Avonmouth Biomethane Project

GENeco gas to grid scheme at Bristol STW

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A class exemption to the standard for oxygen in biomethane, confirmed by the HSE in May 2013, opened the door to the clean-up of biogas produced from anaerobic digestion (AD) plants, and for injection of enriched biomethane into the natural gas network. The class exemption agreed by the HSE was for a relaxation of the standard for oxygen from 0.3% to < 1%. The exemption to the gas standard coupled with the introduction of the government renewable heat incentive (RHI) created the environment in which businesses were encouraged, through generous financial returns, to invest in the gas clean-up plant, and to engage with utility companies to agree the arrangement by which gas injection could be permitted to take place.

Clean-up columns and cooling plant - Courtesy of GENeco

Clean-up columns and cooling plant - Courtesy of GENeco

Renewable heat incentive (RHI)

The RHI scheme provides a guaranteed tariff for each MJ/m^3 of the biomethane injected, with an additional variable tariff related to the market value of the equivalent energy potential of natural gas at that time. The scheme sets out a mechanism for degression of the RHI tariff depending upon the total capacity of biomethane injection plants registered.

The concern for GENeco, Wessex Water's renewable energy company, was that the RHI tariff would be degressed before the tariff could be secured and so a challenging programme for delivery was agreed to ensure securing the contemporary RHI tariff that had been used in financial modelling for the investment decision. The target was to deliver the scheme before the end of 2014.

The calorific value (CV) of natural gas is higher than that of biomethane, as natural gas comprises small percentages of higher order alkanes (ethane, propane, butane, etc) than just methane alone. As the injected gas is required to match the CV of the natural gas, a small quantity of a higher order alkane is required to be mixed with the biomethane to achieve parity with the required CV. Propane is the gas selected by the industry for the purpose of enriching the biomethane to achieve parity of CV.

Feasibility

GENeco engaged the services of CNG Services Ltd (CSL) to provide consultancy support and advice throughout the project, and CSL helped with developing high-level financial models for a number of short-listed Wessex Water sites.

Wessex Water has anaerobic digestion facilities at five sewage treatment and sludge treatment works in its region. Of these sites only one was found to provide a sufficiently attractive prospect for gas to grid. The particular site, at Avonmouth, near Bristol, has Wessex Water's largest sewage sludge AD plant, but is also unique in the UK in that it also has a food waste AD plant as well.


GEU – propane injection assembly - Courtesy of GENeco


GEU – pressure reduction module - Courtesy of GENeco

Another factor in the decision to develop the plant at this site was the willingness of the local gas utility company, Wales and West Utilities, to support GENeco in the feasibility work.

Wales and West Utilities was willing to work with GENeco to achieve an early understanding of the potential capacity of the receiving gas network for the injection of enriched biomethane. The work revealed that there should be sufficient capacity to accept the maximum output of biomethane that the site AD plants could provide.

GENeco's Bristol food waste treatment facility

GENeco's merchant food waste treatment plant has been in operation for nearly 3 years. The plant treats 30,000tpa of source segregated food waste from local authority kerb-side collections, and in particular receives all council-collected waste arising from Bristol and Bath and from Blaenau Gwent, Torfaen, Neath and Port Talbot in South Wales. In addition the plant receives supermarket waste from Asda and Aldi.

Waste is delivered in a range of different trucks that deposit onto a flat concrete floor. From here a mechanical shovel lifts the waste into a hopper which feeds a shredder to break open the packaging.

The process stages then comprise pulping of the waste, separation of packaging from the pulp (feedstock), grit separation and then transfer of the feedstock to a buffer tank. The feedstock is then transferred from the buffer tank to 2 (No.) 2,200m^3 digesters via a batch pasteurisation stage.

After digestion the liquid digestate is pumped to a second buffer tank from where it is pumped to centrifuges for dewatering. Centrate is recycled and the digestate cake is taken for use as a fertiliser replacement on local farms. GENeco has arrangements with 140 farmers who are keen to take the digestate cake rather than inorganic fertiliser.

Gas to grid plant capacity selection

The AD process produces biogas with a content of approximately 60% methane and 38% carbon dioxide. The balance principally comprises oxygen and nitrogen but also contains contaminants (siloxanes, sulphur dioxide and VOCs).

To maximise the potential revenue, the plant output was matched with the total available biogas (allowing for removal of the non-methane elements). The approximate production quantities for the site are 44,000m^3/d from sewage sludge AD and 16,000m^3/d from food waste AD. Thus a plant able to process 2,500m^3/h (60,000m^3/d) of biogas was selected.

Procurement and support arrangements

The gas to grid scheme works was split into the following key work packages:

- Gas clean-up plant.
- Gas monitoring/validation and flow measurement plant (grid entry unit - GEU).
- Propane injection (incorporated with GEU).
- Gas flare.
- Injection pipeline.
- Integration works package (including civil works, gas pipelines and power supplies).

GENeco took on the role of coordinator for delivery of the various work package contracts and had support from the Wessex Water's in-house construction department, Wessex Engineering & Construction Services (WECS), who provided technical support over electrical and mechanical engineering matters, contract administration support, construction supervision and commissioning support.

A number of contractor frameworks had been established for delivery of the Wessex Water Services (WWSL) business capital investment schemes, and the gas to grid scheme was able to benefit from these arrangements by quickly engaging with a willing and suitably experienced contractor who would be able to deliver the integration works. The appointed contractor, Trant, had performed well for the WWSL business and was recommended for the gas to grid scheme.

Similarly, a number of consultancy frameworks had been established for the WWSL business capital investment delivery. Grontmij was a framework consultant to the internal construction business which was able to bring experience with delivering biomethane projects elsewhere to support expediting delivery of the Avonmouth project. GENeco was able to secure the services of Grontmij through the existing framework arrangements that existed between WWSL and the Grontmij business.

Clean-up plant solution: To achieve the challenging programme target set for the scheme, it was important to avoid protracted procurement activities in selecting the clean-up plant contractor. This element of the plant had been identified as the longest lead-time plant delivery. An initial study was made to identify the key suppliers that could provide the clean-up plant solution, for the various optional technologies. The potential technologies had been identified as:

- Membranes.
- Waterwash.
- Pressure swing adsorption.
- Chemical wash.

The Achilles database had previously established a category for biogas technology. Use of the Achilles database therefore precluded the need to advertise in the Official Journal of the EU. All companies that had registered for the provision of this type of plant were included in the procurement exercise, together with all of those that we wished to include in the procurement exercise as determined from our study.

From the tenders received, GENeco was able to refine the choice to a decision between either one waterwash contractor or one membrane plant supplier.

Comparison of the two options revealed that the waterwash plant was able to remove contaminants from the biogas stream as well as dissolving the CO_2 within the clean-up process, and therefore had the benefit of only requiring granular activated carbon (GAC) filters to polish the product gas at the downstream end of the plant.

Conversely, the membrane plant needed protection against clogging of the membranes with contaminants by the provision of upstream GAC filters and that the filters would therefore need frequent replacement to maintain effective protection.

When the operational costs of the two options were compared it quickly became apparent that the waterwash option provided the least whole-life cost solution.

Malmberg, the manufacturer of the waterwash plant was duly appointed for the delivery of this element of the plant.

Grid entry unit: For the grid entry unit, GENeco was obliged to work with one of only four contractors whose designs of plant had been approved by National Grid.

The situation with these four contractors was a legacy from a previous plan where National Grid (NG) had intended to procure all of the GEU installations and own the assets. Having been through an exercise to select the four approved suppliers, NG then decided

not to get involved and instead left it for developers to procure the GEU. Each of the four approved suppliers was invited to tender for the GEU provision: responses were received from three of those invited, with competitive proposals from two.

The selected contractor was Future Biogast.

Injection pipeline: A similar competitive tender exercise was held to select the injection pipeline contractor. The injection pipeline asset would become a WWU asset once the scheme had been completed so it was important to ensure WWU was happy with the selected contractor and with the design of the injection pipeline.

From a list of 4 contractors approved by WWU, AWH Utilities offered best value and was appointed for this element of the project. AWH performed very well and delivered on time and to budget.

Biomethane flare: The final part of the plant was the biomethane flare. Originally it had been hoped that enriched biomethane could be rejected back into the biogas system. However, in discussion with the waterwash plant contractor it became apparent that propane could impair the calibration of gas quality instruments so it was decided to divert rejected gas to flare instead.

Having only recently procured a flare for the biogas stream from Flare Products, who demonstrated good value, they were invited to provide a proposal for delivery of the biomethane flare as well.

Regulatory and investment control

A planning application was prepared once the selection of the clean-up plant had been made. Wessex Water also has an experienced team of environmental planners and ecologists to assist with delivery of capital works projects: these also rest within the WECS department. GENeco was able to take advantage of the expertise within this team to develop the planning application.

For the planning application it was realised that it would not be possible to achieve the target completion objective if planning approval had to be secured before construction could begin.

A proposal to the Board to start construction in advance of the planning determination being received was approved: the first time that a decision of this nature had ever been sanctioned by the Wessex Water Board. The mitigation for this was that pre-application consultation had been made with the local council to ensure that key areas of concern were addressed in preparation of the planning application.

Similarly, the environmental permit application was developed based upon the selected plant. The permit was developed as an extension to the existing environmental permit for the CHP engines, belt drier and food waste plant.

Plant delivery

CNG Services Ltd (CSL) supported the delivery stage of the project by providing draft specifications for each of the work packages and design for the injection pipeline. The support received from CSL was excellent and it would not have been possible to deliver the scheme in the timely manner achieved had it not been for the willingness of CSL to work to the very challenging timescales for delivery set by GENeco.

Grontmij supported the delivery process by providing design services and review of the technical specifications. They also provided a role of maintaining the integrated project programme.

Trant proved to be an excellent choice for the scheme and was pro-active in arranging all subcontracted work in a timely fashion and maintaining a contemporary programme that reflected changes to the process plant programme while endeavouring to maintain the objective of meeting the target completion date.

An unexpected aspect of the work was the discovery that the site could potentially have an unexploded World War II bomb buried somewhere. As all of the works needed to be piled, the risk was that if the bomb was beneath the gas to grid plant, installation of any of the piles could set-off the bomb with catastrophic consequences.

Trant engaged a specialist contractor to comb the site and confirm that no bomb was present.

Malmberg has performed excellently throughout and the equipment is produced to very high material and workmanship standards. The Malmberg plant was delivered to site on time and their support with resolving minor problems and equipment failures since setting-to-work of the plant has been exemplary.

In delivery of the injection pipeline works, CSL and AWH both performed excellently and this element of the project was delivered to programme and budget.

Flare Products also delivered the flare stack plant to the quality, programme and budget required.

Testing and commissioning

The plant was fully installed and able to inject gas by mid-November 2014; and the first gas was injected to the grid on 17 November. The degression of the RHI tariff took place on 1 January, so the objective of securing the highest tariff was achieved.

Commissioning and stabilisation of the plant production has taken longer than was envisaged and still continues. As software glitches are removed and control of the plant improves GENeco is able to gradually increase the production of enriched biomethane towards the plant's maximum capacity. Performance testing of the plant is now expected to be completed during June 2015.

Environmental improvement potential

The availability of enriched biomethane creates opportunities to make improvements to the air quality through the potential for replacing diesel in city transportation vehicles.

GENeco has customised a biomethane bus, the 'Biobus' to publicise the potential opportunity of using biomethane to reduce health risks arising from vehicle emissions. Initially the bus operated between Bristol airport and the centre of Bath but First Group have now taken over the running of the bus and operate it on their No2 route. The bus has since been linked by Bristol City council with Bristol City's Green Capital initiative.

- The exhaust emissions from the alternative fuel offer significant air quality improvements in comparison to diesel:
- <97% reduction in dangerous particulate (PM2.5 and PM10) emissions; microscopic matter which can pass easily from the lungs into the bloodstream. Recent research by Public Health England demonstrates that 1 in 20 of the UK population in urban centres will suffer an early death directly attributable to particulate emissions.
- 80 - 90 % reduction in nitrogen oxides (NOx). High levels of NOx gases contribute to the formation of acid rain and city smog, and have a negative effect on vegetation growth.
- Well-to-wheel', biomethane produces 95% less CO_2 than diesel; 'tank-to-wheel', CO_2 emissions are 20-30% lower than from diesel vehicles. Thus, in the long term, biomethane represents a sustainable and renewably sourced alternative to fossil fuels.

Following the launch of the Biobus, the introduction of the bus to the transport mix in Bristol/Bath was headline news in newspapers and on the TV in November 2014. All of the local media covered the story. The subject was headline news on the BBC and ITV news broadcasts and was the most popular news story on the BBC news website, with 8 million visitors. Thousands of people tweeted the story and it was re-tweeted by companies with thousands of followers. Also, thousands of people watched the YouTube video.

The largest technology blog, Engadget, reported on the Biobus and 110 leading news websites worldwide covered the story. Interviews were held with American, Russian, Chinese and Arab news stations besides all of the UK news stations. As recently as the end of March 2015, Bill Gates drew attention to the work of GENeco, acting as an ambassador for the use of biomethane and indirectly as an ambassador for the technology.

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Biobus at Bristol STW in front of the enzymic hydrolysis plant Courtesy of GENeco


GEU - biomethane analyser room - Courtesy of GENeco