation at minimum ambient temperature. | No significant consequence. | Pipeline minimum design temperature is -10°C, and minimum ambient is -6°C. Thermal mass of steel will prevent low steel temperatures. | | | | | |
| **1-12** | **S1** | IMPURITIES | Failure / reduction of performance of upstream deoxy / drier systems in the electrolyser skid. | Impure hydrogen is sent to the gas panel, which will damage fuel cells that use the gas. | The electrolyser package has a gas analyser which will vent off-specification gas and control logic to reduce impurities. Set points: O2 = 2ppm, Dew point = -75°C | | | | | |
| **1-13** | **S1** | IMPURITIES | Residual debris, water remains in pipeline after the hydrotest. | Required hydrogen purity cannot be achieved. Product off spec, potential damage to fuel cell users. | | Prepare a commissioning procedure involving cleaning, drying and purging to achieve required purity. | 2 | NK / ML | YES | Construction SOW P2G-2099-SW-CN-001(1) Section 2.13.1 outlines the pre-commissioning requirements for the facility and pipeline. The Contractor is required to clean the pipeline and test the purity of the hydrogen at the outlet of the buffer store to achieve ISO 14687:20919 - Fuel quality for PEM fuel cell applications. The nominated Construction Contractor has outlined their proposed cleaning method to Jemena and GPA which has been reviewed and accepted. Mechanical commissioning procedure P2G-2099-CS-PR-001 outlines commissioning steps to achieve hydrogen purity. Hydrogen purity achieved to 99.95% at the time of writing. Moisture levels below 5ppm |
| **1-14** | **S1** | IMPURITIES | Residual debris, water remains in pipeline after the hydrotest. | Required hydrogen purity cannot be achieved. Product off spec, potential damage to fuel cell users. | | Determine need for filtration to be installed downstream near users. To be used as a post commissioning check before selling product. | 1 | SH | YES | This issue was considered in the design review. Refer minuted discussion from the 90% design review in P2G-2099-MM-PM-053(0), *"Filtration for post-commissioning was discussed. The velocities aren't high and no additional filters are required during commissioning. To remove particulates during normal operation a filter is included on each of the piping runs on the gas panel."* |
| **1-15** | **S1** | CHANGE IN COMPOSITION | *No issues identified* | | | | | | | |
| **1-16** | **S1** | CHANGE IN CONCENTRATION | *No issues identified* | | | | | | | |
| **1-17** | **S1** | REACTIONS | Use of incompatible materials, that fail in hydrogen service. | Failure of materials. | Pipeline designed to "no rupture" and use of low design factor (guidance per ASME B31.12). | Confirm that hot tap and all soft component fittings have hydrogen-compatible materials. | 1 | JEMENA | YES | Closed, materials deemed compliant with ASME 31:12 for hot tap. No further action. |
| **1-18** | **S1** | REACTIONS | Use of incompatible materials, that fail in hydrogen service. | Failure of materials. | Pipeline designed to "no rupture" and use of low design factor (guidance per ASME B31.12). | Sparing philosophy to ensure that natural gas service components are not used in hydrogen system when incompatible. | 2 | AW | YES | Closed, Hydrogen specific components, such as gaskets and sensors to be kept on site, so as to avoid mistaken use of incompatible items. no further action required. |
| **1-19** | **S1** | TESTING | Hydrogen leaks from fittings. | Flammable mixture forms around fitting. | Personal gas detection, permit to work procedures. | Design to include use of hoods with gas detectors in locations with multiple fittings and valves. E.g. gas panel, injection panel, pipeline end connections.<br><br>Add short-term isolation function, which shuts in system for 15 minutes and monitors pressure change during shut-in to detect leak. Include as routine test in operating procedures. | 1<br><br>1 | SH<br><br>SD | YES | Hoods have been added to the design of the gas panels, which include hydrogen detectors. Refer P&IDs: P2G-2099-DW-PD-004 and P2G-2099-DW-PD-006. Hoods are not used at the pipeline risers, which are away from the rest of the facility, adjacent a vent and generate a hazardous area with bollards.<br><br>Functional Description P2G-2099-SP-JJ-001 |

**HAZOP Minutes - Nodes** OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **1-20** | **S1** | TESTING | Regular functioning testing of the gas Pressure Reducing Station PRS results in pressure pulses in the gas line. | Reverse flow into hydrogen system. | | PRS testing procedure to be updated to include manual isolation and lock-out of the hydrogen injection line during testing of PRS.<br><br>Provide manual lockout valve to isolate | 1 | AW<br><br>NK | YES | Included in the procedure for opening permits to conduct work on the PRS - Control room will adivse technicians on requirement to isolate the injection panel<br><br>Manual isolation valves provided above-ground at secondary main offtakes. Refer P2G-2099-DW-PD-004. |
| **1-21** | **S1** | OPERABILITY / MAINTAINABILITY | Pipeline blowdown for maintenance | Ignition of released hydrogen due to expansion/velocity. | | Design venting procedure. E.g. limit velocity, nitrogen dilution at vent, flow control valve, or calculate radiation distance and provide exclusion zone. Include requirements in the shutdown procedure.<br><br>Also consider noise attenuation as part of blow down system design and consider cross bonding and earthing across all components.<br><br>Ensure pipework is clearly labelled i.e. H2, CH4, O2 & H2O. | 1 | SH | YES | Radiation distance was calculated and an RO sized to limit the maximum vent rate to avoid danger to the operator (calculation P2G-2099-CA-PI-003). At 90% design review (P2G-2099-MM-PM-053), it was also decided to include an actuated control valve to allow remote operation and control of the flow-rate.<br><br>Noise attenuation was considered in noise study and at design reviews and was rejected. This is a non-routine activity and the flow-rate has been limited by inclusion of an RO. Note operators will have control to reduce vent rate also if noise becomes excessive. Vents have been earthed locally, refer earthing drawing P2G-2099-DW-EL-051.<br><br>Clear labelling of all lines is required in the construction SOW, P2G-2099-SW-CN-001. |
| **1-22** | **S1** | OPERABILITY / MAINTAINABILITY | Air ingress after maintenance. Including from incorrectly connected instrument air tubing. | Flammable mixture forms in pipe and ignites.<br>Localised release of hydrogen | | Strict use of nitrogen purging after maintenance to be enforced in hydrogen service, and included in all start-up/re-commissioning operating procedures | 3 | AW | YES | Closed, Training packages complete and delivered (except vendor specific packages) noting hazards and unique hydrogen properties to be managed. Work Instructions developed that include the purging of equipment, no further action required |
| **1-23** | **S1** | OPERABILITY / MAINTAINABILITY | Air ingress after maintenance. Including from instrument air. | Flammable mixture forms in pipe and ignites. | | Develop competency based training module for the new facility.<br>Make competency based training a requirement for hydrogen service operators . Create register for management of accredited personnel. | 1 | AW | YES | Closed, Jemena has developed a Hydrogen Authority which requires operators to open a hot work permit prior to commencing work, only operators with the HA and Hot Works PTW may work on the plant, an e-log has been established by the control room ensuring only trained and competent staff may open the necessary permits to carry out work, no further action required. |
| **1-24** | **S1** | OPERABILITY / MAINTAINABILITY | Potential for a high leak rate at connections, especially large-bore flanged connections. | Loss of containment of product.<br>Wastage of inventory. | | Review potential alternatives for mechanical connections on large diameter joins, which may have high leak-rate. | 1 | NK | YES | Connection types were reviewed. It was concluded that pigability was more important. Mechanical connections have been minimised by using welding but DN500 pipeline flanges have been retained. Refer also safety management study documentation of this issue: P2G-2099-RP-RM-001. |
| **1-25** | **S1** | ELECTRICAL | Cathodic protection current on buried pipeline. | Current discharges through the above-ground piping making CP ineffective. | *None identified.* | Consider cross-bonding to existing buried assets.<br><br>DRAFTING NOTE: mark up connections from pipeline to tubing as isolation joints with surge diverters. | 1 | NK | YES | Cross-bonding was considered and rejected (JAM-RESTECHQ-000014). The piping will be provided with cathodic protection using a sacrificial anode CP system. |
| **1-26** | **S1** | ELECTRICAL | Electrolyser has 200V DC stack. Design for potentials and touch potentials is mitigated by earthing on the electrolyser package | Discharge through the piping could damage soft components or shock personnel/operators and may cause corrosion over time | Earthing system design of electrolyser package. | Review putting isolation joints at electrolyser connections to isolate electrically. | 1 | NK | YES | Per 18667-LIS-003_X Clarification No. 66: Electrical discharge through piping does not require consideration, no insulation gasket is required at the hydrogen nozzle. All piping is to be earthed. |
| **1-27** | **S1** | INSTRUMENTS | *No issues identified* | | | | | | | |
| **2-1** | **S1** | HIGH FLOW / LEVEL | Downstream rupture. | Continuous flow from the water main. Water accumulates at the leak site, e.g. the utility area in the electrolyser container | Site water can be isolated at the custody transfer from Sydney water. | | | | | |
| **2-2** | **S1** | LOW FLOW / LEVEL | Filter blockage. | | Filter monitoring and change-out requirements to be specified in water treatment package | | | | | |
| **2-3** | **S1** | NO FLOW / EMPTY | Closed valve upstream of electrolyser. | Electrolyser shuts down on low water. | Package trips; about 20 minutes at maximum production between detection and electrolyser shut-down. | | | | | |
| **2-4** | **S1** | REVERSE FLOW | *No issues identified* | | | | | | | |

**HAZOP Minutes - Nodes**

OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **2-5** | **S1** | HIGH PRESSURE | High supply pressure from water mains. | Design pressure for water inlet is exceeded. | High pressure trip on electrolyser inlet line. | Confirm what water network pressure is, and determine the maximum inlet pressure to the electrolyser. Design pressure regulator if required. | 1 | AW | YES | Water pressure verified on site during construction. Confirmed to be in excess of electrolyser package limit (600kPag). Design change to include a PCV, PI and PSV to suit electrolyser pacakge |
| **2-6** | **S1** | LOW PRESSURE | *No issues identified* | | | | | | | |
| **2-7** | **S1** | HIGH TEMPERATURE | *No issues identified* | | | | | | | |
| **2-8** | **S1** | LOW TEMPERATURE | Low ambient temperatures. | Below freezing. Potential blockage of pipe while not running overnight. | No history of this occurring in this location. Unlikely and short-term. | | | | | |
| **2-9** | **S1** | IMPURITIES | *No issues identified* | | | | | | | |
| **2-10** | **S1** | CHANGE IN COMPOSITION | *No issues identified* | | | | | | | |
| **2-11** | **S1** | CHANGE IN CONCENTRATION | *No issues identified* | | | | | | | |
| **2-12** | **S1** | REACTIONS | *No issues identified* | | | | | | | |
| **2-13** | **S1** | TESTING | *No issues identified* | | | | | | | |
| **2-14** | **S1** | OPERABILITY / MAINTAINABILITY | Material of supply line. | | | Change to Polyethylene pipe. | 1 | NK | YES | Polyethylene has been specified, refer drawing P2G-2099-DW-PD-001. |
| **2-15** | **S1** | ELECTRICAL | *No issues identified* | | | | | | | |
| **2-16** | **S1** | INSTRUMENTS | *No issues identified* | | | | | | | |
| **3-1** | **S1** | HIGH FLOW / LEVEL | RO plant malfunction or reduced function (e.g. off-specification water is rejected by water purity or safety function and dumps load of water into reject water system. (Design flow rate is less than 500 L/d)<br><br>OR - Long duration between load-out of storage tank and hence it accumulates inventory until full. | Tanks are full, initiating overflow and leading to shut-down of electrolyser and loss of production. | LSHH 01004/5 on sump trigger shut-down of electrolyser. LSHH01002/3 on storage tank shut-down pump. | DRAFTING NOTE: Pump on/off wrong way around.<br><br>High level on storage tank to shut down pump, rather than electrolyser.<br><br>Conduct review to minimise wastewater production. Design pre-filtration system to reduce waste water production rate from RO system from 30% to target 1%<br><br>Determine sizing of tanks. | 1 | SH | N/A | NULL - this node has changed since the HAZOP. |
| **3-2** | **S1** | LOW FLOW / LEVEL | | | | | | | | |
| **3-3** | **S1** | NO FLOW / EMPTY | | | | | | | | |
| **3-4** | **S1** | REVERSE FLOW | Open DN20 ball valve. | Siphon out tank volume through outlets. | | Prevent siphon through inlet by removing internal fill tube. | 1 | SH | N/A | NULL - this node has changed since the HAZOP. |
| **3-5** | **S1** | HIGH PRESSURE | Blocked discharge on pump due to closed valves. | | | Determine over-pressure requirements on pump to suit pump type; fully-rate piping if possible. | 1 | SH | N/A | NULL - this node has changed since the HAZOP. |
| **3-6** | **S1** | LOW PRESSURE | Low sump level. | Vapour at pump suction / cavitation. | | Determine NPSH potential. Size sump so that there is sufficient time for pump to self-prime if required. | 1 | SH | N/A | NULL - this node has changed since the HAZOP. |
| **3-7** | **S1** | HIGH TEMPERATURE | | | | | | | | |
| **3-8** | **S1** | LOW TEMPERATURE | | | | | | | | |
| **3-9** | **S1** | IMPURITIES | Debris accumulates in sump or storage tank, such as leaves, dirt or snakes. | Blockage accumulates over time, most likely of sump pump suction line. | Sump and tank have cover (but are still atmospheric). | | | | | |
| **3-10** | **S1** | CHANGE IN COMPOSITION | | | | | | | | |
| **3-11** | **S1** | CHANGE IN CONCENTRATION | | | | | | | | |
| **3-12** | **S1** | REACTIONS | Enriched oxygen or hydrogen environment forms in drain due to gas break-through. | Fire/explosion potential. | | Confirm that gas break-through is not feasible from oxygen or hydrogen streams in electrolyser.<br><br>Action for Hydrogenics to identify all feeds to drains. If gas breakthrough can occur in O2 or H2 scrubbers connected to drains, a SIL study will be required on the Low level instrumented functions. | 1 | AP | YES | Per 18667-LIS-003_X Clarification No. 67: Breakthrough is not possible since tanks that are open to atmosphere provide a separation between the water line and the process equipment. |
| **3-13** | **S1** | TESTING | Requirement to test the level indicators and switches. | Access to tank internals may be required. | | Confirm access requirements to get into sump and tank for clean-out, and access to instruments for testing/calibration. | 1 | NK | N/A | NULL - this node has changed since the HAZOP. |

**HAZOP Minutes - Nodes** OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **3-14** | **S1** | OPERABILITY / MAINTAINABILITY | Connection of suck truck to load-out. | Truck will bring their own hose. | | Remove unnecessary hose from storage tank discharge. | 1 | SH | N/A | NULL - this node has changed since the HAZOP. |
| **3-15** | **S1** | ELECTRICAL | *No issues identified* | | | | | | | |
| **3-16** | **S1** | INSTRUMENTS | *No issues identified* | | | | | | | |
| **4-1** | **S1** | HIGH FLOW / LEVEL | All O2 and all H2 in vents are directed into just two vents. These are 5m apart, and also separated in height by ~1m. | H2 can ignite in the vent when doing deliberate venting (larger volume vented), which does not have significant consequences apart from making noise--receptors are only sensitive to noise at night, generally. A noise study is being completed. | | Include ignition noise in noise study. | 1 | BOS | YES | Noise study completed by Marshall Day Acoustics includes assessment of maximum noise level events (venting of hydrogen, oxygen, and pipeline blowdown). The predicted noise level for these maximum noise level events and the frequency of occurrence are such that no further mitigation action is required. See EIS Appendix I [P2G-2099-RP-EV-001]. |
| **4-2** | **S1** | LOW FLOW / LEVEL | Proximity of trees to O2 vent. | Potential for fire. | | Consequence modelling for oxygen vents to be conducted. Results to include offset requirements to nearby foliage. | 1 | SH | YES | Trees are well outside the oxygen vent hazardous zone. The trees are on the other side of the control hut. Refer layout P2G-2099-DW-PI-003. |
| **4-3** | **S1** | NO FLOW / EMPTY | *No issues identified* | | | | | | | |
| **4-4** | **S1** | REVERSE FLOW | *No issues identified* | | | | | | | |
| **4-5** | **S1** | HIGH PRESSURE | *No issues identified* | | | | | | | |
| **4-6** | **S1** | LOW PRESSURE | *No issues identified* | | | | | | | |
| **4-7** | **S1** | HIGH TEMPERATURE | *No issues identified* | | | | | | | |
| **4-8** | **S1** | LOW TEMPERATURE | *No issues identified* | | | | | | | |
| **4-9** | **S1** | IMPURITIES | *No issues identified* | | | | | | | |
| **4-10** | **S1** | CHANGE IN COMPOSITION | *No issues identified* | | | | | | | |
| **4-11** | **S1** | CHANGE IN CONCENTRATION | *No issues identified* | | | | | | | |
| **4-12** | **S1** | REACTIONS | *No issues identified* | | | | | | | |
| **4-13** | **S1** | TESTING | *No issues identified* | | | | | | | |
| **4-14** | **S1** | OPERABILITY / MAINTAINABILITY | *No issues identified* | | | | | | | |
| **4-15** | **S1** | ELECTRICAL | *No issues identified* | | | | | | | |
| **4-16** | **S1** | INSTRUMENTS | *No issues identified* | | | | | | | |
| **5-1** | **S1** | HIGH FLOW / LEVEL | Incorrect reading of natural gas flow at the pressure reduction station metering upstream. | Higher hydrogen flows, resulting in high concentrations of hydrogen in the pipeline stream (higher than the upper limit agreed with the technical regulator). | Specified maximum blend percentage is very low so that no expected impact on appliances.<br>Hydrogen disperses very well in natural gas. | Conduct a LOPA/SIL study to determine integrity requirements for flow metering to prevent over injection of H2 into the gas mains.<br><br>Remove both existing natural gas flow meters and calibrate to within 1% on Jemena meter calibration rig. Put on a | 1<br><br>3 | SH<br><br>MR | YES | Refer SIL study report, P2G-2099-RP-RM-001.<br><br>A tested and calibrated refurbished meter has been installed in the PRS on the duty run only prior to commissioning the injection panel. The second run meter has been tested and calibrated in the workshop ready for installation and in the PM workflow for installation |
| **5-2** | **S1** | HIGH FLOW / LEVEL | During PRS testing there is no gas flow. If there is no gas customer demand and a gas flow instrument error, hydrogen could continue to be injected. | Slug of hydrogen could accumulate in the secondary gas main. Potential for consumer burner flame-out. | Limited hydrogen inventory can be injected in the line due to physical constraints of design.<br><br>Hydrogen disperses well in natural gas.<br><br>Gas demand is usually high. | Add low natural gas flow shut-off of hydrogen injection, so that there is a minimum NG flow required to be injecting.<br><br>Prepare a LOPA for the potential consumer flame-out scenario, determine if any SIL rated instrumentation is required to prevent too much hydrogen injection. | 1 | SH | YES | Refer low-flow interlock on drawing P2G-2099-DW-PD-004 (grid reference A12).<br><br>Refer SIL study report, P2G-2099-RP-RM-001. |
| **5-3** | **S1** | LOW FLOW / LEVEL | *No consequences identified.* | | | | | | | |
| **5-4** | **S1** | NO FLOW / EMPTY | | | | | | | | |
| **5-5** | **S1** | REVERSE FLOW | *Already covered - ref. node 1* | | | Close FV-06003 on PALL-06015.<br><br>Increase low pressure set-point to 1,050 + 10%.<br><br>Add interlock so that XSV is opened before the FV. | 1 | SD | YES | Refer P&ID drawing P2G-0299-DW-PD-004 and C&E P2G-2099-RG-PS-001; PAL-02001 now interlocks FV-06003 (tags renumbered).<br><br>Refer P&ID P2g-2099-DW-PD-008, showing PAL set point of 1,150 kPag.<br><br>Refer Note 3 on P&ID P2G-2099-DW-PD-004 and C&E P2G-2099-RG-PS-001 |

**HAZOP Minutes - Nodes** OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **5-6** | **S1** | HIGH PRESSURE | Hydrogen pressure is up to 3,000 kPag operating pressure (and 3,800 kPag design). | Hydrogen supply can overpressure the natural gas line. | PAHH-06005 closes FV-06002, and PAHH-06006 closes XSV-06001. | Review overpressure control equipment, with consideration to integrity level achieved and Jemena's existing requirements for JGN. | 1 | SH | YES | Jemena standard requirements per GAS-999-DG-FA-001 (Section 2.1.6) requires two independent levels of over-pressure protection. PIT-06005 is part of a flow-control loop (so does not strictly count as over-pressure protection), and PIT-06006 and XSV-06001 together constitute an independent layer of protection. There is realistically no chance of overpressure because there is limited inventory upstream which is insignificant to the volume of the downstream system. The overpressure case was considered by the LOPA report within the SIL assessment (refer P2G-2099-RP-RM-001). |
| **5-7** | **S1** | HIGH PRESSURE | Slow leak across FV. | Over-pressure downstream tubing. | | Move pressure spec. break to downstream manual valve. | 1 | SH | YES | Refer P2G-2099-DW-PD-004; the spec. break is off the panel where there is a change of material. |
| **5-8** | **S1** | LOW PRESSURE | Low inventory | Low injection flow rate | Sizing basis for FV at low-inventory pressures. | | | | | |
| **5-9** | **S1** | HIGH TEMPERATURE | | | | | | | | |
| **5-10** | **S1** | LOW TEMPERATURE | | | | | | | | |
| **5-11** | **S1** | IMPURITIES | | | | | | | | |
| **5-12** | **S1** | CHANGE IN COMPOSITION | | | | | | | | |
| **5-13** | **S1** | CHANGE IN CONCENTRATION | | | | | | | | |
| **5-14** | **S1** | REACTIONS | | | | | | | | |
| **5-15** | **S1** | TESTING | | | | | | | | |
| **5-16** | **S1** | OPERABILITY / MAINTAINABILITY | preparation for maintenance | | | Add vent downstream of panel for double-block-and-bleed. | 1 | SH | YES | Refer P&ID drawing P2G-0299-DW-PD-004, showing double-block and bleed isolations, in addition to the hot-tap operation isolation, which is buried. |
| **5-17** | **S1** | ELECTRICAL | Corrosion | | | Add isolation joint to secondary main tie-in | 1 | NK | YES | Refer P&ID drawing P2G-0299-DW-PD-004, showing flange isolation kits on each secondary main tie-in. |
| **5-18** | **S1** | INSTRUMENTS | Use of instrument gas. | Complaints from neighbours due to odorant from continuous venting of control valves. | Low flowrate from instruments unlikely to reach neighbouring dwelling. | | | | | |
| **6-1** | **S1** | HIGH FLOW / LEVEL | Line rupture / leak. (Note Nodes 6 and 8 combined) | Loss of containment. Generator out of operation. | Quality and integrity management. | DRAFTING NOTE: Change PCVs to fail open. | 1 | SH | YES | Refer drawing P2G-0299-DW-PD-004. |
| **6-2** | **S1** | LOW FLOW / LEVEL | Pressure drop through second regulator may reduce discharge pressure below 700 kPag. (Sensor line currently between the two regulators) | Low flow conditions due to excessive pressure reduction across regulator arrangement. | Regulators to be designed for active-monitor arrangement to achieve 700 kPag min downstream. | DRAFTING NOTE: Active and Monitor labelled wrong way around. | 1 | SH | YES | Refer drawing P2G-0299-DW-PD-004. |
| **6-3** | **S1** | NO FLOW / EMPTY | Expected future operation to take line out of service but leave gassed up. | Dead legs. | Use of SS and PE. | | | | | |
| **6-4** | **S1** | REVERSE FLOW | Future tie-in of hydrogen. | Potential for hydrogen/NG mixing in line. | The generator will be fuelled by hydrogen or natural gas not blends. P&ID note added: Positive isolation will be provided in future case. The drawings will be updated with an MOC to show positive isolation of the gas line once hydrogen fuel is available. | | | | | |
| **6-5** | **S1** | HIGH PRESSURE | Regulator failure. | Overpressure of the inlet to the generator. | Active-monitor arrangement; regulators fail closed. Maximum pressure from upstream is 1,050 kPag (10% above transient is possible), and generator is actually rated for 1,000 kPag. The likelihood of exceeding full rating is low. | Check with manufacturer to test and re-rate/certify to 1050kPa | 1 | SH | YES | PIT-03006 downstream of active-monitor regulators has PAHH set at 1,000 kPag and will close XSV-03002. |
| **6-6** | **S1** | LOW PRESSURE | Reduced operating pressure in the secondary main. | Generator inlet pressure too low. | Generator will trip at low supply pressure. | | | | | |
| **6-7** | **S1** | HIGH TEMPERATURE | *No issues identified* | | | | | | | |
| **6-8** | **S1** | LOW TEMPERATURE | *No issues identified* | | | | | | | |
| **6-9** | **S1** | IMPURITIES | Nitrogen purging. | Nitrogen flow back into NG network. | Check valve at offtake. | | | | | |
| **6-10** | **S1** | CHANGE IN COMPOSITION | *No issues identified* | | | | | | | |
| **6-11** | **S1** | CHANGE IN CONCENTRATION | *No issues identified* | | | | | | | |
| **6-12** | **S1** | REACTIONS | *No issues identified* | | | | | | | |

**HAZOP Minutes - Nodes** OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **6-13** | **S1** | TESTING | *No issues identified* | | | Critical function testing of ESD valves will be required. Create PMs | 3 | AW | YES | Work instructions for maintenance of the site have been developed and confirmed ESD testing is included in the maintenance scopes |
| **6-14** | **S1** | OPERABILITY / MAINTAINABILITY | *No issues identified* | | | DRAFTING NOTE: Add bleed to secondary main offtake to form double-block-and-bleed, and upstream of turbine | 1 | SH | YES | Refer P&ID drawing P2G-0299-DW-PD-004, showing double-block and bleed isolations, in addition to the hot-tap operation isolation, which is buried. |
| **6-15** | **S1** | ELECTRICAL | *No issues identified* | | | | | | | |
| **6-16** | **S1** | INSTRUMENTS | Flow metering does not require temperature correction. | Opportunity to simplify. | Temp data is available from the outlet of PRS if correction is required. | Remove temperature element. | 1 | SH | YES | Not applicable after implementation of design change, refer design change request DCR-001. |
| **8-1** | **S2** | HIGH FLOW / LEVEL | Leak from downstream valve left open or fitting not tightened properly following maintenance. | Uncontrolled release of hydrogen leading to potential explosion. | Panel gas monitor QAH-03013 warning of hydrogen detection. | Jemena to ensure that operator training includes raising awareness of the risks associated with leaving valves open, or not closing them properly, on hydrogen systems.<br>Jemena also to ensure that Jemena procedures for leak testing of flanges be reviewed to ensure they are appropriate for hydrogen service, given the small molecule, and risk of leaks. | 3 | AW | YES | Closed, Training packages complete and delivered (except vendor specific packages) noting hazards and unique hydrogen properties to be managed. Work Instructions developed that include the purging of equipment, an operational risk review (covering special tools) to be conducted on the 19th of may to close out residual risks/concerns with hydrogen operations. No further action |
| **8-2** | **S2** | HIGH FLOW / LEVEL | Failure of PCV. | Damage to filter due to excessive flow/pressure drop.<br>Potential overpressure on some piping components. | Double PCV-03004/03012 (active/monitor).<br>PIT-03006 closes XSV-03002 on high high pressure, set at 1,000 kPag.<br>Line and equipment designed for flow to two consumers: microturbine and fuel cell (i.e., designed for flow that is higher than just flow to fuel cell). | Confirm failure action of PCVs, i.e., both open, both closed, or one open and one closed. (Review decision following potential changes due to close out of action 8-4.) If agreement is that both fail open, confirm filter pressure drop will not lead to damage, and downstream piping components can handle resultant pressure. | 1 | GPA | YES | PCVs are not designed to fail in a particular direction. Action following failure is unknown.<br><br>Filter design pressure 3,800 kPag. If PCVs fail open, downstream PIT-03006 will close XSV-03002 on high high pressure of 1,000 kPag. PIT-03006 has an overpressure limit of 4,000 kPag. |
| **8-3** | **S2** | LOW FLOW / LEVEL | Refer to previous note in Session 1 (Item 6-2). | | | | | | | |
| **8-4** | **S2** | LOW FLOW / LEVEL | Blocked filter F-03011 on gas panel.<br>Blocked filter in fuel cell package.<br>Blocked orifice in FE-0007.<br>PCV not operating properly.<br>Low instrument air pressure causing partial closure of XSV, restricting flow. | Permanent damage to fuel cell, potentially leading to fire (worse case) and hydrogen release. | Fuel cell has low pressure protection but no low flow protection.<br>Unlikely that filters will block after commissioning and the team does not want to add online DP monitoring.<br>Low instrument air pressure was not considered a major cause of restriction, as XSV will shut, albeit slowly. | Confirm PCV active/monitor order. Also consider one stage, two stage pressure cut and sensing lines. (Jemena used to seeing monitor upstream of active.)<br><br>Confirm lower flow rate limit of hydrogen to fuel cell. | 1<br><br>1 | GPA<br><br>DG | YES | Upstream PCV-03004 updated to monitor, set at 850 kPag. Downstream PCV-03012 updated to active, set at 800 kPag.<br><br>Ballard advise that the minimum flow of hydrogen for the fuel cell is approximately 0.04 g/s (0.144 kg/h) at the minimum current, 20A. Refer to email 18667-S12954. |
| **8-5** | **S2** | NO FLOW / EMPTY | Refer to previous note in Session 1 (Item 6-3). | Refer to previous note in Session 1 (Item 6-3). | For maintenance purposes panel will be taken out of service and lines depressurised. | When developing operating procedures, appropriate procedures for purging and re-commissioning to be included in operating procedures. | 2 | AW | YES | Closed, Training packages complete and delivered (except vendor specific packages) noting hazards and unique hydrogen properties to be managed. Work Instructions developed that include the purging of equipment. No further action |
| **8-6** | **S2** | REVERSE FLOW | In the event of stack failure in the fuel cell it is theoretically possible to have flow of air back to the turbine. | Flame out at turbine. | Requires multiple independent failures:<br>- Stack membrane failure<br>- Fuel cell low hydrogen pressure<br>- No flow of hydrogen from upstream.<br>Not deemed credible by the team.<br>Air would be under low pressure. | No action required. | | | | |
| **8-7** | **S2** | HIGH PRESSURE | Refer to previous note in Session 1 (Item 6-5). | Refer to previous note in Session 1 (Item 6-5). | Note addition of PIT-03006 with high pressure shutdown of XSV.<br>PCV may not fail close. | Due to addition of high pressure trip, no further action required. | | | | |
| **8-8** | **S2** | LOW PRESSURE | No new issues raised. | | | | | | | |
| **8-9** | **S2** | HIGH TEMPERATURE | No new issues raised. | | | | | | | |
| **8-10** | **S2** | LOW TEMPERATURE | No new issues raised. | | | | | | | |
| **8-11** | **S2** | IMPURITIES | Iron oxide dust from buffer store. | Contamination of stack within fuel cell. | F-03011 with 5 micron mesh.<br>Additional filter within fuel cell package. | Confirm maximum allowable load of impurities and requirement of filter (size and type). | 1 | DG | YES | Ballard advise that the particulate filter required for microturbine C65 is 10 micron and fuel cell MD30 is 40 micron filtration prior to the fuel inlet. Refer to email 18667-S12963. |

**HAZOP Minutes - Nodes** OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **8-12** | **S2** | IMPURITIES | Nitrogen left in the system following purging operations, or bleeding in through passing valve/fitting. | Reduction in purity of hydrogen to fuel cell. | Operating procedures. | Operating procedures to address activities and risks during start-up, shutdown, nitrogen purging, isolation, and venting. Procedures also to consider including integrity check of piping using local hydrogen detection (hand held devices would be required). | 3 | AW | YES | Closed, Training packages complete and delivered (except vendor specific packages) noting. Work Instructions developed that include the purging of equipment. |
| **8-13** | **S2** | CHANGE IN COMPOSITION | No new issues raised. | | | | | | | |
| **8-14** | **S2** | CHANGE IN CONCENTRATION | No new issues raised. | | | | | | | |
| **8-15** | **S2** | REACTIONS | No new issues raised. | | | | | | | |
| **8-16** | **S2** | TESTING | No new issues raised. | | NOTE: Microturbine is a Type B appliance with predetermined associated testing and procedures. Optimal will apply for Type B certification of fuel cell. | | | | | |
| **8-17** | **S2** | OPERABILITY / MAINTAINABILITY | Lack of signed electrical isolation points for safe isolation. | Electrocution and personnel injury/death. | None identified. | Add appropriate weatherproof signage at the required locations to warn of risk of electrocution and to identify appropriate isolation locations. | 2 | AW | YES | Closed, Main isolation from network and WSGG facility power systems energised and approved by network operator in accordance with national, local and network requirements, including relevant signage. Site signage reviewed and approved. No further action. |
| **8-18** | **S2** | ELECTRICAL | Electrical package information not available to GPA/Jemena. | Uncertainty in the design with potential for something to be missed. | Internal HAZOPs will be held by Optimal with invites to GPA and Jemena representatives. | No further action required. | | | | |
| **8-19** | **S2** | INSTRUMENTS | No remote pressure indication between PCV-03004 and 03012. | If the PCV arrangement and operation is changed, intermediate pressure monitoring may be required, else the protection system may not function properly, leading to overpressure events missed. | None identified. | When reviewing the arrangement of the PCVs (see action 8-4), review overpressure protection is adequate and instruments added/changed, if required. | 1 | GPA | YES | Intermediate pressure monitoring considered adequate with PI-03005. PIT not required given expected costs and short design life of the plant. Manual monitoring can be done via PI. If PCV-03004 fails (and is missed) and PCV-03012 then fails, downstream is PIT-03006 which will close XSV-03002 on high high pressure (1,000 kPag) |
| **9-1** | **S1** | HIGH FLOW / LEVEL | PSV-06012 remains open. | Continuous venting. This PSV is instrumentation type; due to continuous acting, they can release frequently. Neighbourhood complaints due to odorant. | Operator rounds | Maximise difference between PCV and PSV set-points to minimise potential for unintended PSV opening.<br><br>Identify re-seating pressure for PSV from manufacturer, search for PSV with lower re-seat pressure | 1 | SH | YES | Vendor has advised (see response to 18667-S6916) PCV set pressure of 580 kPag and PSV set pressure of 700 kPag – PSV set pressure is 20% greater than PCV set pressure which is considered acceptable. |
| **9-2** | **S1** | LOW FLOW / LEVEL | Blocked filter. | Low flow resulting in actuated valves closing. | Routine maintenance. Bypass around filter to continue IG services during change-out. | | | | | |
| **9-3** | **S1** | NO FLOW / EMPTY | Closure of upstream manual isolation valves (e.g. future case of not using the natural gas supply any more) | Instrument gas cut off, and hence fail closed of injection valves. | No consequence of loss of injection. | | | | | |
| **9-4** | **S1** | REVERSE FLOW | *No issues identified* | | | | | | | |
| **9-5** | **S1** | HIGH PRESSURE | PCV-06014 stops closing properly due to particulates accumulating in the seals. | Potential overpressure downstream. | PSV-06012 protects from over-pressure. Gas is sales gas. Filter installed upstream. | DRAFTING NOTE: Mark fail state of PCV<br><br>Confirm need for PSV, as IG components may be fully rated. | 1 | SH | YES | Actuator design pressure is 790 kPag for XSV-06001/XSV-06011 therefore PSV is required for overpressure protection. PSV set pressure of 700 kPag as per vendor advice (ref. email 18667-R5610). |
| **9-6** | **S1** | HIGH PRESSURE | Transient high pressure due to operational checks upstream. | | PSV-06012 protect from over-pressure. | | | | | |
| **9-7** | **S1** | LOW PRESSURE | Low supply pressure of network. | Lose IG supply, and valves fail closed. | No consequence of loss of injection. | | | | | |
| **9-8** | **S1** | HIGH TEMPERATURE | *No issues identified* | | | | | | | |
| **9-9** | **S1** | LOW TEMPERATURE | *No issues identified* | | | | | | | |
| **9-10** | **S1** | IMPURITIES | *No issues identified* | | | | | | | |
| **9-11** | **S1** | CHANGE IN COMPOSITION | *No issues identified* | | | | | | | |
| **9-12** | **S1** | CHANGE IN CONCENTRATION | *No issues identified* | | | | | | | |
| **9-13** | **S1** | REACTIONS | *No issues identified* | | | | | | | |
| **9-14** | **S1** | TESTING | *No issues identified* | | | | | | | |
| **9-15** | **S1** | OPERABILITY / MAINTAINABILITY | - | | | Change bypass and isolation needle valves for ball valve. | 1 | SH | YES | Refer drawing P2G-0299-DW-PD-004. |

**HAZOP Minutes - Nodes** OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **9-16** | **S1** | ELECTRICAL | *No issues identified* | | | | | | | |
| **9-17** | **S1** | INSTRUMENTS | Upstream connection has ball and needle. | Simplify. | | Change to just a ball valve. Change vents to ball valve w. ventable plug for all natural gas service lines. | 1 | SH | YES | Refer drawing P2G-0299-DW-PD-004. |
| **7-1** | **S1** | HIGH FLOW / LEVEL | | (note: micro turbine has not been run in the field off H2 before; control philosophy maybe to control to downstream exhaust temperature) | | DRAFTING NOTE: Change PCVs to fail open.<br><br>The control system of the micro-turbine may react differently when the fuel is changed from Natural Gas over to Hydrogen (different burn and product characteristics) therefore the vendor needs to confirm that a high flow scenario cannot occur, where the fuel control valve demands more fuel than the turbine requires . | 1 | SH | YES | Refer drg. P2G-2099-DW-PD-006. |
| **7-2** | **S1** | LOW FLOW / LEVEL | Blocked filter. | Low flow, restricted supply to generator and reduced output. | Unlikely due to cleanliness requirements of service. | DRAFTING NOTE: Change name of active and monitor. | 1 | SH | YES | Refer drg. P2G-2099-DW-PD-006. |
| **7-3** | **S1** | NO FLOW / EMPTY | *No issues identified* | | | | | | | |
| **7-4** | **S1** | REVERSE FLOW | Purge nitrogen migrates back to storage pipeline. | Off-specification H2. | | Start-up procedures to ensure purging pressure is below the hydrogen storage pressure. | 1 | AW | YES | Closed, Commissioning procedure developed to enable sequential commissioning without risk of contamination.<br>no further action required. |
| **7-5** | **S1** | REVERSE FLOW | - | | | DRAFTING NOTE: Remove check valve. | 1 | SH | YES | Action no longer relevant after design change, documented in design change request DCR-001. |
| **7-6** | **S1** | HIGH PRESSURE | Blocked discharge OR PCVs fail open. | Overpressure of the inlet to the generator. | Active monitor pressure regulation arrangement (PCV 03017, 03019) and PAHH-03006 controlling XSV-03001. | DRAFTING NOTE: Electrical signal should come off PAHH, not PI block.<br><br>Move design pressure change to downstream manual valve.<br><br>LOPA assessment required for pressure | 1 | SH | YES | Electrical signal take off updated.<br><br>Design pressure change moved to downstream manual valve.<br><br>LOPA assessment completed (SIF 3 in P2G-2099-RP-RM-001), SIL not required. |
| **7-7** | **S1** | LOW PRESSURE | *No issues identified* | | | | | | | |
| **7-8** | **S1** | HIGH TEMPERATURE | *No issues identified* | | | | | | | |
| **7-9** | **S1** | LOW TEMPERATURE | *No issues identified* | | | | | | | |
| **7-10** | **S1** | IMPURITIES | *No issues identified* | | | | | | | |
| **7-11** | **S1** | CHANGE IN COMPOSITION | *No issues identified* | | | | | | | |
| **7-12** | **S1** | CHANGE IN CONCENTRATION | *No issues identified* | | | | | | | |
| **7-13** | **S1** | REACTIONS | *No issues identified* | | | | | | | |
| **7-14** | **S1** | TESTING | *No issues identified* | | | | | | | |
| **7-15** | **S1** | OPERABILITY / MAINTAINABILITY | *No issues identified* | | | Provide connections and layout for future expansion adding second generator. | 1 | NK | YES | Generator supply line is isolatable. Tubing run to future generator can be implemented easily, no specific offtake is provided. Refer drg. P2G-2099-DW-PD-003. |
| **7-16** | **S1** | ELECTRICAL | *No issues identified* | | | | | | | |
| **7-17** | **S1** | INSTRUMENTS | *No issues identified* | | | DRAFTING NOTE: Remove thermowell reference, retain 'TE'. | 1 | SH | YES | Refer P2G-2099-DW-PD-006. |
| **10-1** | **S1** | HIGH FLOW / LEVEL | Supplied from electrolyser package. IA / IG. No longer required. | | | | | | | |
| **10-2** | **S1** | LOW FLOW / LEVEL | | | | | | | | |
| **10-3** | **S1** | NO FLOW / EMPTY | | | | | | | | |
| **10-4** | **S1** | REVERSE FLOW | | | | | | | | |
| **10-5** | **S1** | HIGH PRESSURE | | | | | | | | |
| **10-6** | **S1** | LOW PRESSURE | | | | | | | | |
| **10-7** | **S1** | HIGH TEMPERATURE | | | | | | | | |
| **10-8** | **S1** | LOW TEMPERATURE | | | | | | | | |
| **10-9** | **S1** | IMPURITIES | | | | | | | | |
| **10-10** | **S1** | CHANGE IN COMPOSITION | | | | | | | | |
| **10-11** | **S1** | CHANGE IN CONCENTRATION | | | | | | | | |
| **10-12** | **S1** | REACTIONS | | | | | | | | |
| **10-13** | **S1** | TESTING | | | | | | | | |
| **10-14** | **S1** | OPERABILITY / MAINTAINABILITY | | | | | | | | |
| **10-15** | **S1** | ELECTRICAL | | | | | | | | |
| **10-16** | **S1** | INSTRUMENTS | | | | | | | | |

**HAZOP Minutes - Nodes** OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **10-17** | **S2** | HIGH FLOW / LEVEL | Regulator failure. | Increased pressure in system. | PSV at accumulator set at 1000 kPag (within electrolyser package) - see action 10.21, however.<br>PSV-03015 at gas panel package set at 700 kPag. | No further action required. | | | | |
| **10-18** | **S2** | LOW FLOW / LEVEL | Regulator failure. | All valves will close on loss of instrument air pressure (fail closed valves).<br>No failures of equipment expected purely due to closed valves; however, could lead to uncontrolled shutdown of the facility with unexpected and unpredictable consequences. | Fail closed position of all valves considered the plant fail safe mode. | Add a low pressure alarm on instrument air system (either a new instrument, or reusing an existing instrument within ANT package) and discuss with Jemena the required response to this alarm. During assessment, review the interaction with the injection system, which has a separate instrument gas supply and may, therefore, remain on line while the rest of the facility shuts down. | 1 | GPA | YES | The pressure transmitter on the electrolyser instrument air system system PIS0210 shown on P&ID 195947A-IA-1 is available via a communications link and will be configured to raise an alarm on low instrument air pressure. There will be no further response to the alarm. The loss of instrument air will result in all XSVs actuated by instrument air to move to the fail safe position which is closed. Injection into the natural gas network will continue (if currently injecting at the time of losing instrument air), until the pipeline buffer store reaches its minimum pressure 1,150kPag at which the flow control valve on the injection panel will close. |
| **10-19** | **S2** | NO FLOW / EMPTY | As above for low flow. | | | | | | | |
| **10-20** | **S2** | REVERSE FLOW | Instrument air only supplies instruments and not the process. No downstream source of pressure and therefore no reverse flow possible. | | | | | | | |
| **10-21** | **S2** | HIGH PRESSURE | Failure of air compressor discharge overpressure protection. | If PSV on accumulator not sized for compressor discharge flow, high pressure can damage instruments downstream, particularly valve actuators. | None identified (although it is expected that the compressor will have a discharge PSV, but set pressure is unknown). | ANT to confirm overpressure protection provided (e.g., PSV on compressor discharge), as well as buffer tank PSV sizing basis. | 1 | ANT | YES | Safety valve set at 11 barg and designed for greater than maximum flow of the compressor. |
| **10-22** | **S2** | LOW PRESSURE | As above for low flow. | | | | | | | |
| **10-23** | **S2** | HIGH TEMPERATURE | Air compressor has after cooler and dryer. Failure of these. | High air temperature could damage some instruments | None identified. | Confirm maximum temperature of air from instrument air package within electrolyser and confirm over temperature protection provided. | 1 | ANT | YES | Compressor includes overtemperature protect. The outlet temp downstream the CDx dryer is maximum ambient temp +10°C. The design temp of the vessel is +100°C |
| **10-24** | **S2** | LOW TEMPERATURE | No issues identified. | | | | | | | |
| **10-25** | **S2** | IMPURITIES | Dryer failure. | Wet instrument air, potential failure of actuators. | F-0200 in electrolyser package. | Confirm what protection exists against moisture transfer to downstream system. | 1 | ANT | YES | Visual inspections of 2 downstream filters. Filters will prevent sudden failures. |
| **10-26** | **S2** | CHANGE IN COMPOSITION | No issues identified. | | | | | | | |
| **10-27** | **S2** | CHANGE IN CONCENTRATION | No issues identified. | | | | | | | |
| **10-28** | **S2** | REACTIONS | No issues identified. | | | | | | | |
| **10-29** | **S2** | TESTING | No issues identified. | | | | | | | |
| **10-30** | **S2** | OPERABILITY / MAINTAINABILITY | No issues identified. | | | | | | | |
| **10-31** | **S2** | ELECTRICAL | Loss of electrical supply. | IA buffer tank no longer topped up as compressor will stop. | Does not affect instrument signals which are on UPS.<br>Plant philosophy is to fail safe, which is the plant status if all valves close on loss of air supply. | No action required. | | | | |
| **10-32** | **S2** | INSTRUMENTS | Mechanical regulating valve on buffer tank outlet set up incorrectly (appears to be controlling upstream pressure - expect it should be downstream pressure). | Starve system of instrument air. | None identified. | Confirm set pressure of air regulator (within electrolyser package) and function (upstream or downstream pressure regulation). | 1 | ANT | YES | Regulator on compressor controls downstream pressure. Maximum pressure is 11 barg = PSV. Air system rated to >11 barg. Second regulator fitted after compressor. Secondary regulators fitted to low air pressure requirement valves. |
| **12-1** | **S2** | HIGH FLOW / LEVEL | Regulator failure. | Pressure build-up at turbine as it will only consume as much gas as is required for power output. | Trip on high pressure.<br>Double solenoid isolation at turbine. | Confirm rating of all piping/equipment components downstream of CNG supply appropriate for system maximum pressure. If not, ensure over pressure protection provided. | 1 | AW | YES | All components downstream of of CNG supply designed to SH3D specification. CNG bottle will be supplied with pressure regulation, indication and protection to protect piping between CNG supply and gas train. |

**HAZOP Minutes - Nodes** OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **12-2** | **S2** | LOW FLOW / LEVEL | Hose rupture/breakaway. | Loss of containment.<br>Potential for fire and equipment damage, personnel injury.<br>Flameout of turbine itself not a serious consequence. | None identified. | Confirm details of pressure regulation, overpressure protection and isolation on the truck.<br>These need to be upstream of the hose.<br>Confirm details relative to standard Jemena hook up arrangement.<br>Review need for additional overpressure protection and also breakaway protection. | 1 | AW | YES | CNG supply fitted with pressure regulation, pressure relief and indication |
| **12-3** | **S2** | LOW FLOW / LEVEL | Regulator failure. | Flameout of turbine, no serious consequence. | | No action required. | | | | |
| **12-4** | **S2** | NO FLOW / EMPTY | Gas supply depleted (empty cylinders). | Turbine will shut down on low pressure, no adverse consequences expected. | | No action required. | | | | |
| **12-5** | **S2** | REVERSE FLOW | Future connection of hydrogen will not be simultaneous with CNG connection, so no reverse flow possible from hydrogen supply. | Potential for flow of hydrogen into natural gas and onto turbine or natural gas into hydrogen and onto fuel cell - potential damage of fuel cell | | No action required.<br><br>Confirm vent sizing.. | | | | |
| **12-6** | **S2** | HIGH PRESSURE | Regulator failure. | Loss of containment with potential for fire. | None identified. | Update P&ID with details of pressure regulation, pressure indication, and overpressure protection.<br><br>Update micro turbine P&ID to show details including regulation, overpressure protection, etc. | 1<br><br>1 | GPA<br><br>CD | YES | Pressure regulation/relief will be supplied by Jemena on the CNG supply truck. Refer to "new scope kick-off" meeting minutes 18667-MOM-064-rA Item 5 and scope change request 18667-CR-026-rH Item 2.3.4.6.<br><br>P&ID 19002-DP-00002-r0 includes a pressure regulator set at 534 kPag and a slam shut valve set at 690 kPag (slam shut intake installed downstream of the pressure regulator). |
| **12-7** | **S2** | HIGH PRESSURE | Incorrect procedure/installation of gas cylinder pack connection to piping. | Loss of containment with potential for fire. | None identified. | Appropriate signage on line to indicate required pressure and service.<br>Consider special fitting for connection to ensure correct truck connection. | 1 | AW | YES | Type 50 gas connection for N2 supply to ensure nitrogen cylinder packs cannot be connected to the line. Tubing stickers included to indicate service. |
| **12-8** | **S2** | LOW PRESSURE | Regulator failure. | Flame out at turbine.<br>Refer to low flow (Item 12-3). | | No action required. | | | | |
| **12-9** | **S2** | HIGH TEMPERATURE | No issues identified. | | | | | | | |
| **12-10** | **S2** | LOW TEMPERATURE | Expansion of gas across regulator. | Minimum temperature requirement of 0 °C for micro turbine. Liquid in line, damage to turbine, loss of performance. | None identified. | Confirm minimum temperature of all components downstream of CNG supply.<br>Consider addition of liquid knock-out.<br>Check length of piping required for temperature recovery.<br>Add temperature indication upstream of connection to turbine.<br><br>Consider appropriate measures to ensure damage to the turbine is | 1<br><br>1 | GPA / JEMENA<br><br>CD | YES | • All components in the balance of plant piping downstream of the CNG supply point are within the SH3D pipe specification and therefore have a minimum design temperature of at least -29°C. Jemena confirmed in a teleconference with Optimal and GPA on 15/10/2020 that the supplied fuel gas will be controlled to meet the temperature limits of microturbine (0°C to 30°C). Fuel temperature will be controlled through either the use of an ambient vaporiser or water bath heater supplied by Jemena, located downstream of the regulation equipment on the supply truck.<br>• The action to consider the addition of liquid knockout is no longer required. Jemena have confirmed that the fuel gas temperature will be maintained within the microtrubine limits.<br>• An informal calculation has been done to determine the ambient recovery. It is noted that there is approximately 40meters of DN25 1.65mm WT tubing, which will assist in ambient temperature recovery above 0degC<br>• Temperature indication upstream of the microturbne is no longer required. Jemena have confirmed that the fuel gas temperature will be maintained within the microtrubine limits and it was agreed between Jemena and Optimal that temperature monitoring in the BOP was not required.<br><br>As above, Jemena confirmed in a teleconference with Optimal and GPA on 15/10/2020 that the supplied fuel gas will be controlled to meet the temperature limits of microturbine (0°C to 30°C). No changes to microturbine P&ID for low temperature protection. |

**HAZOP Minutes - Nodes** OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **12-11** | **S2** | IMPURITIES | Natural gas comes from known sources and will be free of impurities and of known composition.<br>Future plan to mix natural gas and hydrogen; current details unknown. | Turbine can accept maximum 17% hydrogen. Incorrect operation/ damage of the turbine if hydrogen concentration too high. | | No action required at this stage. Future activity and scope. | | | | |
| **12-12** | **S2** | CHANGE IN COMPOSITION | See above (Item 12-11). | | | | | | | |
| **12-13** | **S2** | CHANGE IN COMPOSITION | Accidental connection of nitrogen to CNG supply or vice versa. | Nitrogen to turbine causes flameout, which is not unsafe.<br>CNG to electrolyser package can result in package damage. | Colour coded labels for gas supply already specified.<br>Fittings for the different gas cylinders are not interchangeable so gas cannot be connected to the wrong supply. | No further action required. | | | | |
| **12-14** | **S2** | CHANGE IN CONCENTRATION | No issues identified. | | | | | | | |
| **12-15** | **S2** | REACTIONS | No issues identified. | | | | | | | |
| **12-16** | **S2** | TESTING | No earthing connection for truck at loading point. | Risk of explosion due to ignition of gas (in case of a leak) from static discharge. | None identified. | Show earthing connection to CNG truck on P&ID.<br>Confirm truck electrical connection equipment and procedure for connecting gas. | 1<br>1 | GPA<br>CD | YES | CNG truck earthing connection shown on P&ID.<br>Operating procedure and associated SWMS includes earthing for the CNG supply |
| **12-17** | **S2** | OPERABILITY / MAINTAINABILITY | Connection to CNG truck pressurised once supply is open. | Cannot remove the connection without causing gas release, and potential for injury. | None identified. | Add appropriate vent and second isolation valve at truck connection to allow coupling and uncoupling. | 1 | GPA | YES | CNG supplied with appropriate valving to allow pressure bleed on truck (refer CNG suppy P&ID A2-HP-5913_rev4) |
| **12-18** | **S2** | OPERABILITY / MAINTAINABILITY | Ground slopes towards loading point behind truck.<br>Truck handbrake not applied. | Truck rolls towards loading point causing damage to equipment and potentially loss of containment. | None identified. | Add bump stop unless site can be graded such that slope is removed. | 1 | GPA | YES | A bollard has been included in the design, positioned in front of the concrete footing that supports the nitrogen cylinder manifold pack and the natural gas tie in point. This bollard will protect the equipment from potential vehicle impact, in the event the trucks handbrake is left off and the nitrogen cylinder manifold pack and natural gas tie in point are in the “line of fire” of the moving vehicle. It is also noted that the slope in this area is 1:50 and the nominated space where the vehicle is to be parked is located within close proximity, and therefore any impact is likely to be at very low speeds. |
| **12-19** | **S2** | OPERABILITY / MAINTAINABILITY | Existing trucks and known operation in new facility with, potentially, special and different requirements. | Unfamiliarity leading to human error and unpredictable consequences/injury/facility damage. | None identified. | Review the impact of any actions in this HAZOP relative to existing Jemena procedures related to CNG trucks. | 1 | AW | YES | A dedicated operating procedure is available for the CNG supply. Modifications to the procedure will be made to accommodate use of CNG supply for commissioning |
| **12-20** | **S2** | ELECTRICAL | Note: Operation is not intended during a lightning storm. | | HAZOP of turbine package will be conducted. | No action required. | | | | |
| **12-21** | **S2** | INSTRUMENTS | No issues identified. | | | | | | | |
| **13-1** | **S2** | HIGH FLOW / LEVEL | Higher flow than expected, caused by transient changes/start-up/shutdown. | Higher pressure drop leading to lower suction pressure at the compressor. | None identified. | Confirm flow vs pressure differentials across piping and compare with compressor operating range. | 1 | AB | NO | Minimum compressor inlet pressure to be confirmed by Coregas. XV-03008 will shut on low outlet pressure from the buffer storage from PALL-03001B set at 1,150 kPag.<br><br>OPEN - FUTURE PACKAGE - DESIGN NOT FINALISED |
| **13-2** | **S2** | LOW FLOW / LEVEL | Blocked filter.<br>Blocked flow element.<br>Low instrument air pressure closing shutdown valve. | Refer to compressor HAZOP, no consequence. | | No further action required. | | | | |
| **13-3** | **S2** | NO FLOW / EMPTY | No issues identified. | | | | | | | |
| **13-4** | **S2** | REVERSE FLOW | Compressor failure. | Discharge side pressure is much higher than suction due to connection to cylinders, leading to high pressure hydrogen flowing back into buffer storage.<br>Failure of the piping upstream of the compressor, loss of containment leaing to potential for fire/explosion. | Check valve between compressor and cylinder filling.<br>Pressure detection on compressor suction which closes suction XSV. (Relief valve on compressor suction.) | Confirm chances of reverse flow within compression package.<br><br>Suction PSV set pressure and capacity to be confirmed to enable accepting PSV as safeguard. | 1 | WJ | NO | 21/08/2020 - Coregas response [18667-R9219] - The system has been designed to have automatic shut down (PLC driven) if the inlet or outlet PT goes out of the tolerance banding as outlined in the system spec. Then the pressure relief valve is there as the mechanical back up. The Pressure relief valves themselves are sized to accommodate (plus additional safety factor) the maximum potential flow from of the system therefore there is no risk of back flow.<br><br>OPEN - FUTURE PACKAGE - DESIGN NOT FINALISED |
| **13-5** | **S2** | HIGH PRESSURE | No issues identified. All components upstream of compressor rated for maximum upstream pressure. | | | | | | | |

**HAZOP Minutes - Nodes** OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **13-6** | **S2** | LOW PRESSURE | Compressor runs either when it should have stopped or is not meant to run. Draws down pressure in the buffer store. Risk of drawing gas from Secondary Main network back into the buffer store. | Contamination of hydrogen store; negative commercial impact with customer(s). | Layers of protection:<br>- Check valve on injection panel<br>- low pressure alarm on the buffer store at 1150 kPag. | Confirm low pressure cut off for compressor package. Should be set at 1150 kPag or above.<br><br>Confirm compressor minimum low pressure aligns with design and alarms. | 1 | WJ | NO | 21/08/2020 - Coregas response [18667-R9219] - With the current selected booster, due to the limitations on the H-Drive (compression ratio), the lowest inlet pressure we could accept is - 18 bar if we go to 330 bar and 27 bar if we go to 500 bar. Therefore the system will be set to these figures therefore there is no risk of low pressure suction below 1150kpa (11.5 bar)<br><br>OPEN - FUTURE PACKAGE - DESIGN NOT FINALISED |
| **13-7** | **S2** | HIGH TEMPERATURE | No issues identified. | | | | | | | |
| **13-8** | **S2** | LOW TEMPERATURE | No issues identified. | | | | | | | |
| **13-9** | **S2** | IMPURITIES | Iron oxide dust from buffer store. | No consequence to compressor however contamination of product gas. | Filters on both suction and discharge of compressor. | Add sample points upstream and downstream of compressor. Isolation with 1/4" NPT fitting (sample equipment to be provied by others when needed). | 1 | GPA | YES | Sample points added to the P&ID. |
| **13-10** | **S2** | IMPURITIES | Nitrogen left in the system after purging or bleeding in from passing valve or fitting. | No consequence to compressor; however, contamination of product gas. | Operating procedures. | No further action required. | | | | |
| **13-11** | **S2** | CHANGE IN COMPOSITION | No issues identified. | | | | | | | |
| **13-12** | **S2** | CHANGE IN CONCENTRATION | No issues identified. | | | | | | | |
| **13-13** | **S2** | REACTIONS | No issues identified. | | | | | | | |
| **13-14** | **S2** | TESTING | No issues identified. | | | | | | | |
| **13-15** | **S2** | OPERABILITY / MAINTAINABILITY | Filter maintenance requires line to be purged before putting back in service. | Air in line if not purged properly, leading to flammable mixture in compressor with potential for explosion. | Operating procedures. | Coordination procedure required for doing regular maintenance on items outside of compressor package. Procedure to amalgamate balance of plant and compressor requirements. | 3 | AW | YES | Purging procedures have been developed |
| **13-16** | **S2** | ELECTRICAL | Inadequate certification and proof of correct equipment supply. | Potential for ignition sources, failure to receive certification by Australian authorities, production impact on loss of power in the event of substandard fittings, cabling, power supply equipment. Inability to handle surges damaging sensitive equipment. | None identified. | HA certification rating to be IECex.<br>IEC compliance to be as per AS electrical standards compliance.<br><br>Loss of power to PLC impact to be confirmed.<br><br>Confirm the need for surge protection on new scope nodes. | 1<br><br>1<br><br>1 | WJ<br><br>AW<br><br>GPA | NO | 21/08/2020 - Coregas response [18667-R9219]<br>1) The electrical components are dual certified to ATEX and IECEx and will be compliant with IEC regulations, we have already specified equipment for installation in Australia<br>2) Loss of PLC power – the system has a UPS to allow for the safe shutdown and recording of data if power is lost on the PLC<br>3) Surge protection – The Main (MCCB) are all fitted with surge protection<br><br>OPEN - FUTURE PACKAGE - DESIGN NOT COMPLETE FOR THIS PROJECT |
| **13-17** | **S2** | INSTRUMENTS | No issues identified. | | | | | | | |
| **14-1** | **S2** | HIGH FLOW / LEVEL | Compressor is fixed speed and cannot produce more flow than design. | | | No action required. | | | | |
| **14-2** | **S2** | LOW FLOW / LEVEL | No issues identified. | | | | | | | |
| **14-3** | **S2** | NO FLOW / EMPTY | No issues identified. | | | | | | | |
| **14-4** | **S2** | REVERSE FLOW | Covered in Item 13-4. | | | | | | | |
| **14-5** | **S2** | HIGH PRESSURE | Failure of the compressor controls.<br><br>Maximum compressor outlet pressure of 689 barg.<br>Burst disc on tube trailer ruptures, leading to uncontrolled release of tube trailer contents, whcih can be a large volume. Potential for large fire/explosion. | Overpressure of downstream components and loss of containment leading to gas release and potential for fire. | Compressor discharge PSV protects against overpressure downstream.<br><br>Burst disc is weak point, but also offers protection against catastrophic overpressure failure. | Confirm pressure rating of compressor discharge piping to cylinder filling package. 300 barg min requirement.<br><br>Confirm compressor discharge PSV set pressure. Set to protect the lowest rated pressure in the downstream system.<br><br>Review control philosophy for outlet of compressor, i.e., number of transmitters and their locations, and shutdown result (i.e., what happens?). | 1<br><br>1<br><br>1 | GPA<br><br>WJ<br><br>WJ | NO | HOLD - Discharge piping design to 24MPa following clarification of pressure requirement<br><br>21/08/2020 - Coregas response [18667-R9219] -<br>- Pipework pressure rating – haskel will be using BUTECH pipework rated to 1380 bar<br>- Compressor Discharge PSV – this will be set to whatever is required based on the downstream equipment – this is normally around 550bar<br>- Control Philosophy – To be discussed in more detail once full scope of supply is understood. The 4 tier shut down Philosophy has already been supplied<br><br>OPEN - FUTURE PACKAGE - DESIGN NOT FINALISED |
| **14-6** | **S2** | LOW PRESSURE | Compressor malfunction. | No filling of cylinders. | | No action required. | | | | |

HAZOP Minutes - Nodes OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Session | Guideword | Cause | Consequence | Existing safeguard | Action required | Priority | Responsible | Complete Yes/No | Close-out Comments and References |
| 14-7 | S2 | HIGH TEMPERATURE | Failure of compressor discharge cooler. | Hot gas damages cylinders (seals, etc), leading to potential loss of containment.<br>Personnel safety (burns). | High temperature trip - details to be confirmed. | Confirm maximum discharge temperature from the compressor.<br><br>Appropriate signage to be added on compressor discharge piping to warn against hot surface temperatures. | 1<br><br>1 | WJ<br><br>AW | NO | 21/08/2020 - Coregas response [18667-R9219]<br>- Maximum discharge temp – this is no more than 180 degrees C (pre heat exchanger) after the heat exchanger the temperature will be back to ambient and there are PT's located before and after the heat exchanger on the gas line and also on the chiller coolant line which are linked to the PLC and will shut down if out of tolerance banding<br>- Signage – this is included as standard for hot and cold surfaces.<br><br>OPEN - FUTURE PACKAGE - DESIGN NOT COMPLETE FOR THIS PROJECT |
| 14-8 | S2 | LOW TEMPERATURE | No issues identified. | | | | | | | |
| 14-9 | S2 | IMPURITIES | Refer to Items 13-9 and 13-10. | | | | | | | |
| 14-10 | S2 | CHANGE IN COMPOSITION | No issues identified. | | | | | | | |
| 14-11 | S2 | CHANGE IN CONCENTRATION | No issues identified. | | | | | | | |
| 14-12 | S2 | REACTIONS | No issues identified. | | | | | | | |
| 14-13 | S2 | TESTING | No issues identified. | | | | | | | |
| 14-14 | S2 | OPERABILITY / MAINTAINABILITY | Inadequate isolation (incorrect type) under pressure instruments in high pressure systems. | Unnecessary depressurisation of piping to gain access to instruments.<br>No ability to do online maintenance. | None identified. | Provide appropriate isolation for service. | 1 | GPA | YES | Appropriate isolation added. |
| 14-15 | S2 | OPERABILITY / MAINTAINABILITY | Once hose connected to truck and pressurised, cannot remove without gas release under high pressure. | Loss of containment, personnel injury from fire/explosion or hose whip. | None identified. | Add 1/2" plug (isolation) valve on truck side of flexi hose. | 1 | GPA | YES | Coregas have provided a P&ID of a typical tube trailer which shows suitable isolation and vent valves to allow de-pressurisation of the flexible hose at the truck connection point. Refer email correspondence 18667-R10255 |
| 14-16 | S2 | OPERABILITY / MAINTAINABILITY | Operations for cylinder filling by third party outside high security fence. | Difficulty carrying out tasks without proper lighting if after hours, potential clashes or miscommunication between Jemena and third party operations leading to incidents. | None identified. | Confirm requirement for local lighting at cylinder filling area.<br>Confirm interaction between compressor package, cylinder filling package and balance of plant with respect to ESD shutdowns.<br>Appropriate signage needs to be confirmed and provided. | 1 | AW | NO | 18667-R9428 - No lighting will be provided in the turnaround area for the following reasons: 1- Filling would be restricted to day time, 2-Security cameras would be infra-red and not depend on lighting in this area, 3-If operators / emergency personnel needed to access this area at night, they can provide their own lighting (e.g. via vehicle lights) and 4-Cost associated with additional lights is limited by the project budget<br>OPEN - FUTURE PACKAGE - DESIGN NOT COMPLETE FOR THIS PROJECT |
| 14-17 | S2 | OPERABILITY / MAINTAINABILITY | Operations for cylinder filling by third party outside high security fence with inappropriate surface preparation for cylinder trucks/trailers. | Trucks have insufficient clearance to manouvre, impact with fences/lighting poles, tipping of trailers, all potentially leading to personnel injury and equipment damage. | None identified. | Concrete slab required for landing legs of trailers to prevent sinking into the ground and tipping trailer.<br>Consideration required for positioning of trailers relative to hose location and potential parallel operation (two fill locations). | 1 | GPA | YES | 31/08/2020 - MJL/AW - 18667-S11431 - The option to provide a concrete slab for trailer landing legs was considered in the design. This option has been rejected as the bitumen surface of the turnaround circle is expected to provide sufficient resistance to the sinking of landing legs for the short duration of the facilities mission life. It is also noted that the failure of the bitumen surface to provide sufficient resistance to the sinking of landing legs is not expected to occur suddenly, which would provide the opportunity for this issue to be rectified prior to tipping a trailer. The installation of a concrete slab in the turning circle area at this stage of the project is also cost prohibitive.<br>29/09/2021 - AW - Steel plates will be fitted in the turnaround circle area for this requirements.<br><br>Consideration was given by the design team for providing two fill points, so that trailers could be filled back-to-back (i.e. a full trailer could be picked up and an empty trailer could be dropped off during one trip to the site). This option has been rejected as the facility does not have capacity to fill back-to-back trailers, and because this requirement is not necessary to fulfil the core objectives of the project. Physical space has been provided in the turnaround circle to allow trucks and busses to pass each other. Therefore, a future project could upgrade the capacity of the facility and provide a second fill point on the inside of the turning circle should this be warranted. |
| 14-18 | S2 | ELECTRICAL | No issues identified. | | | | | | | |

**HAZOP Minutes - Nodes** OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **14-19** | **S2** | INSTRUMENTS | Operations for cylinder filling by third party outside high security fence and insufficient communications or information between packages/parties. | Miscommunication leading to incidents. | None identified. | Confirm comms philosophy between packages and how this relates to operation of the facility both by Jemena and clients. Requires preparation of a coordination procedure for third party operations, including inductions, safety requirements, operating procedures, etc. | 3 | AW | NO | OPEN, High level communication and operational intent agreed through Term Sheet, signed 28th April. Contract currently being drafted, to include operating principles agreed by both parties.<br><br>OPEN - FUTURE PACKAGE - DESIGN NOT COMPLETE FOR THIS PROJECT |
| **15-1** | **S2** | HIGH FLOW / LEVEL | Regulator failure | Potential component failure downstream of regulator leading to nitrogen release with potential to cause asphyxiation within the closed space of the electrolyser container. | Container is ventilated.<br>Personnel entering the container will have gas detectors.<br>Nitrogen PSV/PRV inside package. | Confirm with ANT what protections are provided against nitrogen line failure.<br><br>Jemena to ensure that gas detectors for operators include low oxygen warning. | 1<br><br>3 | ANT<br><br>AW | YES | Ventilation rate (600m³/hr) - nitrogen leak would need to be >50m³/h to bring the Oxygen content below 19% - this would be very Audible....(800l/min)<br><br>Closed, Work Permit requires use of gas detector which include low oxygen alarms, no further action required. |
| **15-2** | **S2** | LOW FLOW / LEVEL | All users inside electrolyser package open simultaneously, or component failure, or vent open, unexpectly leading to higher consumption of nitrogen than designed. | Early depletion of the nitrogen supply leading to inadequate purging leading to off spec hydrogen. (several other consequences may occur; only one example listed here). | Flow switches (x2) - FIZS0125 / 0126 | Confirm with ANT action resulting from flow switch activation. | 1 | ANT | YES | Insufficient flow for required period of time will fail inert gas purge and prevent start of the system. (Safety System). |
| **15-3** | **S2** | NO FLOW / EMPTY | Refer to Action 12-2 | Pressurised hose breakaway leading to whipping leading to injury (if a flexible hose is required to connect the nitrogen bottles to the balance of plant piping). | | See action 12-2 and confirm whether a hose will be used or not | 2 | AW | YES | Flexible hose is fitted with anti-whipping cable to prevent such a failure result. This is a standard requirement for flexible hoses. |
| **15-4** | **S2** | REVERSE FLOW | Relief of hydrogen from PSVs in hydrogen purification system at 38 barg causing reverse flow into the nitrogen supply system. | Hydrogen release at the nitrogen cylinders - most likely through PSV, but can alos be through open vents, or fittings if leaking. | NRV in nitrogen supply line within the electrolyser package.<br>Nitrogen supply line would have to be at very low pressure to cause reverse flow of hydrogen.<br>Open valve or failure at the cylinders would be required for a release. | Not deemed credible. No further action required. | | | | |
| **15-5** | **S2** | REVERSE FLOW | Hydrogen flow through the nitrogen network within the elecrolyser. | Hydrogen into lines that normally contain oxygen - potential for flammable mixtures that could result in fire | | Item covered within ANT HAZOP of electrolyser package.<br><br>No further action required | | | | |
| **15-6** | **S2** | HIGH PRESSURE | Nitrogen bottles supply pressure higher than expected and designed for. | Failure of downstream piping and fitting components and exceeding PSV capacity. | AS 2473.3 Type 50 connection type at cylinder cage preventing connection of higher pressure bottles. | Confirm details of nitrogen supply (bottle pressure and whether regulation and relief is going to be included on the bottles) and pipe specification.<br><br>Also refer action 12-7 | 1 | ML | YES | Nitrogen system design to SHX spec which is for 37,000kPag. Bottle supply pressure is 30,000kPag. Nitrogen instrument system design to regulate pressure down to supply pressure for electrolyser as per P&ID P2G-2099-DW-PD-007<br><br>ANT COMMENT: Refer to P&ID P2G-2099-DW-PD-007 for nitrogen supply design.<br>Nitrogen system pipework within the electrolyser is rated to pressures approx 100 barg and is fitted with safety releif valve at 35barg. Safety valve able to release approx 800m³/hr at set pressure. |
| **15-7** | **S2** | LOW PRESSURE | No issues identified | As per 15-2 | | | | | | |
| **15-8** | **S2** | HIGH TEMPERATURE | No issue identified | | | | | | | |
| **15-9** | **S2** | LOW TEMPERATURE | Expansion of gas across regulator. | Gas cools to low temperature; however, consequences inside package are unknown. Vendor has stated a minimum nitrogen temperature of -40 °C is required. | Ambient temperature recovery after regulator. | Calculate lowest temperature possible on cold day following gas expansion through regulator, and check against the required limit. If colder than limit, check heat recovery possible from ambient heating. | 1 | AB | YES | With ambient temperature of -6 °C and regulating pressure from 26,710 kPag (N2 cylinder supply is 30,000 kPag at 15 °C) to 1,000 kPag (PCV setpoint), resulting temperature is -48.8 °C. Regulator minimum design temperature is -51 °C.<br>Ambient air will heat nitrogen to -7.8 °C through approximately 55m of DN25 tubing to the electrolyser N2 inlet, which is greater than the -40 °C minimum required temperature |
| **15-10** | **S2** | IMPURITIES | No issues identified based on assumption that supplied gas will not contain impurities. Refer Safeguard and action. | Impurities could result in inadequate purging. | Assumption - nitrogen will be supplied by reputable suppliers.<br>Electrolyser vendor has stated nitrogen purity needs to be 99.996%. | Jemena to ensure nitrogen purity meets electrolyser specification of 99.996%. | 2 | AW | YES | Supplied nitrogen quality is confirmed to be 99.99% quality. Refer ANT comment below<br><br>NOTE from HYGE: Poor gas qulaity will only result in slower reaction time of the analyser panel at start up and slower time to required purity after start up. For purging purity requirement is 99.5%. |
| **15-11** | **S2** | CHANGE IN COMPOSITION | Refer action 12-13. | | Refer to action 12-7 relating to signage. | | | | | |
| **15-12** | **S2** | CHANGE IN CONCENTRATION | No new issues raised. | | | | | | | |

**HAZOP Minutes - Nodes** OPTIMAL

| | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **Guideword** | **Cause** | **Consequence** | **Existing safeguard** | **Action required** | **Priority** | **Responsible** | **Complete Yes/No** | **Close-out Comments and References** |
| **15-13** | **S2** | REACTIONS | No issues identified. | | | | | | | |
| **15-14** | **S2** | TESTING | Lack of appropriate purge/test point(s). | Inadequate purging due to lack of suitable purge/test point in/near the electrolyser package where the purged gas can be tested for oxygen | No safeguards identified. | Confirm whether purge/test points are required and at which locations. | 1 | DK | YES | Purge points located on nitrogen supply line at the high point adjacent to electrolyser tie in point |
| **15-15** | **S2** | OPERABILITY / MAINTAINABILITY | Only one purge valve currently in design at the upstream end. No other spare connections (utility points) for other potential uses along the line. | Limited ability to depressurise other lines and use nitrogen elsewhere on site. | No safeguards identified. | Add purge valves and nitrogen access points at suitable locations. | 1 | ML | YES | Nitrogen offtakes have been included on P&ID P2G-2099-DW-PI-007 Rev 1A. A nitrogen line is dedicated for the electrolyser and compressor package. Additional two offtakes are shown on P&IDs (007 & 005) – one near the R&D area and another near the electolyser. Cross lease hydrogen piping features several offtake points where nitrogen connections can be made. Generally these offtakes are located near equipment packages to avoid having hazardous areas on the cable runs. |
| **15-16** | **S2** | ELECTRICAL | No issues identified. | | | | | | | |
| **15-17** | **S2** | INSTRUMENTS | No issues identified. | | | | | | | |

ACTIONS:

GPA
JEMENA
ANT
BALLARD
COREGAS
OPTIMAL

| Client | Jemena | | | Document Title | Document Subtitle | Document No. |
|---|---|---|---|---|---|---|
| Client | P2G-2099 | GPA | 18667 | HAZOP Minutes | HAZID | P2G-2099-MM-HZ-001 |
| Project | Western Sydney Green Gas Project | | | | | |

**HAZID Minutes**

| Node | | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | Session | System / Plant | Guideword | Cause | Consequence | Existing Proposed Safeguards | New Proposed Safeguards | Priority | Responsible | Complete Yes/No | Comments / Notes |
| H-1 | S1 | Hydrogen Systems | CHEMICAL ENERGY | Corrosion - internal or external<br><br>Underground pipeline is carbon steel pipe, which is susceptible to hydrogen embrittlement. | Release of Hydrogen to atmosphere, ignition occurs instantaneously or delayed resulting in a jet or flash fire. Property damage and potential fatality/s | Buried pipe is designed with low design factor and relatively low-strength grade (X52) material to ensure low stress conditions protecting against rupture due to H2 embrittlement. This pipe is also coated and has cathodic protection.<br><br>Facility piping is stainless steel, which is less susceptible than carbon steel to H2 embrittlement, and is also operating under low stress conditions which will prevent a rupture.<br><br>As part of the quality management plan, defect testing of the piping and equipment will occur post manufacture.<br><br>Exhaust fans and H2 gas detectors initiating an ESD in Electrolyser building.<br><br>Ignition control: To be managed by Jemena's permit to work system, operator clothing will be antistatic and flame retardant. | HAZOP action O-4<br>Review requirements relating to hydrogen-assisted fatigue crack growth (HA-FCG), relating to defect inspection, weld defect tolerances, and monitoring etc. | 2 | AW | YES | Refer action O-4. |
| H-2 | S1 | Buried Steel | ELECTRICAL ENERGY | Stray currents | Compromised cathodic protection leading to corrosion - including of existing assets. | | Consider cross-bonding to existing buried assets. HAZOP action 1-25. | 1 | NK | YES | Refer action 1-25 |
| H-3 | S1 | Electrolyser | CHEMICAL ENERGY | Mol sieve material passing through into filters - on the electrolyser package. | Loss of performance | Maintenance procedures and operations monitoring. | | | | | |
| H-4 | S1 | SS Piping | CHEMICAL ENERGY | Dissimilar metals. | Galvanic corrosion. | | Include isolation joints in the design. | 1 | NK | YES | Refer drawing P2G-2099-DW-PD-004 and -008. |
| H-5 | S1 | Buried Steel | CHEMICAL ENERGY | CP Interference | - | | The potential for CP Interference will be mitigated in the CP design. CP design to address other buried structures CP interferences.<br><br>Submission of the new design to the Electrolysis committee may required for approval TBC. | 1 | ML | YES | Interference considered in CP design. Refer design drawings P2G-2099-DW-EL-055,015,053,054 and calculation 18667-CALC-007 |
| H-6 | S1 | Steel | HARM TO PLANT | Hydrogen effects on steel | Embrittlement and fatigue crack growth. | To be susceptible, a combination of three factors is required: presence of (and diffusion of) hydrogen, susceptible material, and stress.<br><br>The design of piping will be 'no rupture' to ensure that any potential fatigue cracks will not propagate due to the low stress conditions.<br><br>Material susceptibility is being managed by material selection (compatible with hydrogen), post manufacture defect testing such as hydrotest and radiography. | | | | | |
| H-7 | S1 | Buried Steel | CHEMICAL ENERGY | Soil corrosion - potential for acid sulphate soils. | Corrosion of piping. | Coating and CP of buried pipe. | Procedure for handling of piping and equipment during construction to be created to avoid soil contact.<br>Training of construction personnel is a requirement. | 2 | DK | YES | Construction SOW, P2G-2099-SW-CN-001 Section 4.4.1 includes requirement to keep pipe clean and undamaged. |

**HAZID Minutes**

| Node | | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **System / Plant** | **Guideword** | **Cause** | **Consequence** | **Existing Proposed Safeguards** | **New Proposed Safeguards** | **Priority** | **Responsible** | **Complete Yes/No** | **Comments / Notes** |
| **H-8** | **S1** | **Electrolyser** | ELECTRICAL ENERGY | Vents - sparking due to flaps/moving components and velocity. | Ignition of hydrogen when venting. | | Design of all vents to be non-sparking. | 1 | AP | YES | Needle valves are used for all hydrogen bleeds, to limit flow rate. Toroidal ring also used on main hydrogen vent which is earthed. Flow rate can be controlled on main vent also. Together these provide every practical mitigation of ignition potential. Refer Isometric P2G-2099-DW-ISO-015. |
| **H-9** | **S1** | **Pipeline** | ELECTRICAL ENERGY | Vents - sparking due to flaps/moving components and velocity. | | | Design of all vents to be non-sparking. Use a sock. | 1 | NK | YES | Vents will be earthed and fitted with vent 'socks' to prevent rain ingress. Refer Isometric P2G-2099-DW-ISO-015 for earth lugs and rain cap protection. |
| **H-10** | **S1** | **Electrolyser** | THERMAL ENERGY | Failure of electrolyser chilling systems- max temp 80°C. | Potential burns to personnel touching pipe. | Electrolyser package will trip on high discharge temperature. TTZ 1160 is a temperature switch set at 80°C, the gas sent to the vent stack will never exceed this temperature, not even during regeneration, this is because heat exchanger X-1156 is present. | | | | | |
| **H-11** | **S1** | **Electrolyser** | THERMAL ENERGY | No low temperature issues. Considered Joule-Thompson, and chiller system harm to personnel (it operates to min. 5°C) | | | | | | | |
| **H-12** | **S1** | **Generator** | THERMAL ENERGY | Hot components, and exhaust temperatures. Potential for hydrogen attack (on steel components). | Personnel injury, corrosion. | Controlled by design. Cladding will be installed to protect operators. Internal materials are designed to prevent hydrogen attack. Vent stack has air shrouded combustion. | | | | | |
| **H-13** | **S1** | **Whole site** | RADIANT ENERGY | Fire from adjacent facility, or bushfire. | Hydrogen facility potentially damaged if a neighbouring natural gas pipeline incident occurs, but it unlikely to cause an escalation that is beyond the existing risk.<br><br>There is bushland adjacent to the facility but only 2 trees on site. | In the event of a bush fire or incident at a neighbouring facility, the hydrogen plant will be remotely shutdown. | Response plans to be created/updated to include remote shutdown of hydrogen facility in the event of nearby fire. | 1 | AW | YES | Emergency response plan developed |
| **H-14** | **S1** | **Whole site** | ELECTRICAL ENERGY | Battery on generator, and two UPS'. | Stored energy release if battery fails. Potential for fire/explosion. | Jemena and battery vendor management procedures to be applied for battery management. | Preventative maintenance work orders to be created for inspection/testing. | 3 | AW | YES | Closed, work code has been set up for maintenance of battery as per vendor recommendations, no further action required. |

**HAZID Minutes**

| Node | | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Session** | **System / Plant** | **Guideword** | **Cause** | **Consequence** | **Existing Proposed Safeguards** | **New Proposed Safeguards** | **Priority** | **Responsible** | **Complete Yes/No** | **Comments / Notes** |
| **H-15** | **S1** | **Electrolyser** | ELECTRICAL ENERGY | Electrolyser current discharge. | Arc flash may occur resulting in personnel injury. Considered a low risk in this application. | Low risk. Reviewing design. Arc flash detection? Bus bars may be heavy. | ANT to minimise potential for arc flash in the electrical design. Determine if arc flash detection is required and include in the design.<br><br>GPA also to review design regarding arc flash requirements. | 1<br><br>1 | AP<br><br>JD | YES | ANT response (18/05/2020): Hydrogenics follow the design codes IEC 60204 and IEC 61439 and no requirement for arc flash detection is listed in these standards, hence it is not included in the package to be supplied. No system provided by Hydrogenics to date is equiped with any kind of arc flash detection. Refer ANT Clarifications Register 18667-LIS-003-rZ.<br><br>MCC specification includes arc flash detection. Refer P2G-2099-DS-EL-006. |
| **H-16** | **S1** | **Transformer** | ELECTRICAL ENERGY | Supplied pad-mount from the grid by electricity supplier. | | | | | | | |
| **H-17** | **S1** | **Whole site** | ELECTRICAL ENERGY | Ignition of releases. | Fire if loss of containment occurs. | A hazardous area study will be completed. The equipment will be hazardous area designed and rated as per report requirements.<br>The existing Jemena permit system will be reviewed for the new application and applied in operation.<br>Equipment will be procured with IECEx compliance suitable for hydrogen. - (International Electro technical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx System)) | Review and update if required existing Jemena permit system for application in hydrogen operation.<br><br>To further control ignition sources, determine whether non-sparking tooling is required for all maintenance work. Provide training and equipment per specifications. | 1 | AW | YES | Closed, Jemena has developed a Hydrogen Authority which requires operators to open a hot work permit prior to commencing work, only operators with the HA and Hot Works PTW may work on the plant. In addition to the Hot Work, Jemena is removing all potential sources of ignition that may otherwise be considered acceptable under a Hot Permit for Natural Gas applications, such as mobile phones, etc, within the hazardous area. Work on the system will only be carried out once purging with Nitrogen has been completed. no further action required. |
| **H-18** | **S1** | **Whole site** | ELECTRICAL ENERGY | Static risks - ignition source for explosive environment.<br><br>Numerous visitors expected to the site, including media. | Fire if loss of containment occurs. | Anti-static clothing a requirement for anyone entering the site.<br>Mobile phones and other devices that may be potential ignition sources to be managed by Jemena's reviewed permitting system. for this site.<br><br>No-go / exclusion zones to be marked out e.g. electrolyser building. | Induction process to be created for workers / visitors.<br>Hydrogen gas detectors a requirement for personnel. | 3 | AW | YES | Closed, a visitors site induction has been completed and is available on-line. 4 hydrogen specific personel gas detectors have been procured and are required to be used whilst operating the plant, no further action required. |
| **H-19** | **S1** | **Whole site** | ELECTRICAL ENERGY | Mowers, vehicles | Fire if loss of containment occurs. | Jemena's Permit to Work system. | Define exclusion zone around pipeline riser using bollards.<br><br>Define all exclusion zones and install a light barrier. | 1 | SH | YES | Exclusion zone is demarcated with chain-link bollards. Refer plot plan, drg. P2G-2099-DW-CV-001. |

**HAZID Minutes**

| Node | | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | Session | System / Plant | Guideword | Cause | Consequence | Existing Proposed Safeguards | New Proposed Safeguards | Priority | Responsible | Complete Yes/No | Comments / Notes |
| **H-20** | **S1** | **Whole site** | CHEMICAL ENERGY | Small leaks. | Loss of product, potential fire. May go undetected. | Hydrogen detectors are located in in the electrolyser building. Detection will trip the electrolyser (confirm).<br><br>Jemena personnel will be required to wear H2 detectors when entering the site, exclusion zones will be created for areas with a higher potential for leaks of venting.<br><br>HAZOP action 1-19<br>Balance of plant design to include use of hoods with gas detectors in locations with multiple fittings and valves. E.g.. gas panel, injection panel, pipeline end connections. | Create leak response procedure for hydrogen leak detection.<br><br>Add short-term isolation function, which shuts in system for 15 minutes and monitors pressure change during shut-in to detect leak. Include as routine test in operating procedures. | 3<br><br>1 | AW<br><br>SD | YES | Workscope created, procedure under draft sufficient to close this HAZOP action.<br><br>Functional Description P2G-2099-SP-JJ-001 reflects the requirement for the leak detection algorithm. |
| **H-21** | **S1** | **Whole site** | CHEMICAL ENERGY | Large leaks | Fire | Video cameras reporting to remote control room are a part of the design. Remote shut-down of the facility is available.<br>An ESD button will be available at the entrance gate. | Determine requirements for an infrared camera to be installed on site.<br><br>Provide Infrared cameras for personnel entering the site.<br><br>Leak detection to initiate a local beacon/siren. Make siren interlock with gate (so only alarms if someone is there). | 3<br><br>1 | AW<br><br>SD | YES | Closed, Infrared not specifically required (although nice to have) The new security upgrade will include multi-spectral cameras, which may be effective at identifying a hydrogen leak or flame, but will not be the main risk control. Jemena has consulted with leading industry experts and found that handheld IR is not used for hydrogen applications of this scale. no further action required.<br><br>No dedicated gate for this purpose is provided for the WSGGP compound, however door switches on the local EER are included. We propose to close this action by having the use (toggle) of an EER door enable the sirens for a period of 10 hours, enough for 1 day of site attendance then sirens will automatically be disabled. Beacons are always active. Re-opening a door re-arms the siremes for 10 hrs. Updated FD and C&E matrices are formally capture this philosophy. |
| **H-22** | **S1** | **Whole site** | KINETIC ENERGY | Impact from vehicle | Loss of containment. | Design will propose a layout to minimise vehicle traffic considering access requirements for maintenance/production etc. | Conduct further layout review to minimise potential for vehicle impact. Consider all access requirements. Install bollards where required. | 1 | NK | YES | Vehicle access was considered at each design review, resulting in bollard installation. Refer layout drawings. |
| **H-23** | **S1** | **Whole site** | NOISE ENERGY | Noise | Residential disturbances/complaints. | A noise study will be conducted in the design phase. | | | | | |
| **H-24** | **S1** | **Electrolyser** | GRAVITATIONAL ENERGY | Working on top of electrolyser package | Fall from height | Jemena working at heights procedures will be applied. | Consider moving maintainable components to the side.<br>Confirm roof railings are provided. | 1 | AP | YES | Elevated equipment (chiller unit) has been removed from the roof so that access is not required. |
| **H-25** | **S1** | **Whole site** | GRAVITATIONAL ENERGY | Soil settlement | Stress on fittings causing leaks. | Tubing flexibility, civil design to consider local conditions. | | | | | |
| **H-26** | **S1** | **Electrolyser** | NATURAL ENERGY | Hailstones | Damage to the cooling fans on the electrolyser roof. | | Hydrogenics to advise on requirements for protection from hail damage. | 1 | AP | YES | Most of the package is in a shipping container and is expected to be relatively durable. The interconnecting pipework and cooling fans could be impacted by heavy hail but consequences are expected to be minimal. Design is considered acceptable. |

**HAZID Minutes**

| Node | | | Problem Description | | | Safeguards and Controls | | Action | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | Session | System / Plant | Guideword | Cause | Consequence | Existing Proposed Safeguards | New Proposed Safeguards | Priority | Responsible | Complete Yes/No | Comments / Notes |
| **H-27** | **S1** | **Electrolyser** | NATURAL ENERGY | Lightning | Electrolyser damage. | | ANT/Hydrogenics to advise on required protection mechanisms against lightning damaging the electrolyser package. | 1 | AP | YES | Lightning risk assessment P2G-2099-RP-EL-003 completed and issued. 2 x lightning rods included in the design and earthed. The proposal to install lightning rods has been accepted by ANT on 19/06/2020 (refer email 18667-R10256) |
| **H-28** | **S1** | **Oxygen System** | CHEMICAL ENERGY | Oxygen loss of containment. | Oxygen enriched fire in the electrolyser building, from pipework or around vents | Continuous purging flow through the enclosure with exhaust fans. | Hydrogenics to provide input from package HAZOP on management of oxygen risks.<br><br>Is O2 building analyser included in the package?<br><br>Confirm SIL rating of exhaust fan failure detection as well as H2 and O2 detection in the building.<br><br>HAZOP action 3-12<br>Action for Hydrogenics to identify all feeds to drains. If gas breakthrough can occur in O2 or H2 scrubbers connected to drains, a SIL study will be required on the Low level instrumented functions. | 1 | AP | YES | Per 18667-LIS-003 Clarification No. 68: There is an oxygen analyser in hydrogen ATZ 1520 (SIL 1) to monitor the gas quality on P&ID ANA-1. The ventilation system is guarded by a differential pressure transmitter PDTZ 1311 (SIL 1 level) on P&ID GGS-1 |
| **H-29** | **S1** | **Whole site** | CONTROLS AND CONTROLLERS | Human error - maintenance activities. | Hydrogen and oxygen services are new to Jemena. Will require some additional training ad new practices. | HAZOP action 1-23<br>Develop competency based training module for the new facility.<br>Make competency based training a requirement for hydrogen service operators . Create register for management of accredited personnel. | Jemena to contact existing hydrogen/oxygen industries (industrial gases) to further understand specific risks and risk management.<br><br>Create procedure for management of spare parts specific for hydrogen and oxygen service.<br><br>Ensure field auditing of procedural activities occurs for the new facility. More intensively during initial operation. | 3 | AW | YES | Closed, Site visits and exchange with Coregas have taken place, with their feedback being incorporated into operational activities. Spare parts philosophy agreed. Jemenas asset risk and assurance team have instigated multiple audits (internally facilitated and external) which have been conducted with very positive feedback. no further action required.<br><br>Direct engagement with technical regulator including on-site during early phases. |
| **H-30** | **S1** | **Whole site** | THIRD PARTY HAZARDS | Malicious damage; theft etc. (this has happened before at this location) | Damage | Secure location, away from the roadside, on an existing industrial facility. Signposting will not draw unwanted attention to the facility.<br>Facility will be fenced and locked with authorised personnel entry only signage.<br>Jemena is carrying out an action to review designs from a site security perspective. | | | | | |
| **H-31** | **S1** | **Whole site** | CHEMICAL ENERGY | Air ingress during commissioning, start up after maintenance | Explosion within piping | HAZOP action 1-22<br>Strict use of nitrogen purging after maintenance to be enforced in hydrogen service, and included in all start-up/re-commissioning operating procedures.<br><br>HAZOP action 1-23<br>Develop competency based training module for the new facility.<br>Make competency based training a requirement for hydrogen service operators . Create register for management of accredited personnel. | | | | | |
| **H-32** | **S1** | **Whole site** | KINETIC ENERGY | Distortion of soft components in hydrogen service e.g. gaskets, Swagelok, treads, valve internals | Loss of containment. | Design and liaison with material vendors.<br>Leak detection | | | | | |