PUBLIC OPERATIONAL KNOWLEDGE SHARING REPORT

H2 BLENDING PROJECT

ATCO GAS AUSTRALIA

Jandakot Depot, 81 Prinsep Rd, Jandakot WA 6164

15/01/2024

Contents

Government of **Western Australia**
Department of **Jobs, Tourism, Science and Innovation**

ACKNOWLEDGEMENT OF FUNDING

The project (Project) received grant funding from the Western Australian Government's Renewable Hydrogen Fund, which is administered by the Department of Jobs, Tourism, Science and Innovation (the Department).

DISCLAIMER

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EXECUTIVE SUMMARY

In 2019, the Western Australia (WA) Government released its Renewable Hydrogen Strategy, delivering a roadmap to a low-carbon future through renewable hydrogen (H_2) for the state, with WA aiming to become a significant producer, exporter and user of renewable H_2. Within this strategy, the WA Government lists blending H_2 into the existing gas network as one of its key milestones, with 2022 the target date for distributing renewable H_2 in the gas network. By 2040, the aim is for WA's gas pipelines and network to contain at least a 10% renewable H_2 blend.

The H_2 Blending Project described in this report enables the delivery of up to 2% (v/v) blended natural gas to approximately 2850 residential and commercial gas consumers located in the estates of Glen Iris, Calleya and Treeby.

During the trial period, a total 41kg's of H_2 has been injected into the distributed gas network resulting in a reduction of 253kg's of CO_2 emissions.

Operational costs from Jan 2023 to 30th Oct 2023 is $296,730, compared to an estimate of $295,805.

For the purposes of the trial, the cost of H_2 production have been absorbed by ATCO due to the low quantities injected into the gas distribution network. Consequently, there are no cost impacts to gas consumers. This decision will be reconsidered in future trials involving higher blending percentages.

ATCO engaged with the community and stakeholders through in-person information sessions and discussions with the City of Cockburn, gas retailers and community groups; letter drops to all affected customers; and established a dedicated phone line to take enquiries and website with detailed information. The website received over 3000 individual hits, which indicated a high level of engagement from consumers. Only three phone calls were received indicating that the website was an effective means of disseminating useful information regarding the trial.

ATCO's experience in implementing the H_2 Blending Project demonstrated that early and ongoing engagement with key stakeholders including gas customers, the Regulator, the Gas Plant Safety Case nominated auditor, community groups and the like was crucial in ensuring that the project

was completed in a timely manner. Moreover, the use of proven design and equipment for the blending skid with support from an experienced technical consultant were also key factors in the success of the project.

OVERVIEW

ATCO, with support from the Government of Western Australia, is installing a H_2 Blending Gas Plant at the Jandakot Operations Centre. The Jandakot H_2 Blending Gas Plant (Gas Plant) is designed to blend up to 10 volume% (% v/v) H_2 into natural gas stream and distribute within a discrete Jandakot (Glen Iris estate) and Treeby (Treeby and Calleya estates) GDS local area sub-network (the H_2 Blending Project Sub-network) to down-stream connected consumer gas installation. Only Type A appliances are installed in the area.

The total duration of this project is 2 years including design, construction and the blending trail period.

The Gas Plant is designed to accommodate the maximum modelled gas flow rate of 730 Sm3/hr and blend 0 to 10% (v/v) H_2 into the natural gas stream. At the completion of this project, the Gas Plant will be capable of delivering up to 2% (v/v) blended natural gas to consumers.

Commissioning of the Gas Plant was completed by the end of November 2022, achieving a short term WA H_2 Renewable Strategy goal to have renewable H_2 distributed in a WA gas network by 2022.

The H_2 Blending Gas Plant project was delivered by ATCO on-time and under-budget, however ongoing operational costs have exceeded budget due to CPI.

1. MILESTONES TABLE

Milestone Number	Description of Milestone and Milestone Deliverables	Status
1.1	Feed & Detailed Design completed	Delivered previously
1.2	Major equipment procured	Delivered previously
1.3	Community engagement commenced	Delivered previously
1.4	Safety case works commenced	Delivered previously
1.5	Draft FEED Knowledge Sharing Reports	Delivered previously
2.1	Blending skid fabrication completed	Delivered previously
2.2	Gas network modifications completed	Delivered previously
2.3	Final FEED Knowledge Sharing Reports	Delivered previously
3.1	Construction complete, commissioning and blending commencement	Delivered previously
3.2	Community engagement completed	Delivered previously
3.3	Safety case works completed	Delivered previously
3.4	Draft Commissioning Knowledge Sharing Reports	Delivered previously
4	Final Commissioning Knowledge Sharing Reports	Delivered previously
5	Final Operation Knowledge Sharing Reports (note: draft operational knowledge sharing reports to be provided 4 weeks prior to this date)	Completed
6	Acquittal Report	Pending

2. MILESTONE 5

2.1 Public Operational Knowledge Sharing Report

2.1.1 Update information where there have been material changes from the FEED (Stage 1) and Commissioning (Stage 2) reports.

No changes to FEED or Commissioning Reports, however implemented 2nd Flowmeter and control systems as per planned design and schedule.

2.1.2 Forecast and actual OPEX with discussion of variances.

Forecast and Actual OPEX

Breakdown	Estimated Cost, $	Actual Cost, $
Estimated Operating Costs (project life)		
Estimated Total OPEX	**295,805**	
Actual Total OPEX		**296,730**
Estimated Total Project Cost	***2,627,765***	***2,636,627***

Refer to Appendix A for a detailed breakdown of the forecast and actual expenditures.

The cost variances observed is due to the lower volumes of H_2 delivered to the network. The original forecast was to be blending at 10% v/v throughout the trial period with a resultant 3456kg of H_2 delivered for the year. This was not able to be delivered. Due to concerns with the emissions safety of end user appliances, third party and independent verification was required to be completed and reviewed prior to safety case approvals to allow the 10% blending percentage. The timing of the final approved appliance testing report from FFCRC, review and interpretation of these reports to internal and external bodies such as DMIRS and finally the amendment of safety case documentation resulted in a blend percentage of 2% H_2 v/v being conducted year to date. The durations for the 2% v/v percentage blend were also restricted to ensure the accuracy of the metering units be achieved at this lower blend percentage. A high natural gas flow rate was required to ensure the accuracy of the H_2 flow meter. This resulted in 41kg of H_2 being blended with the Natural gas this year to date. It should be noted that approvals to increase the blend percentage to 10% are underway, with the expectation that by the end of 2023, that blend percentages of 10% H_2 v/v could be delivered.

2.1.3 Key maintenance and upgrade items and description of frequency and cost.

Costs for H_2 production shared with refuelling and power generating facilities. Maintenance elements on the Blending facility consist of the quality and verification elements, such as the Gas chromatograph, flow, pressure and temperature measuring equipment. Yearly inspection and calibration checks with the associated consumables are the key actions and costs.

Upgraded items included the installation of second Natural gas flowmeter to enable redundancy for flow data. This redundancy enables the automation of the operational controls to improve the efficiency in H_2 delivery whilst maintaining H_2 blend accuracy and the associated safety for end users.

2.1.4 Forecast and actual H_2 utilised on a weekly basis.

Forecast		Actual	
Total H_2 Produced (kg)	3,456.00	Total H_2 Produced (kg)	1,314

Chart of production 1314 kg total

Electrolyser data		Totalised value kg	Monthly total	total to date
Jan	3rd	662.00	150.00	150.00
Feb	28th	969.00	157.00	307.00
Mar	31st	1,133.00	164.00	471.00
Apr	30th	1,250.00	117.00	588.00
May	31st	1,382.00	132.00	720.00
Jun	30th	1,467.00	85.00	805.00
Jul	31st	1,639.00	172.00	977.00
Aug	31st	1,756.00	117.00	1,094.00
Sep	30th	1,790.00	34.00	1,128.00
Oct	31st	1,895.00	105.00	1,233.00
Nov	30th	1,976.00	81.00	1,314.00
Dec	14th	1,976.00	-	1,314.00

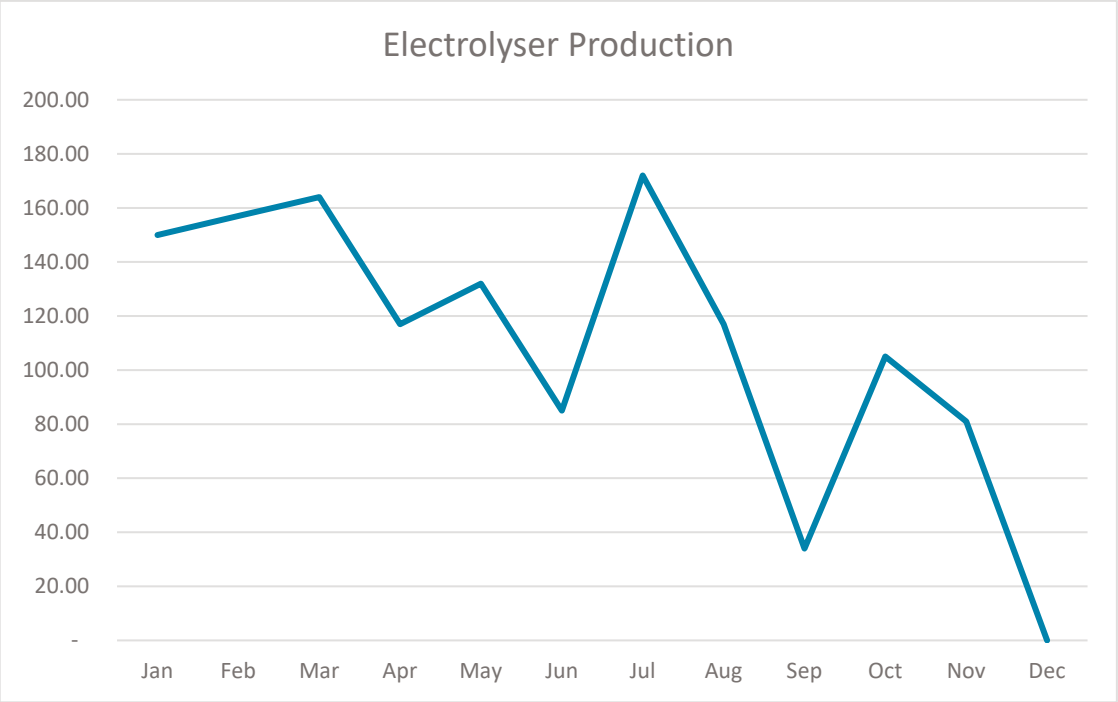
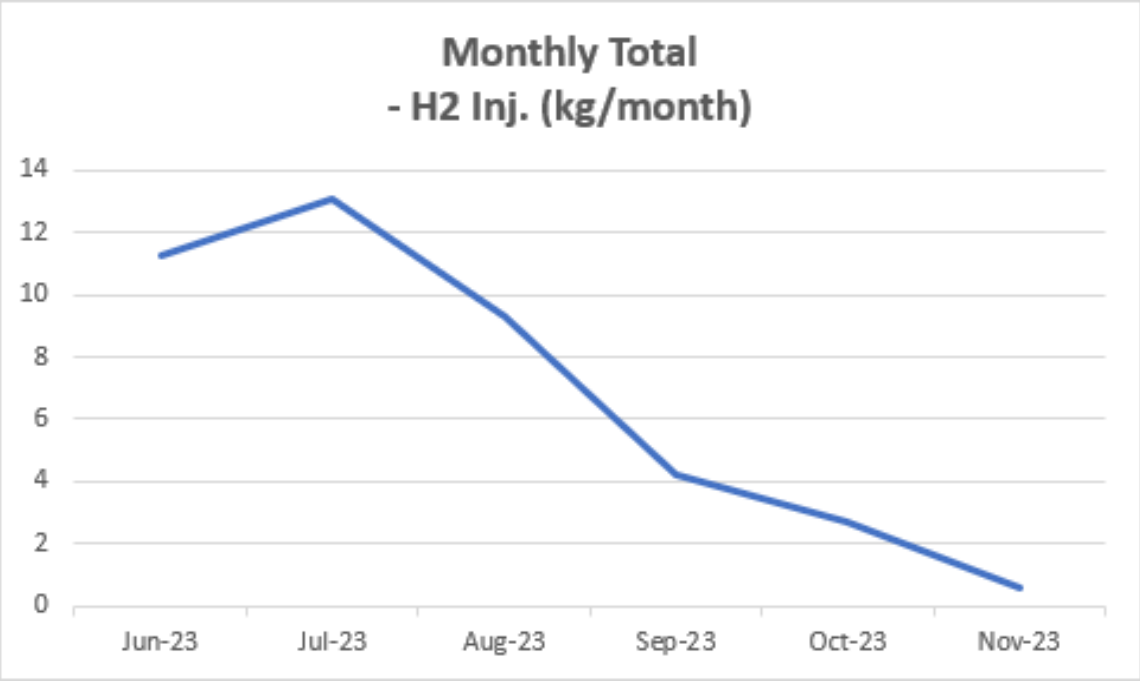


Chart of 41 kg H2 injected through blending skid

Month	Monthly total - H_2 Inj. (kg/month)
Jun-23	11.22
Jul-23	13.056
Aug-23	9.3075
Sep-23	4.233
Oct-23	2.686
Nov-23	0.6205



2.1.5 Forecast and actual levelized cost of H_2 per kilogram produced.

Forecast		Actual	
LCOH	$24.56	LCOH	$45.20

Annualised costs were the basis of the calculation, therefore monthly average will be consistent. The LCOH figures presented here are for this particular small scale blending project and is not intended to be reflective of commercial scale or other H_2 projects. The high LCOH is due to the low volumes of H_2 utilised during this stage of the trial.

2.1.6 H_2/Fuel quality specification and information.

H_2 quality for blending with Natural gas is not required to be "Five Nines" or 99.999% H_2. However as high purity H_2 is required for power generation, and this is required within the ATCO facility. Therefore, the same high-quality gas is utilised for the blending project. Quality reports from ACS are provided in Appendix C.

2.1.7 Forecast and actual six monthly electricity and water consumption.

Technical Specifications of Key Components and Equipment

	Forecast	Actual
Water consumption	147 ltrs/hr or 54.2 l/kg	92.3 l/hr or 34.08l/kg
Power consumption	275kWh	227kWh

2.1.8 Financial performance of the Project (including high level comparison of actual to budget forecast and new revenue opportunities).

Refer to section 2.1.2 for financial comparison. . Due to the regulated nature of ATCO Gas as a distribution utility, there are no plans to produce or retail H_2. There are no planned financial revenue opportunities.

2.1.9 Environmental impact, incidents, constraints and mitigation.

None from this project. H_2 release is only expected in abnormal operational situation (Over pressure). Gas Plant will be established within an existing area within ATCO's Jandakot depot known as the Clean Energy Innovation Hub (CEIH) where the existing electrolyser with balance of plant is installed.

As a consequence, there will be no additional impact on the environment.

2.1.10 Regulatory impacts, constraints and mitigations.

As part of the regulatory approvals necessary to enable blending of H_2 in to the GDS, ATCO submitted to Department of Mines, Industry Regulation and Safety (DMIRS), the Regulator, for approval the documents described in Section 2.1.8 above.

Key issues that had to be resolved with the Regulator to enable approvals to be obtained within the extremely tight project timeframe are described below.

1. "Light under" condition where with increasing percentage blend of H_2, there is a possibility that the flame burns under the cap of the kitchen stove-top burner and is not visible through the burner nozzles. This can result in excess carbon monoxide production leading to potential poisoning of household occupants.
2. This was mitigated by installing an orifice plate to limit the amount of H_2 that can be physically injected into the natural gas stream. Refer to Section 2.2.3 above for details of the implementation.
3. Approval of the ATCO Inspection Policy Statement and Plan Revision - Addendum to Revision 7 (AGA-R&R-PL11-FM01) to allow ATCO to undertake 5% inspection of new and additional Gasfitting Work within the H_2 blended natural gas sub-network for the phased H_2 blending up to a maximum of 2.8% by volume.In early discussions with the Regulator, there was an expectation for 100% inspection.

   This was mitigated through early and close engagement with DMIRS representatives to agree on the most appropriate approach to ensure public safety when blending H_2 into the GDS.
4. Safety Integrity Level 1 (SIL1) Safety Instrumented Function (SIF) on low

natural gas flow to mitigate the risk of over-blending of H_2 by volume. An outcome of the Layer of Protection Analysis (LOPA) workshop was to incorporate a flow meter capable of mass (or standard volumetric) flow, either natively, or with internal compensation from actual volume flow and compatibility with minimum target of SIL 1.

Due to timing constraints for commissioning with respect to design and procurement lead times, a low flow SIF-2 was not included in the project initially. Over-blending risk reduction is achieved by 100% operator attendance with manual stop on low flows, i.e.

< 250 Sm^3/hr. The Gas Plant is currently commissioned and operational.

A low flow SIF-2 is currently in procurement phase and will be added to remove the operator attendance constraint. Injection of H_2 into the natural gas stream will be automatically shut-off on detection of low flow.

Moreover, the Gas Plant Safety for the Blending project was the first to be developed and submitted to the Regulator for approval under Schedule 3 of the Gas Standards (Gas Supply and System Safety) Regulations 2000. ATCO engaged GPA Engineering to develop the Gas Plant Safety Case based on their recent experience with the HyP SA blending project.

In all of the above cases, the critical factor that facilitated timely regulatory approvals was early, regular and close engagement with the Regulator in a highly collaborative approach.

This was also the case in ATCO's engagement with the Independent Auditor for the Gas Plant Safety Case.

2.1.11 Safety impacts, incidents, constraints and mitigations.

No safety incidents with this project. Operating in accordance with Safety Case for facility.

2.1.12 Periodic fuel quality reporting method.

H_2 quality reports from ACS. Refer to Appendix A.

APPENDIX A. H_2 QUALITY REPORTS

ACS laboratories (AUSTRALIA)

ACS Laboratories (Australia)
ABN 85 [illegible]
37 Stubbs Street
Kensington, VIC 3031
P.O. Box [illegible], Kensington, VIC 3031
T [illegible]
E [illegible]
W [illegible]

Results of Analysis

Client Name: ATCO
Contact Name: Salvatore Gialusisi
Client Address: 81 Prinsep Road
Jandakot, WA 6164
Sample Container: Gas Cylinder
Sample Matrix: Pressurised Hydrogen

ACS Job Number: ACS2335991
Date Received: 23/08/2023
Date Reported: 23/08/2023
Purchase Order# na
Page: 1/1

Sample Number				ACS2335991-1	
Analyte	Method	Units	Reporting Limits	Results	Specifications
Hydrogen Fuel Index	ISO21087-1	mol%	0.01	<99.97	99.97%
Nitrogen	ISO21087-2	umol/mol	10	<10	300
Oxygen	ISO21087-2	umol/mol	1	<1	5
Moisture	ISO21087-3	umol/mol	1	<1	5

Sample of Hydrogen gas was taken on the 21th of August 2023 at ATCO, Jandakot, Perth.

Tha sample was analysed to the requirements of ISO 210897.

Note NR indicates test not required

Note: Samples are analysed as received.

Regards

Andrew Higgins
Senior Consultant

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Results of Analysis

Client Name: ATCO
Contact Name: Salvatore Glalusisi
Client Address: 81 Prinsep Road
Jandakot, WA 6164
Sample Container: Gas Cylinder
Sample Matrix: Pressurised Hydrogen

ACS Job Number: ACS2437291
Date Received: 3/01/2024
Date Reported: 5/01/2024
Purchase Order# 4700125079
Page: 1/1

Sample Number				ACS2437291-1	ACS2437291-2
Client Sample Reference				HRS HP1	HRS HP2
Analyte	Method	Units	Reporting Limits	Results	Results
Hydrogen Fuel Index	ISO21087-1	mol%	0.01	<99.97	<99.97
Nitrogen	ISO21087-2	umol/mol	10	<10	28
Oxygen	ISO21087-2	umol/mol	1	<1	3.3
Moisture	ISO21087-3	umol/mol	1	<1	<1

Sample Number				ACS2437291-3	ACS2437291-4
Client Sample Reference				HRS MP1	HRS MP2
Analyte	Method	Units	Reporting Limits	Results	Results
Hydrogen Fuel Index	ISO21087-1	mol%	0.01	<99.97	<99.97
Nitrogen	ISO21087-2	umol/mol	10	<10	<10
Oxygen	ISO21087-2	umol/mol	1	<1	<1
Moisture	ISO21087-3	umol/mol	1	<1	<1

Sample Number				
Analyte	Method	Units	Reporting Limits	Specifications
Hydrogen Fuel Index	ISO21087-1	mol%	0.01	99.97%
Nitrogen	ISO21087-2	umol/mol	10	300
Oxygen	ISO21087-2	umol/mol	1	5
Moisture	ISO21087-3	umol/mol	1	5

Sample of Hydrogen gas was taken at ATCO, Jandakot, Perth.

Tha sample was analysed to the requirements of ISO 210897.

Note NR indicates test not required

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Regards

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[illegible]

Results of Analysis

Client Name:	ATCO	ACS Job Number:	ACS2437306
Contact Name:	Salvatore Giaiusisi	Date Received:	4/01/2024
Client Address:	81 Prinsep Road	Date Reported:	6/01/2024
	Jandakot, WA 6164	Purchase Order#	NA
Sample Container:	Gas Cylinder	Page:	1/1
Sample Matrix:	Pressurised Hydrogen		

Sample Number				ACS2437306-1	
Client Sample Reference				Dispenser	
Analyte	Method	Units	Reporting Limits	Results	Specifications
Hydrogen Fuel Index	ISO21087-1	mol%	0.01	<99.97	99.97%
Nitrogen	ISO21087-2	umol/mol	10	12	300
Oxygen	ISO21087-2	umol/mol	1	<1	5
Moisture	ISO21087-3	umol/mol	1	<1	5

ACS Lab. No.	Description
ACS2437306-1	H2 Dispenser Purity Check test

Sample of Hydrogen gas was taken at ATCO, Jandakot, Perth.

Tha sample was analysed to the requirements of ISO 210897.

Note NR indicates test not required

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