Jemena Ltd: Malabar Biomethane Injection Project

LESSONS LEARNT REPORT [3]

Project Details

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EXECUTIVE SUMMARY

The Malabar Biomethane Injection Project (MBIP) delivered by Jemena and sponsored by ARENA, aims to receive excess biogas from the Sydney Water: Waste Water Recovery Facilities Anaerobic Digesters and upgrade it to an equivalent AS4645:2020 gas quality to be distributed to the Jemena Gas Network through NSW. As part of the project delivery the commitment to report on knowledge to be shared with ARENA and their recipients with key focus on outcomes related to:

- Demonstration of the technical viability and the pathway to commerciality of biomethane production for injection into the natural gas network.
- Development of a renewable gas market through a certification system
- Increased uptake of biomethane technology by the Australian waste (e.g., wastewater and anaerobic digestion) industry.

Throughout the Construction Phase of the project, several key learnings were identified:

1. Allowance for Biogas Supply Variations: Fluctuations in biogas quality and flow can impact operations. The addition of a biodome buffer improved operational stability, reduced shutdowns, and increased plant lifespan.
2. Efficiencies of Modular Fabrication: Pre-manufactured modules facilitated compliance with regulations, simplified installation, and allow for easier future upgrades, reducing facility downtime.
3. Management of Hydrogen Sulfide (H_2S) Risk: Strict risk controls were implemented due to the flammability and toxicity of H_2S. Segmenting plants and modelling dispersion rates are important considerations to minimize risks.
4. Recycle of Upgraded High Pressure gas during station trips: Overpressure scenarios caused by reverse flow during emergency shutdowns and station trips were identified late in the project. Future projects should consider applicable process safety for the release or segregation of migrating gas.
5. Improved Reliability of GC Sampling: Delays in gas composition analysis caused unnecessary recycling of gas. Relocating sample points reduced delays, improving efficiency and reducing off-spec gas export.
6. Supply of Renewable Electricity: Ensuring a reliable supply of renewable energy is crucial for maintaining green gas certification. Considerations include monitoring, validation, and alternative electricity production.

These lessons have important implications for future projects in the renewable gas sector, guiding decisions regarding equipment sizing, procurement, risk management, operational performance, and renewable energy supply that should be recognized in the early design of the project.

KEY LEARNINGS

<u>Lesson learnt No.1:</u> Allowance for Biogas supply variations/fluctuations
Category: Technical

Objective: Demonstration of the technical viability and the pathway to commerciality of biomethane production for injection into the natural gas network

Detail: The supply of biogas from the wastewater anaerobic digestor (AD) has fluctuations in quality and flow. After the initial design of the plant it was evident that a Biodome (large low pressure buffer) was required to allow for smooth operations of blowers and compressors. The biodome operates at 4kpa and hold approximately 1 hr run time of Biogas supply for the upgrader.
The biodome serves two functions: a buffer to steady operations and as a mixing chamber for biogas. The addition of a biodome will increase the life of plant as it will reduce the ramp rates and number of shut down and start-ups per year.

Implications for future projects:

- Future projects should consider the sizing of biodome/buffer to allow for steady state operations of upgrading equipment. Riding out Waste water anaerobic digestor variations in quality and flow rate
- Weigh capex cost of dome to operations.
- Have upgrader supply analyser on the outlet of the biodome to allow for well mixed biogas supply and hence more uptime and small periods of off spec gas will blend into the dome.

<u>Lesson learnt No.2:</u> Efficiencies of Modular fabrication and Onsite alignment.
Category: Technical

Objective: Demonstration of the technical viability and the pathway to commerciality of biomethane production for injection into the natural gas network

Detail: Eneraque fabricated Upgrader Container, Filtration and Cooling modules in their Brisbane, QLD workshop. This allowed for to manage the Australian compliance compared to a module imported from Europe that may have to be retrofitted to variances in European and Australian regulations. Modular units also allow for effective installation onsite and are capable of simpler overhauls throughout the facility lifecycle allowing for exchanging of units to reduce facility downtime. The installation onsite was convenient for mounting on pads and alignment of piping spools, mitigating unnecessary field welds and reducing the amount of onsite testing. With expected time savings of 4-6 weeks.

Implications for future projects:

- Pre manufacture skids and modules to reduce delay risk when mobilised to site.
- Look to reduce number of modules and increase size to minimise alignment requirements on site.
- Developing and carrying out an effective QA/QC strategy for factory inspections and testing.

<u>Lesson learnt No.3:</u> Hydrogen Sulfide (H_2S) partial pressure and risk.
Category: Technical

Objective: Demonstration of the technical viability and the pathway to commerciality of biomethane production for injection into the natural gas network

Detail: Hydrogen Sulphide (H_2S) is a colourless gas known for its pungent "rotten egg" odor at low concentrations. It is extremely flammable and highly toxic working with this gas requires strict risk controls. A further detailed risk assessment was completed looking specifically into the dispersion of the gas in the Malabar Facility. It was determined that due to the upgrader operating at low pressures (4kPa) the rate of dispersion is very low and therefore the risk of engulfment by a H_2S cloud is minimised and you would smell it much before you were in danger. The process removes the H_2S at the Activated Carbon membranes before it is compressed to 1050kPa where if still present the H_2S would be a major hazard to personnel.

Implications for future projects:

- Segment plant and controls to appropriate risk profile
- Model dispersion rates for vents and mixtures

<u>Lesson learnt No.4:</u> Migration of Upgraded High Pressure gas in the event of a Station Trip.
Category: Technical

Objective: Demonstration of the technical viability and the pathway to commerciality of biomethane production for injection into the natural gas network

Detail: A layer of protection analysis (LOPA) investigation was completed during the design stage of the project. This analysis concluded there was no overpressure scenario that could exceed the maximum allowable operating pressure (MAOP) of the Biodome. It resulted in the removal of the Pressure Safety Valve (PSV) located at the Biogas inlet. However, during the mechanical completion, it was noted that the design had overlooked an overpressure scenario caused by reverse flow from the high-pressure system back to the biodome while the inlet valve (tie-in from Sydney Water) was closed, which happens on Emergency Shutdowns (ESD), and could result in the over pressurisation.

Finally, a design change was implemented to reinstate the PSV at a set pressure of 4kPag and the project proceeded to commissioning.

Implications for future projects:

- Future projects should consider the sizing of the inlet low pressure system to the Station Isolation to allow for equalisation of the high pressure system to avoid unnecessary venting.
- Future projects should consider if an inlet tie in valve is required between the gas source and the upgrader, and if required can the valve be manually operated only, ensuring sufficient volume in the low pressure system is always available to absorb settle out pressures should the facility shut down automatically.

- Future projects should consider segregating the low and high pressure systems during ESD events by means of shut down valves (SDVs).
- Consideration of localised flare systems for biogas releases.

Lesson learnt No.5: Improved reliability of GC sampling to recover on spec gas.
Category: Technical

Objective: Development of a renewable gas market through a certification system

Detail: The Biomethane Gas Chromatograph (GC) determines whether the Upgraded Biomethane is in compliance with AS4645:2005. During commissioning, it was identified that there was ~30min lag for the GC to read the actual composition of the gas in the delivery line when compared to the high-frequency Gas Analyzer. This delay resulted in a prolonged recycling period prior to determining Biomethane gas was compliant, gas and suitable to be exported to the Custody Transfer Station (CTS). A design change was implemented to relocate the sample point to reduce the tube length. This will reduce the delay between a composition change and the measurement by the GC to 6-8mins, thus reducing unnecessary gas recycling within the facility and the chance of exporting off-spec gas to the CTS.

Implications for future projects:

- Determining lag of GC sampling and optimising with the frequency of the GC configuration.

Lesson learnt No.6: Supply of renewable electricity for the Upgrading Process to deliver Green Gas Certification.
Category: Commercial

Objective: Development of a renewable gas market through a certification system

Detail: The MBIP receives a predominant supply of electricity from renewable energy (ie. Biogas Cogen) from the Sydney Water Facility. In the event that the Cogen goes offline a grid supply is provided to the facility, to maintain the certification of the green gas initiative the validation of the energy supply origin should be consistent with other renewable sources thus MBIP may require to purchase LGCs to offset electricity supplied directly from the grid.

Implications for future projects:

- Ensure reliable supplies of Renewable Energy Supplies to upgrading facilities.
- Ensure there are reliable sources to purchase LGCs if Renewable Energy Supplies are ceased to meet the certification of the green gas initiative.
- CAPEX considerations for the development of alternative renewable electricity production.
- Metering of electricity from independent Energy sources.

Q&A Register

Question 1: Under Lesson 1, implications, point one: Please clarify what is meant by "Riding out Waste water anaerobic digestor variations in quality and flow rate".

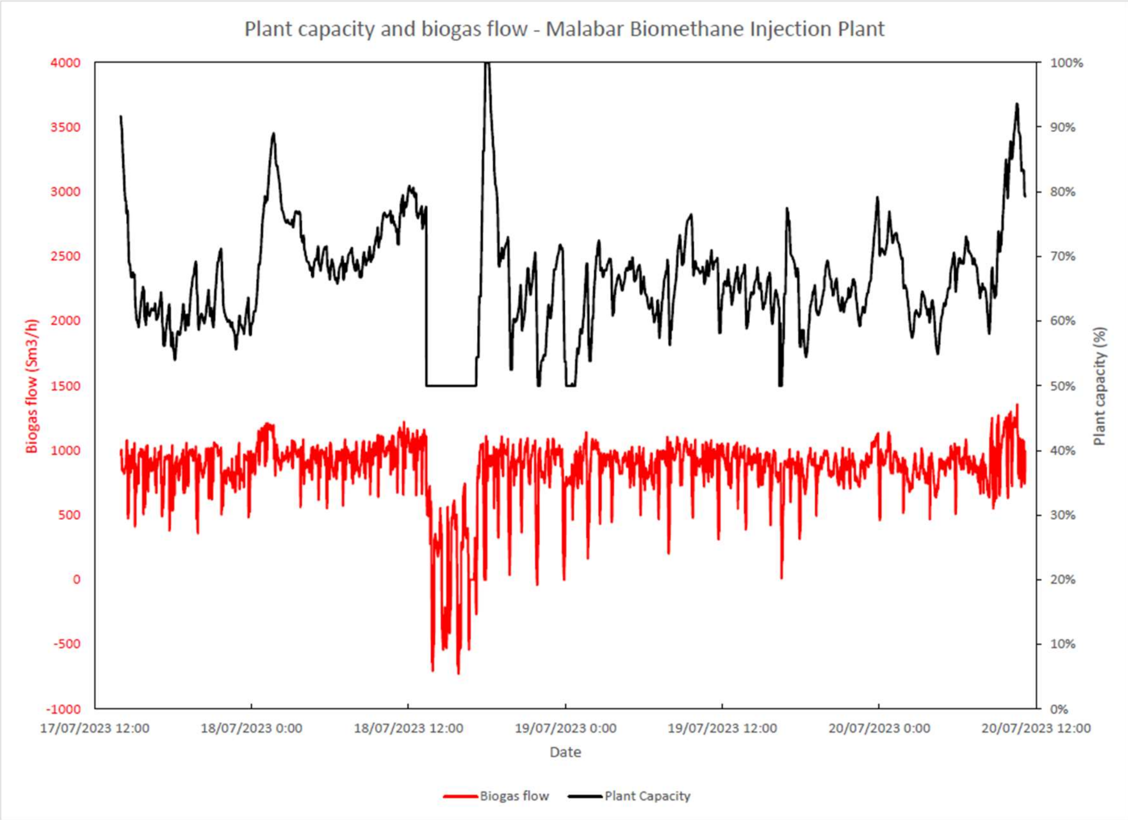
Response: The utilization of the biodome dampens the variations in flow, allowing the facility to run at a more stable capacity despite variations in flow coming from the Wastewater Treatment Plant. Please see the attached chart. The incoming biogas flow rate drops to less than 500 Sm3/h a number of times per day, but the capacity of the facility (i.e. compressor speed) does not drop as sharply, varying between 50% and 80% throughout the day. The biogas flow rate tends to drop sharply when the Sydney Water waste gas burners turn on. The biodome has no impact on the gas quality/composition.

Question 2: Under Lesson 2, implications, point three: Please clarify if they (a) had a QA/QC process in place – and if yes did they see it as effective; (b) have any lessons on what an effective QA/QC strategy would include for these modules.

Response: Eneraque conducted a very limited Factory Acceptance Test, which included basic verifications such as checking manual valves and whether all equipment was tagged. An effective FAT should have a much broader scope to minimize issues during the Site Acceptance Test (SAT) as much as possible. An effective FAT should include piping and equipment internal inspection and preservation, leak tests, instrument calibration, flange management, test runs with rotating equipment, communications testing, I/O testing, tracking electrical installation progress, control loop function check, etc.

Question 3: Under Lesson 3, implications, point two: can anything further be shared on the modelling approach taken.

Response: The dispersion modelling used in the Malabar Project used standard methods for dispersion analysis. The point we are trying to make is that such analysis must be conducted in the early stages so that the design team can have an accurate understanding of the risks associated with H_2S and therefore design the facility with vent and gas detection systems that are fit for purpose.


Plant capacity and biogas flow - Malabar Biomethane Injection Plant
Biogas flow (Sm3/h)
4000
3500
3000
2500
2000
1500
1000
500
0
-500
-1000
Plant capacity (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
17/07/2023 12:00
18/07/2023 0:00
18/07/2023 12:00
19/07/2023 0:00
19/07/2023 12:00
20/07/2023 0:00
20/07/2023 12:00
Date
Biogas flow
Plant Capacity