Jemena Limited

Western Sydney Green Hydrogen Hub (WSGHH) Project

Performance Report

Copyright statement

© Jemena Limited. All rights reserved. Copyright in the whole or every part of this document belongs to Jemena Limited, and cannot be used, transferred, copied or reproduced in whole or in part in any manner or form or in any media to any person other than with the prior written consent of Jemena.

Printed or downloaded copies of this document are deemed uncontrolled.

Table of Contents

1. Executive Summary

This report detailed the performance tests that were undertaken by Jemena for the Western Sydney Green Hydrogen Hub (WSGHH) in 2022, for the generation, storage, and injection of hydrogen gas into the natural gas network of the Western Sydney area. **Key performance tests were conducted** according to the Testing Program Plan developed for the facility that assessed the electrolyser package, the hydrogen injection panel, and the buffer storage pipeline at the WSGHH.

The proton exchange membrane (PEM) electrolyser package at the WSGHH was found to operate with an **average efficiency of approximately 60 %** when operating with a fixed output hydrogen pressure. A small variation of 3 % in the average efficiency as a function of the output load level was observed, with a **load level of 60 % generating the greatest overall efficiency** of 62 %. Additionally, the rapid ramping capability of the electrolyser was observed from incremental changes to the load to be **4.5 % per minute ramping up and 25 % per minute when ramping down.** The electrolyser was also observed to be capable of providing a very stable pressure increase into the on-site buffer storage, highlighting the strength of operating with a fixed output pressure.

The accuracy of the hydrogen injection system was tested by injecting a known amount of hydrogen at the WSGHH facility and collecting a sample of the downstream blend at four locations to determine how well the gases were mixed. The results of the test demonstrated that the downstream gas compositions contained had a **hydrogen blend that deviated from the amount injected at the facility by up to 9 %,** which was within the acceptable range of ±10 %. Additionally, to comply with Australian Standards, the Wobbe Index of the natural gas and hydrogen blend was measured and estimated for future blends of up to 10 %, which demonstrated that gas from the facility should remain well within the acceptable limits within the scope of the program.

Some critical issues that occurred during the testing program led to the **cessation of operations at the facility for a total of four months in 2022.** The main issue involved the **overheating of the diodes** used in the electrolyser package, which reached their rated operating temperature of 100 degrees Celsius and consequently faulted upon operation of the electrolyser above 70 % of its rated capacity for a period of greater than eight hours. The diodes were replaced, however, the long lead time for their procurement prevented the operation of the facility for two months. During this period, **several leaks were identified in the hydrogen buffer storage,** that lead to the decay of pressure over time. These were ultimately located and fixed, highlighting the need for laser-welds as opposed to Swagelok threaded connections when dealing with hydrogen gas. **The hydrogen and oxygen cross contamination sensors** in the output tanks of the electrolyser package were also found to be faulty, requiring monthly calibration or replacement. This issue, as well as the overheating of the diode, are still under investigation and may require alterations to the electrolyser package to continue operations in the future.

The Testing Program Plan developed for the WSGHH outlined more tests to be conducted at the facility than what was performed in 2022. These tests involve assessments to network ancillary equipment, end user appliances, electrolyser response tests, and development of regulations and standards regarding hydrogen blending with natural gas. Future tests at the WSGHH will also involve the operation and assessments of new technologies, including a hydrogen fuel cell and micro-turbine, as well as hydrogen cylinder filling for vehicle refuelling, which have been procured are planned to be commissioned at the WSGHH facility.

The ongoing completion of the Testing Program Plan has ultimately allowed Jemena to successfully achieve the objectives of the Western Sydney Green Hydrogen Hub demonstration project and will allow for the increased integration and understanding of hydrogen technologies with the natural gas network in NSW in the future.

2. Introduction

2.1 Purpose

The purpose of this document is to capture and analyse the technical operational data of the WSGHH facility that is obtained from the testing program set out in this report and to share the issues and lessons learnt with ARENA.

2.2 Objectives

Jemena's most fundamental aim is to determine whether hydrogen gas can serve as a viable long-term replacement for natural gas and as an interim means of reducing the carbon footprint of the network in NSW. The objective of the project is to demonstrate the integration of the Power-to-Gas (PtG), technology of water electrolysis to produce renewable hydrogen and to evaluate if the produced hydrogen can be safely and efficiently introduced into the Jemena gas distribution network without compromising its integrity, nor the integrity of its ancillary equipment and end users' appliances. The key activities required to be performed to meet the objective of the project include the following:

- Ensure a sound understanding and address technical, regulatory, environmental, social, and economic barriers to the PtG technology in an Australian context – including knowledge of operation, cost, deployment, utilisation, and scalability.
- Promote the awareness of large-scale renewable energy storage and distribution offered by gas pipeline infrastructure, thus providing additional opportunities for the installation of renewable energy generation.
- Enable gas pipelines to accommodate small-scale gas injection to support the uptake of PtG technology more broadly (as well as other forms of renewable/distributed gas production).
- Analysis of the possibility of blending hydrogen and natural gas with the aim of distributing it to residential, commercial and or industrial customers.

2.3 Western Sydney Green Hydrogen Hub

The uptake of renewable power generation, coupled with the growing demand for the decarbonisation of energy sectors in Australia presents a series of challenges and opportunities to the gas transmission and distribution network in NSW. Jemena, as the sole owner of the NSW distribution network, seeks to understand and develop technologies that allow for a transition to a low or zero carbon gas network, whilst delivering a competitive and sustainable consumer product. Jemena believes that multiple strategies will be required, one of which is known as Power-to-Gas (PtG), which involves the transfer of electrical to chemical energy in the form of gaseous products. An example of PtG is the production of hydrogen from renewable electricity and water via electrolysis, which produces no emissions when combusted. Renewable hydrogen can thereby be mixed with natural gas to help decarbonise the natural gas network in NSW.

Jemena, supported through co-funding from the Australian Renewable Energy Agency (ARENA), has successfully completed the design, construction, and commissioning of the Western Sydney Green Gas Hydrogen Hub (WSGHH), which is a Power-to-Gas & Gas-to-Power demonstration facility located at Horsley Park, Western Sydney.

The facility includes a 500 kW proton exchange membrane (PEM) electrolyser package to produce green hydrogen from renewable electricity, a DN500 buffer store pipeline with an approximate length of 335 metres (first of its kind in Australia), a hydrogen injection panel (to regulate/control and inject the amount of hydrogen to be blended directly into the gas network), a gas panel package (to regulate hydrogen to other users), power generation equipment (such as a micro-turbine/fuel cell to produce power using green hydrogen), and a hydrogen compression package (a future plan). Figure 1 shows a diagram of the WSGHH facility, including the plans for future developments.

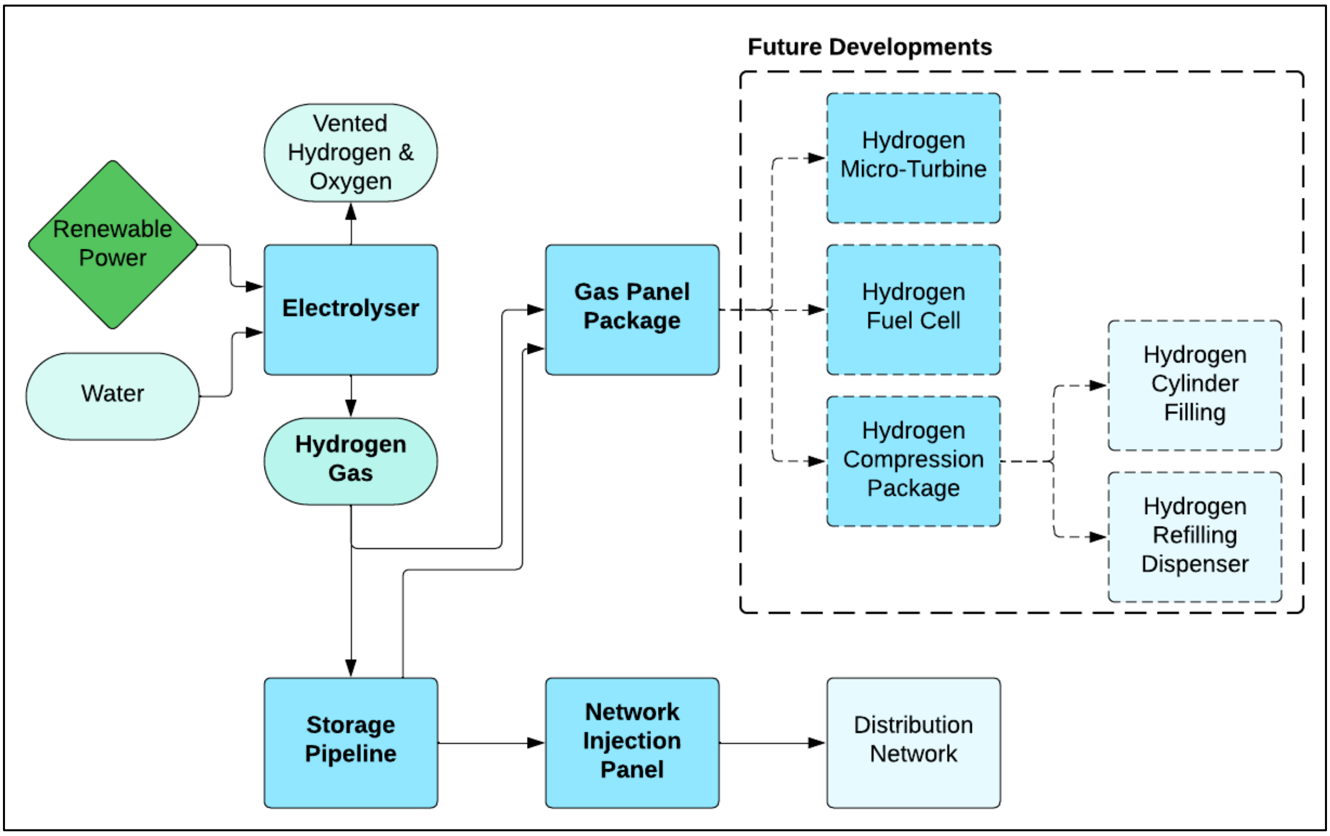

Figure 1: Block flow diagram of the WSGHH.

The facility has been in operation since November 2021 and is used to generate, store, and blend green hydrogen into the Jemena gas network in the Western Sydney area. Figure 2 shows an aerial view of the WSGHH facility, with the major plant components labelled. Several operational/blending tests have been completed with some results and issues discussed in this report.

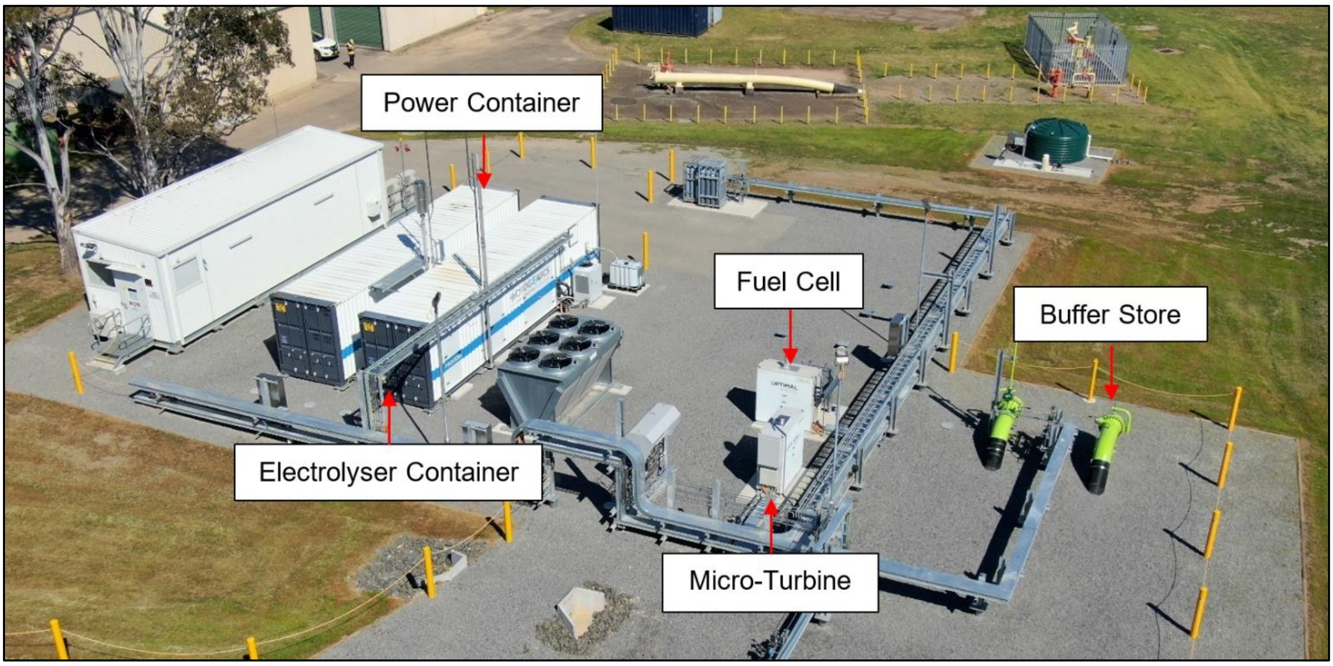

Figure 2: Aerial view of the WSGHH.

3. WSGHH Testing Program

The current focus of the WSGHH testing program is set on acquiring operational experience, understanding optimal design configuration, and improving maintenance and asset management expertise. In addition, in order to understand the accuracy of blending hydrogen with natural gas and study the impact of hydrogen on Jemena's existing natural gas network and its ancillaries, the following activities were set out as the main drivers of the testing program:

- Emergency response testing
- Hydrogen production and electrolyser performance testing
- Hydrogen injection panel performance testing
- Hydrogen purity testing
- Hydrogen leakage testing
- Material testing
- Safety and compliance testing
- Seasonal test activities (bound by test conditions, such as peak summer natural gas flowrates)
- Testing for regulatory and standards development
- Customer focused testing involving demand response testing
- Future Fuels Cooperative Research Centre (FFCRC) Projects
- Other academic testing and research, led by students
- Onsite demonstration activities

The diagram in Figure 3 summarises the Testing Program Plan developed for the WSGHH to understand the viability of operating the facility, blending hydrogen into the natural gas network accurately and investigating the impact on the gas network and its ancillaries.

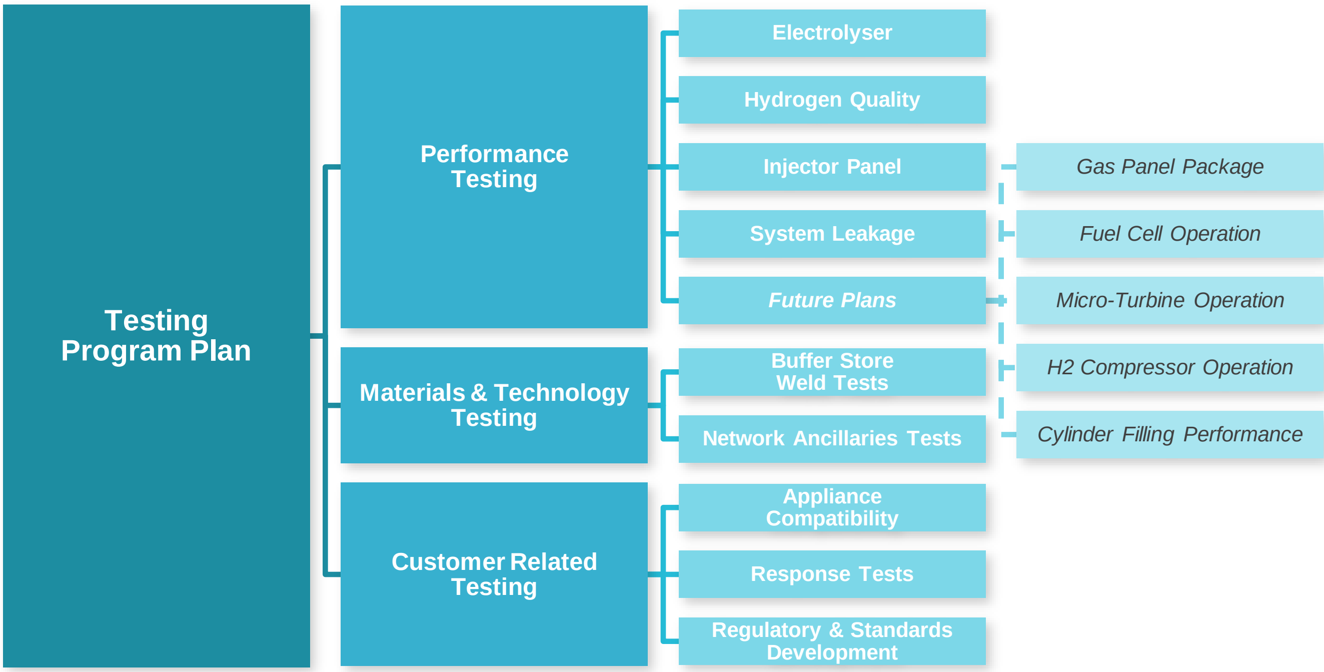

Figure 3: The WSGHH Testing Program Plan.

4. Testing Results and Analysis

Several performance tests were undertaken during 2022 to examine the operational capability of the WSGHH facility. The methodology of these tests was based on the testing program plan discussed in **Section 3** and aimed to establish a baseline performance of the plant. The tests investigated the plant's performance in terms of reliability, accuracy, energy efficiency, the response to fluctuating load conditions, and the properties of the hydrogen generated.

Each component of the plant was operated across its full operating range, and all performance data was recorded and compared to previous tests where applicable. Tests were conducted at least once a month, establishing a history of the baseline performance for all key equipment at the facility, which will be useful in future projects to model and analyse the changing integrity of such systems over time.

The following subsections detail the specific tests performed for each system component, including a sample of the results, analysis, and discussion.

4.1 Electrolyser Performance

The electrolyser package at the WSGHH is responsible for the production of all hydrogen at the facility and consists of a 500 kW electrolyser with a nameplate production rate of 9.7 kg/h of hydrogen, or 108 Nm^3/h and a water consumption of approximately 12 L/kg of hydrogen produced. The electrolyser package can be operated under various operational modes that include:

- pressure control mode, which maintains a constant output pressure of hydrogen gas;
- flow control mode, which maintains a constant output flowrate of hydrogen gas;
- power control mode, which maintains a constant input electricity consumption and;
- time schedule throughput mode.

The nameplate hydrogen production rate and electricity consumption were tested over a period of approximately five hours, whereby the electrolyser package was incrementally ramped up to its rated output. The test was conducted in pressure control mode with the maximum output hydrogen flowrate calibrated to 100 Nm^3/h (or 9 kg/h), and with both the input electricity consumption and output hydrogen flowrate metered. Figure 4 shows the results of the test and indicate that the electrolyser power consumption closely matches the output hydrogen flowrate while the load increases from 15 % to 100 %, which was expected. Additionally, the rapid ramping capabilities of the PEM electrolyser were also observed as the load was increased from 15 to 50 % in the first 20 minutes of the test, whereby the electrolyser was able to respond within minutes of the load change, at a rate of approximately 4.5 % per minute. This was further seen at each incremental increase in the load and moreover as the machine was powered down, where the most rapid change of the entire test was observed of approximately 25 % per minute. At the maximum load, the power consumption ranged between 505 to 513 kW.

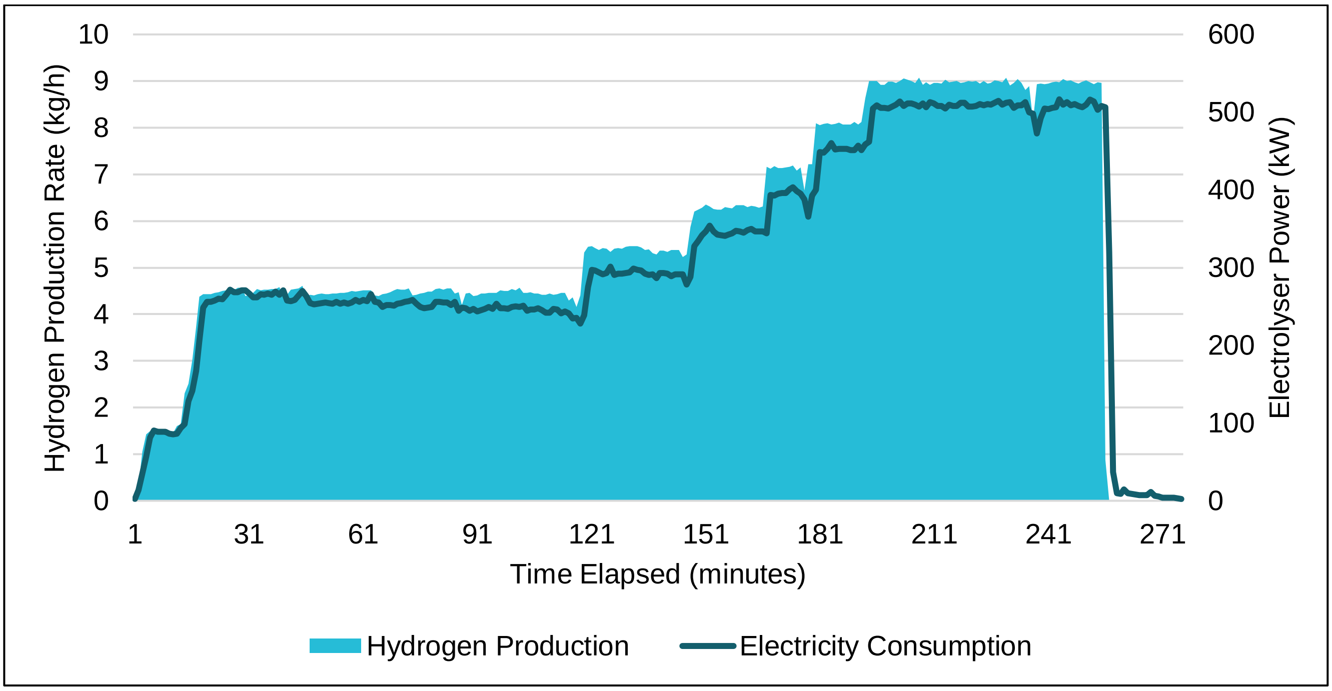

Figure 4: The electrolyser hydrogen production and electricity consumption recorded during the performance test.

Following this test, the average efficiency of the electrolyser was computed for the various load levels tested, with the results summarised in Table 1. From the values calculated, the efficiency during the test was observed to fluctuate around an average of 55.5 kWh/kg of hydrogen, or 60.2 %. It was also observed that the average efficiency of the electrolyser rose to a maximum of 54.2 kWh/kg or 61.6 % at a load level of 60 % (corresponding to 60 Nm^3/h or 5.4 kg/h of hydrogen production and 300 kW of power draw). This indicates that the electrolyser's performance is not proportional to the load level, however, the difference between the greatest and lowest average efficiency was only 2.8 %.

Table 1: The calculated average electrolyser efficiencies from the performance test for different load levels.

Load Level (%)	Time Period in Graph (minutes)	Average Efficiency (kWh/kg)	Average Efficiency (%)
15	1 - 17	56.7	59.8
50	18 - 120	56.6	59.0
60	**121 - 147**	**54.2**	**61.6**
70	148 - 167	54.4	61.4
80	168 - 180	54.8	60.9
90	181 - 194	55.4	60.2
100	195 - 255	56.7	58.8
Average		*55.5*	*60.2*

At the same time that the electrolyser performance test was conducted, the pressure level of the buffer store was also metered, to observe the stability of hydrogen entering the storage pipeline. Figure 5 shows the pressure level of the storage during the test and demonstrates a very stable rise in pressure over time, which is a consequence of the electrolyser package operating in pressure control mode.

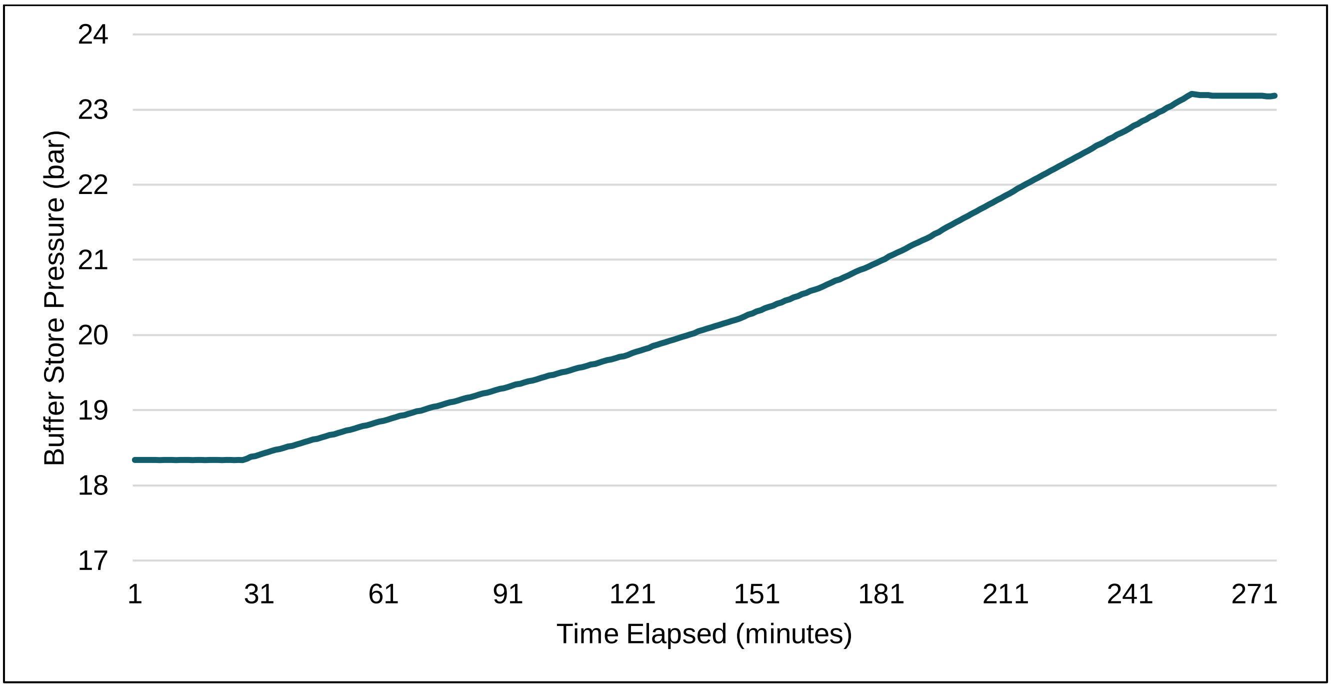

Figure 5: The storage pressure of the buffer store pipeline during the electrolyser performance test.

Further tests were conducted on the electrolyser, which involved operating the package for extended periods of time. As a result of such, the electrolyser encountered a critical issue related to the overheating of some diodes within the package when operating above a load of 70 % for eight hours or more. As a result of this issue, the diodes were replaced, however, the fault was observed to occur again, which is discussed in **Section 5.**

4.2 Hydrogen Injection Panel Performance

The hydrogen injection panel is used to regulate, control, and inject the correct amount of hydrogen to be blended directly into the gas network. The injection panel receives hydrogen from the buffer store and is designed to meter the supply to the secondary main, which contains a natural gas and hydrogen blend. The metering system consists of an actuated shut down valve, a filter, a Coriolis flow meter, a pressure regulator, and an actuated flow control valve with a smart positioner. The panel has several pressure gauges and transmitters to monitor temperature and pressure. Figure 6 shows a photograph of the network injection panel at the WSGHH.

Figure 6: Network Injection Panel

In order to test the performance and establish the accuracy of the injection system, as well as to assess the behaviour of the hydrogen and natural gas blend, a series of tests were undertaken. These tests aimed to demonstrate that hydrogen readily mixes with natural gas at the injection point and that the downstream blend contains a hydrogen percentage close to the amount that was injected. This involved injecting a known amount of hydrogen into the natural gas grid from the injection panel and collecting samples downstream to measure and validate the composition of the blend against the set point in a real-world setting. Hydrogen was injected into the grid at blend ratios ranging from 0 to 1 % in 0.2 % increments for a sufficient amount of time (more than four hours for each test) and samples of the blended gas were subsequently retrieved from two District Regulator Sets (DRSs) downstream. The DRSs supply natural gas to approximately 26,500 residential, 100 commercial and 7 industrial customers within the Western Sydney area and are located at:

- the intersection of Elizabeth Drive and Windsor Road at Cecil Hills (approximately 7.7 km from the injection panel), and;
- the intersection of Brabham Drive and Huntingwood Drive at Bungarribee Park (approximately 6 km from the injection panel).

The samples were analysed via a third-party laboratory analysis by Coregas, using a calibrated gas chromatograph. Table 2 summarises the tests conducted, including the network pressure at which each test was taken.

Table 2: The planned tests to measure blend ratios, including pressures at which gas sampling is to be taken.

Test No.	Blending Ratio (%)	Network Pressure: 1,050 kPa	Network Pressure: 210 kPa
1	0.2	×	×
2	**0.4**	✓	×
3	**0.6**	✓	×
4	0.8	×	×
5	**1.0**	✓	✓

✓ Sampling required | × Sampling not required

Tests 1 to 5 were attempted, with all sampling conducted successfully, except for two cases:

- For Test 1, the panel flow control valve was found to have a minimum operational blending ratio of greater than or equal to 0.4 %, meaning the test could not be conducted.
- Test 4 was not conducted as the results of Tests 2 and 3 were very accurate, and Test 5 was conducted for training purposes only.

Table 3 shows the results of the gas composition analysis for both DRS locations.

Table 3: Gas composition test results.

DRS Sample Location	Test 2 0.4 % H_2 blend		Test 3 0.6 % H_2 blend		Test 5 1.0 % H_2 blend			
	1,050 kPa Network Pressure		*1,050 kPa Network Pressure*		*210 kPa Network Pressure*		*1,050 kPa Network Pressure*	
	H_2 blend measured (%)	Deviation (%)	H_2 blend measured (%)	Deviation (%)	H_2 blend measured (%)	Deviation (%)	H_2 blend measured (%)	Deviation (%)
Intersection of Elizabeth Dr & Windsor Rd, Cecil Hills	-	-	0.574	-4.3	1.09	9.0	0.988	-1.2

DRS Sample Location	Test 2 0.4 % H_2 blend		Test 3 0.6 % H_2 blend		Test 5 1.0 % H_2 blend			
	1,050 kPa Network Pressure		*1,050 kPa Network Pressure*		*210 kPa Network Pressure*		*1,050 kPa Network Pressure*	
	H_2 blend measured (%)	Deviation (%)	H_2 blend measured (%)	Deviation (%)	H_2 blend measured (%)	Deviation (%)	H_2 blend measured (%)	Deviation (%)
Intersection of Brabham Dr & Huntingwood Dr, Bungarribee Park	0.411	2.8	0.612	2.0	0.952	-4.8	1.06	6.0

Overall, the deviation between the blend set point and the tested ratio of the samples ranged between -4.8 % to +9 %, which is within the acceptable range of 10 % from the known injected amount, with one source of error identified as the fluctuation in the pressure reduction station outflow rate of natural gas at the injection panel.

Additionally, to comply with the requirements set out in AS 4564:2020 (General-purpose natural gas), the Wobbe Index (WI) of the natural gas blend must be tested and be within the acceptable range. The WI is a measure of the combustion acceptability for given appliances of natural gas and is the most important parameter to consider in terms of gas combustion safety. The WI is a function of the higher heating value and relative density of a given gas mixture and must remain between 46.0 and 52.0 MJ/m^3 according to the standard.

The WI was calculated for a sample of natural gas taken from the WSGHH and compared with the WI of the maximum hydrogen blend limit at the facility of 2 %. Furthermore, as the facility is anticipated to contribute up to 10 % hydrogen blend rates in the future, the WI for this value was also estimated. This was achieved based on a study by GPA Engineering in partnership with FFCRC, which found that the WI can be expected to decrease by approximately 2 % with the blending of 10 % hydrogen with a typical natural gas stream. Table 4 summarises the results of these calculations, and ultimately shows a minimal impact on the gas quality, as is recommended in the AS 4564 standard.

Table 4: Wobbe Index calculation for the blended hydrogen and natural gas mixture.

Gas Sample	Wobbe Index (MJ/m^3)
Actual WSGHH Gas Sample	49.160
Maximum blend limit of the WSGHH of 2 %	48.178
Theoretical blend limit of WSGHH of 10 %	48.946

4.3 Storage Pipeline Performance

The pure hydrogen buffer store pipeline was designed to allow for hydrogen storage on site at the WHSS to be used for blending, power generation and or refuelling purposes. The pipeline has a length of 348 metres and is made of the same material used in Jemena's high pressure gas pipelines network (DN500 pipe, API 5L X52m, 9.2WT) to allow for the impact of hydrogen on the existing high pressure steel pipelines to be studied at the site. Figure 7 shows a photograph of the hydrogen buffer store at the WHSS facility.

Figure 7: WSGHH hydrogen storage pipeline (buffer store).

Despite the design of the pipeline being suitable for hydrogen service, a low design factor of 0.4 was applied, meaning the pipeline will operate at pressures that cause low pipe stress (12 to 37 bar), reducing the risk of hydrogen embrittlement. The performance of the buffer store was tested by monitoring for pressure reduction in the pipeline over a period of two months of ceased operation, which was made possible due to the facility undergoing a hazardous area classification assessment and a fault in the electrolyser, discussed in **Section 5.**

Figure 8 presents the buffer store pressure for the two-month period of April and May 2022, which demonstrated a slight pressure decay of approximately 40.5 kPa over the period. The cause of the pressure drop was initially linked to the impact of temperature fluctuation on the pipe, however, after careful analyses of the data, the most reasonable explanation was found to be a leak. Overall, the pressure drop over 60 days was 40.5 kPa.

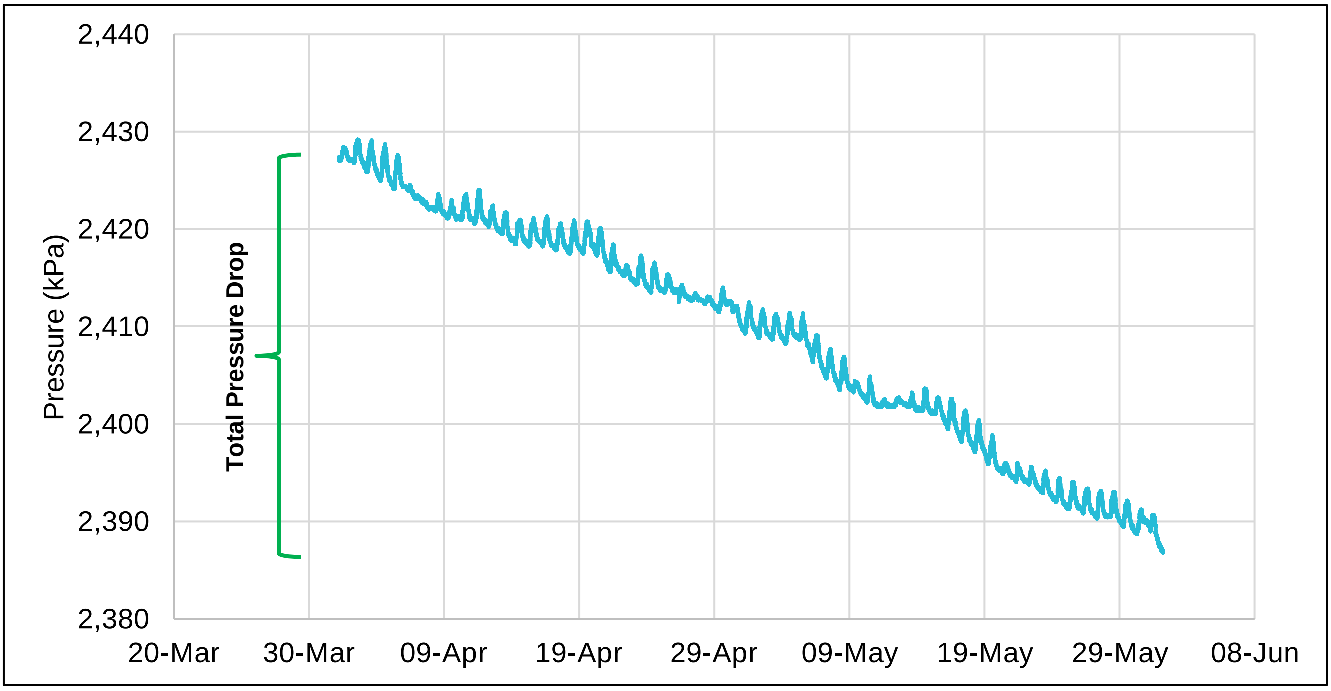

Figure 8: Total pressure drop recorded over two months.

As a result of the measured pressure drop in the buffer store, a leakage survey for all above ground connections was subsequently undertaken, which identified two minor leaks. Both leaks occurred at the Swagelok threaded connection at the buffer store inlet flange and the inlet shutdown valve, as shown in Figure 9. The outcome indicates that such connections should be avoided when dealing with pure hydrogen, with laser-welds recommended instead.

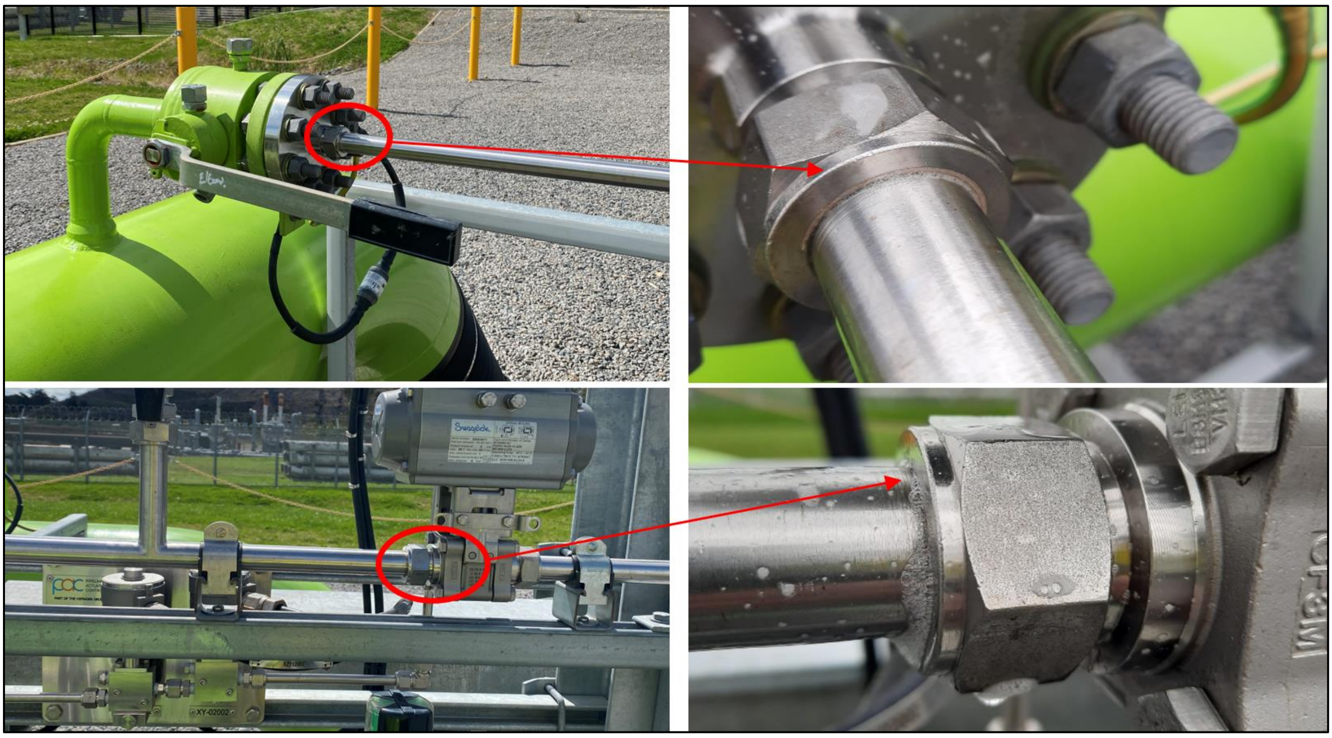

Figure 9: The leaks found in the buffer store.

4.4 Hydrogen Panel Package & Power Generation

The hydrogen panel package was not operational at the time of testing and will not be tested until the required regulatory approvals are obtained to operate the hydrogen fuel cell and the micro-turbine. Photographs of the gas panel, micro-turbine and hydrogen fuel cell are shown in **Appendix 7.**

5. Complications During Testing

During the operation of the WSGHH several issues were encountered that often resulted in the cessation of operation at the WSGHH. These issues were primarily the result of equipment faults and ultimately led to the facility being out of operation for four months in total in 2022.

The most impactful issue that arose from the tests conducted as part of this work was the overheating of the diode sets in the electrolyser package, which caused the electrolyser to lose power and consequently cease operation. The diode sets used in the electrolyser package (IRKE 1070 Series) are comprised of four individual diodes, with three sets required in total. The rated operating temperature of each diode is 100 degrees Celsius, which was reached by the electrolyser when operating at above 70 % of the rated power for more than eight continuous hours. Following the overheating of one diode set, the other two sets consequently faulted as well, as a result of the increased electrical current. The diode sets were ultimately replaced, however, this proved to impede the testing program significantly due to their long lead times. The thermal management issue is still being investigated and may require changes to the design to allow for extended electrolyser operation. Figure 10 shows a photograph of one set of diodes from the electrolyser package that had faulted.

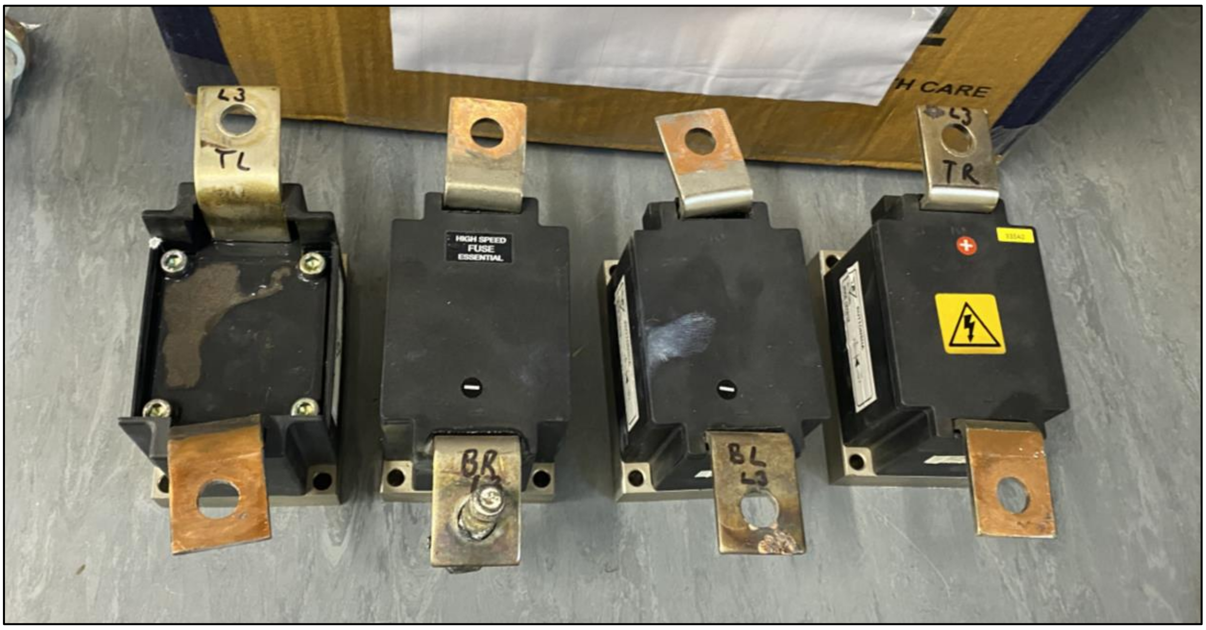

Figure 10: One set of diodes from the electrolyser package that faulted.

The other major issue that disrupted operation and testing was related to the oxygen and hydrogen sensors that measure traces of cross contamination in the output streams of both gases from the electrolyser. These sensors disconnect the electrolyser from the power supply once contamination exceeds 2 parts per million of either gas in the opposite stream and caused continuous shutdowns during the testing program. Following consultation with the sensors' manufacturer, it was found that the sensors require monthly calibration. The issue is still being investigated and may require the utilisation of sensors from a different manufacturer if the issue persists. Figure 11 shows a photograph of a faulty oxygen sensor from the system.

Figure 11: A faulty oxygen sensor from the system.

6. Conclusion

This report detailed the performance tests that were undertaken for the Western Sydney Green Hydrogen Hub in 2022, for the generation, storage, and injection of hydrogen gas into the natural gas network of the Western Sydney area. From the Testing Program Plan developed for the facility, key performance tests were performed, including assessments on the electrolyser package, the hydrogen injection panel, and the buffer storage pipeline.

The electrolyser was found to operate with an average efficiency of approximately 60 % when operating with a fixed output hydrogen pressure. Small variation of 3 % in the average efficiency as a function of the output load level was observed, with an output of 60 % of the nameplate capacity leading to the greatest overall efficiency of 62 %. Additionally, the rapid ramping capability of the electrolyser was observed from incremental changes to the load. Increases in the load revealed a ramp rate of 4.5 % per minute, and a complete shutdown demonstrated a ramp rate of 25 % per minute, which is important to allow for minute changes in blending requirements from the natural gas network. Furthermore, whilst operating in this mode, the electrolyser was observed to be capable of providing a very stable pressure increase into the on-site buffer storage, which highlighted the strength of operating the package in pressure control mode.

To assess the accuracy of the hydrogen injection system into the natural gas grid, four tests were performed that involved injecting a known amount of hydrogen at the facility and measuring the downstream blend at different locations. The results of the test demonstrated a deviation from the known injection amount between -4.8 and 9 %, which was within the acceptable range of ±10 %. Additionally, to comply with Australian Standards, the Wobbe Index of the natural gas and hydrogen blend was measured and estimated for future blends of up to 10 %, which demonstrated that gas from the facility should remain well within the acceptable limits within the scope of the program.

Some critical issues occurred during the testing program, which led to the cessation of operations for a total of four months in 2022. The main issue involved the overheating of the diodes used in the electrolyser package, which reached their rated operating temperature of 100 degrees Celsius and consequently faulted upon operation of the electrolyser above 70 % of its rated capacity for a period of greater than eight hours. The diodes were replaced, however, the long lead time for their procurement prevented the operation of the facility for two months. During this period, several leaks were identified in the hydrogen buffer storage, that lead to the decay of pressure over time. These were ultimately located and fixed, highlighting the need for laser-welds as opposed to Swagelok threaded connections when dealing with hydrogen gas. Finally, the hydrogen and oxygen cross contamination sensors used in the output tanks of the electrolyser package were also found to be faulty, requiring monthly calibration or replacement. This issue, as well as the overheating of the diodes, are still under investigation and may require alterations to the electrolyser package to continue operations in the future.

The Testing Program Plan developed for the WSGHH outlined more tests to be conducted at the facility than what was performed in 2022. These tests involve assessments to network ancillary equipment, end user appliances, electrolyser response tests, and development of regulations and standards regarding hydrogen blending with natural gas. Furthermore, future tests at the WSGHH will also involve the operation and assessments of new technologies, including a hydrogen fuel cell and micro-turbine, as well as hydrogen cylinder filling for vehicle refuelling, which have been procured are planned to be commissioned at the WSGHH facility.

The ongoing completion of the Testing Program Plan has ultimately allowed Jemena to successfully achieve the objectives of the WSGHH demonstration project, including understanding barriers to the PtG technology in Australia, promoting awareness for large-scale renewable energy storage and distribution via gas pipelines, accommodating small-scale hydrogen injection. The continued operation of the facility and execution of the Testing Program Plan will allow for the increased integration and understanding of hydrogen technologies with the natural gas network in NSW in the future.

7. Appendix

7.1 Additional Equipment

The Gas Panel receives hydrogen from the electrolyser and the buffer store through two separate 1” tubes. The panel is designed to control the distribution of the hydrogen to the hydrogen generator “micro-turbine”, fuel cell and connections for future compressor. Figure 12 shows a photograph of the gas panel package at the WSGHH.

Figure 12: The gas panel package at the WSGHH.

Figure 13 shows the hydrogen micro-turbine at the WSGHH.

Figure 13: The 65 kW hydrogen micro-turbine at the WSGHH.

Figure 14 shows the hydrogen fuel cell at the WSGHH.

Figure 14: The 35 kW hydrogen fuel cell at the WSGHH.