Operational Efficiency

water e-journal
Online Journal of the Australian Water Association
ISSN 2206-1991
Volume 3 No 3 2018
https://doi.org/10.21139/wej.2018.029

ENERGISING SYDNEY THROUGH CO-DIGESTION FOODWASTE

Sydney Water's Waste to Energy Program

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INTRODUCTION

There are long-term problems with landfill capacity in metropolitan Sydney, leading to an increase in landfill costs. Alternatives to landfill for food waste include soil injection and composting, however these options have limitations and are being pushed further out from Sydney. Converting food waste to energy using anaerobic co-digestion is emerging as a more sustainable (Parry, 2012) and cost competitive waste disposal option both within Australia and overseas. Sydney Water is uniquely placed to help reduce this waste burden using its existing wastewater facilities. Sydney Water benefits from additional renewable energy and a gate fee, which helps keep customer wastewater charges down. The waste customer receives a more cost effective, sustainable waste disposal solution.

YEAR CASE STUDY WAS IMPLEMENTED

2014 to 2016 (ongoing)

CASE STUDY SUMMARY

Sydney Water's Food Waste to Energy 2020 Plan established the vision that by 2020 Sydney Water will provide a sustainable food organics disposal service to our business customers. To achieve this vision the plan outlined a series of research and pilot programs to be established from 2015.

The aims of the co-digestion pilots are to prove that co-digesting trucked, high strength organic waste at a Waste Water Treatment Plant (WWTP) increases biogas production and gain a better understanding on how to receive trucked organic waste. The pilot success is measured against two objectives.

This paper highlights the steps that Sydney Water has followed in developing the program to this point. It will also detail how the process has changed as we continue to accumulate learnings in this new area. The program has evolved from ad hoc lab scale research to a pilot, and is now a more defined research and development (R&D), pilot and implement life cycle. The initial research used glycerol, a by-product from the manufacture of biodiesel. This product looked very promising and the lab scale research indicated impressive biogas production.

The first pilot plant constructed was at Bondi WWTP. As the program evolved a second pilot plant was designed and constructed to receive fruit and vegetable waste at Cronulla WWTP, this plant became operational in late 2016 and is currently within the commissioning phase.

The results from our pilots highlighted the complexity of identifying positive and negative impacts in operational treatment plants. The Bondi pilot showed lab and bench scale digesters provided good data on expected gas and energy outputs, however they could not reproduce the limitations of using the material in a functioning treatment plant because we were unable to dose to the same level. As Sydney Water moves through available products from basic glycerol and sugary water such as soft drinks to more complex food wastes such as commercial kitchen and grease trap waste, a better understanding of impact on digester operation and digestion outputs is required.

Limitations in lab scale research and natural variability of gas production within operating WWTPs highlighted the need for a middle ground, a large-scale research digester. Through the support of the Australian Research Council, the University of Wollongong, University of NSW, DC Water and Sydney Water a 3-year research program was designed which included the construction of two 1 kilolitre anaerobic digesters at our Shellharbour WWTP. This program will provide more accurate outcomes and outputs from more complex co-digestate products for future pilot plants.

KEY LEARNINGS TO DATE

- The R&D program provides a good understanding of the expected energy benefits but is limited in providing practical infrastructure and handling requirements.
- Piloting is an essential component to understanding the real-world application and energy recovery
- Piloting highlights the infrastructure requirements of our treatment facilities to be able to conduct co-digestion.
- Variability between types of waste and within each load, impacts both the physical design of receiving infrastructure but also the dosing rates.
- Measurable results have taken longer than anticipated, but despite these setbacks we would do the program again but with some modifications.

CASE STUDY DETAIL

Bondi

The Bondi glycerol trial was designed to measure the energy impact on dosing a mixture of glycerol and municipal primary sludge into an operational mesophilic anaerobic digester. The baseline to measure increased biogas was 629.53 kg of biogas per hour, based on the average gas production from 12 January 2014 to 30 June 2014. The pilot begun dosing glycerol at a constant rate in late October 2014 and was able to maintain periods of constant dosing until early April 2015. During this consistent dosing period, biogas production has increased to 732.70 kg per hour; representing a 16.34% increase over the baseline. A t-test concluded that at the 95% confidence level this result lies outside the natural variability.

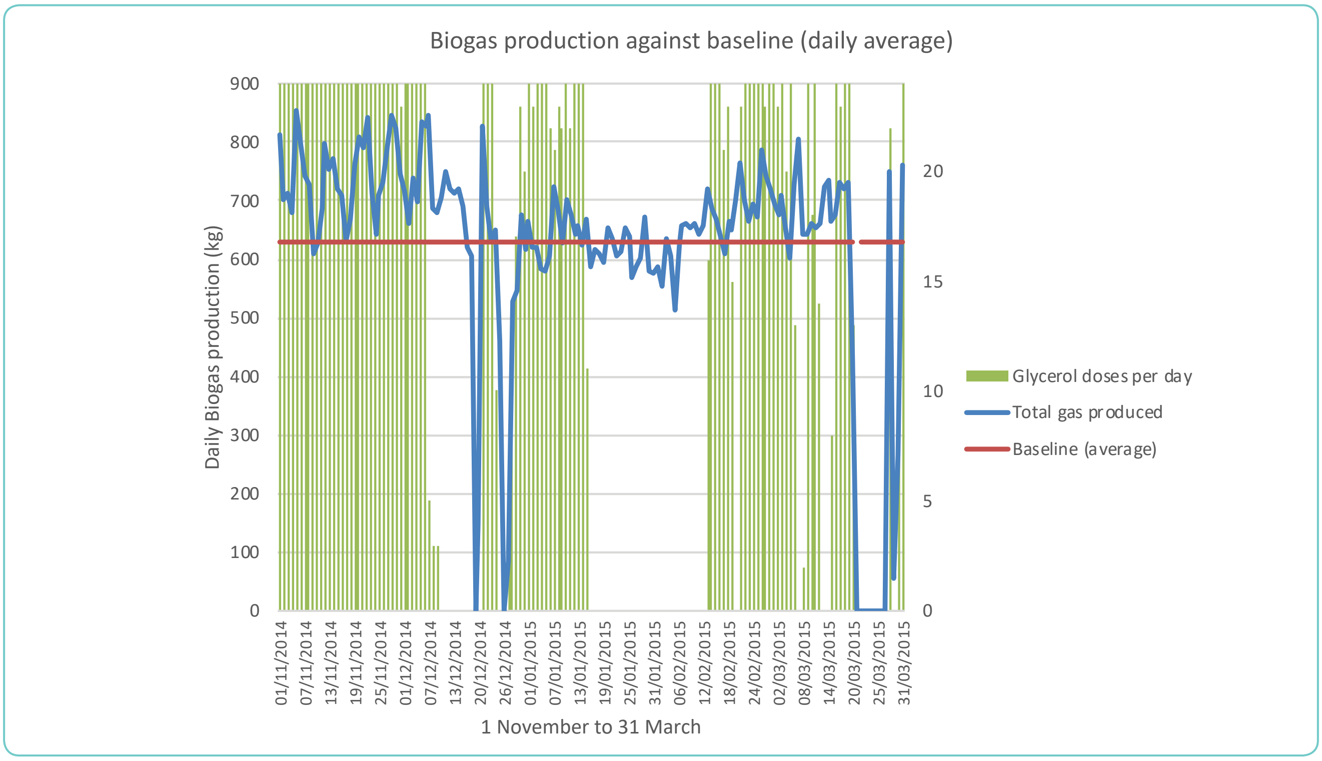


Figure 1: Bondi Biogas Production

The increase of biogas by 16% with the addition of 70 kg glycerol per hour (which is 0.2% of the sludge volume and 10% of the theoretical maximum loading), is consistent with lab scale testing of 100% increase in biogas production using 2% of glycerol on a volume to volume ratio (Nghiem, et al., 2014). The pilot met the first objective. However, regression analysis on the glycerol dosing and biogas production indicated that we could not conclude that the glycerol dosing was the definitive cause of the biogas increase.

The level of dosing and gas production of the early stages of the pilot were not sustainable and over the length of the pilot it became impossible to continue dosing glycerol at those levels consistently. Supply issues of glycerol as well as plant upgrades resulted in a stop/start dosing programs and resulted in smaller doses of glycerol into the digester. Dosing of Glycerol ceased completely by the end of 2015.

The project identified that although glycerol is a high-energy value product, it would not be economically sustainable as a co-digestion product, due to the high transport/delivery cost and other factors such as limited cogeneration engine capacity and low electricity feed in tariffs.

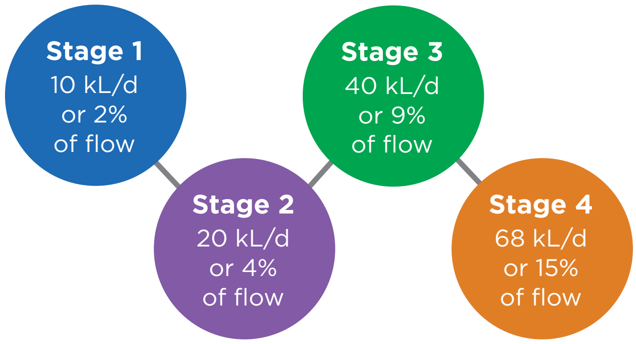
Using the data obtained from this pilot, further analysis showed that energy generation and grid electricity purchase savings alone would not be sufficient for any other plant to meet the cost of investment. And as such the use of glycerol as a co-digestion product would not be pursued.

Cronulla

The Cronulla WWTP treats approximately 56 ML/d of raw sewage, producing approximately 264 m^3/d of thickened primary sludge (TPS) and 120 m^3/d of thickened waste activated sludge (TWAS). (Lee, 2014). There are two anaerobic digesters at Cronulla WWTP, equipped with heating and recirculating pumps (used for recirculation, loading and wasting of the digester contents). These digesters were recently converted to operate in series. A third digester operates as a raw sludge feed tank. Digested sludge is transferred to a sludge-holding tank where it is stored prior to transfer to the sludge dewatering facility for processing and disposal.

The selected product for piloting at Cronulla was the result of a Multi-criteria Analysis (MCA) incorporating data from biomethane potential tests (Wickham, et al., 2016) conducted by the University of Wollongong, overseas literature as well as a waste market review examining available organic waste generation. The preference for a local generated waste product and the ability for the product to be pulped at source weighted the decision into selecting the pulped fruit and vegetable waste generated by food waste supplier. This product produced good levels of biogas, was similar in solids content to the raw sludge with a low risk to downstream processes.

The dosing plan developed was to introduce the co-digestate from the food waste holding tank into the raw sludge feed tank at progressively higher feed rates. The duration of each stage was 30 days (2 times the SRT) to investigate the impact of additional food wastewater to the digesters. The staging of the flow rates was:



Typically, anaerobic digestion can occur in single or multi staged digesters. The multi stage (e.g. acid/gas phase digestion) offers several benefits over a single stage digester. In acid/gas phase digestion, the first digester is typically operated at a low SRT (12 hours to 1.5 days) to promote the growth of acid-forming microorganisms, while the following digester has a high SRT (greater than 15 days) to allow for the establishment of a methane forming biomass.

Studies suggest improved performance of acid/gas phase digestion versus single stage digestion as measured by VS reduction (Ghosh, 1985). Although there are no dedicated acid phase digesters at Cronulla STP, it appears that the feed tank shows similar characteristics (i.e. high VFA concentration and low pH) as an acid phase digester.

For the pilot trial, the feed tank was an ideal food waste dosing location as it may benefit from the acid phase characteristics of the feed tank.

The Cronulla pilot has provided the best example so far of the risk of variability of waste products that may impact our treatment systems. We identified the risk of this variability at the start of the program and the Bondi pilot confirmed this risk. When Cronulla begun to receive product, the extent of variability observed was substantial. The product presented with gross contamination of plastics and was significantly higher in total solids. During testing, the product presented was around 4% Total Solids, similar to our raw sludge. During the first stages of commissioning, the delivered products arrived with total solids as high at 9%. The total solids do not present an issue for digestibility, but it does require a recalculation on our dosing schedule. The gross contamination presented a larger problem, which the supplier has been willing to work with us to overcome. A strength of the pilot approach is that the supplier and Sydney Water are working cooperatively to make this program happen; co-digestion is mutually beneficial to all parties involved.

Shellharbour Co-digestion Pilot Plant

The pilot plant was built as part of the ARC Linkage project "Analytics to predict anaerobic co-digestion & downstream process performance". This project is a collaboration between University of Wollongong and Sydney Water. The main objectives include better understanding on the factors that limit carbon rich waste in the anaerobic digesters and the impact of co-digestion on biosolids quality (odour) and quantities. The project will ultimately result in a novel analytics based tool for decision making to optimise planning, design and performance of co-digestion digestion.

The pilot plant, installed at Shellharbour WWTP, contains two 1 kilolitre anaerobic digesters. One digester will act as a control while the second will be used to test wastewater sludge and co-digestate materials. Both digesters have separate 200 litre tanks available (if required) that can be used as acid phase digesters. The plant also has separate gas handling and measuring lines. The pilot plant is fully automated and can be remotely operated.

Figure 2: Research Co digestion pilot plant installed at Sydney Water's Shellharbour Wastewater Treatment plant

The project has several deliverables besides the output data for the co-digested products. One deliverable is a data and predictive analytic decision-making tool. This tool will assist plant operators, system designers, asset managers, researchers and regulators to better understand and eventually optimise treatment plants with co-digestion facilities.

The analytics tool will be a web-based, interactive platform designed for visualisation and analysis of complex data in graphical, tabular, and process-based formats. The tool will allow the users to define specific co-digestion scenarios (e.g. type/quantity of organic wastes and wastewater sludge, digester volume and historical performance, and operational regime). For example, the user can visually inspect the impacts of co-digestion on individual processes (e.g. pre-treatment, biosolids dewatering, and beneficial reuse of biosolids) as well as the interaction amongst these processes within the anaerobic digestion flow sheet. This innovative analytics tool will be the first of its kind for an industrial process and will maximise the transfer of research results to practical implementation.

CONCLUSIONS

Sydney Water has followed two parallel process to improve our understanding of co-digestion. The Research and Development program both at the lab scale and now at the Shellharbour pilot plant will give Sydney Water a better understanding of how complex materials affects our residuals including biosolids and dewatering centrate. The second area is piloting of selected products to gather information on how to receive, process and introduce highly variable waste material into an operating plant.

The major learnings so far have come from these pilot plants. Both the Bondi and Cronulla full scale pilot plants have shown how to receive and handle trucked high-strength organic waste. A further understanding is that waste products have a large variability in their quality, contents and even physical appearance. This variability has and will continue to be a challenge for the co-digestion program; it has also provided the evidence that research on products is not sufficient to show if a material should or should not be included. Lower value or lower yielding products may in time prove to be a better alternative as they provide fewer challenges.

We believe that the program mix of operating pilots within WWTP and large-scale research digesters is an ideal model. This model provides for the assessment of two distinct outcomes. The full-scale pilot plants have become focused on better understanding of the how to receive process and to integrate these products into our existing infrastructure. The strongest learnings for Sydney Water so far have come from these non-traditional areas, while the research digesters are providing the verifiable impacts and outcomes to help build future decision making. The research digesters are simply unable to provide the learnings needed as to how these materials are delivered and the daily variability. The full-scale pilot plants have an inherent difficulty in separating the outcomes associated with co-digestion with those of natural variability in biogas and biosolids production. The program benefit is when these two programs operate in conjunction.

ACKNOWLEDGEMENTS

The authors thank Professor Long Nghiem (University of Wollongong) for useful discussions and information on the Shellharbour pilot plant installation.

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Brendan Galway has over 15 years' experience working in the waste and sustainability fields for both public and private organisations. His work at Sydney Water includes identifying and developing new opportunities to enable Sydney Water to become more resource efficient including opportunities in the co-digestion of wastewater and other organic wastes. He recently accepted a role in Service Planning and Asset Strategy and is working on long term planning of Sydney water's Residuals.

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Phil's role as Service Planning Lead (Energy) is to develop the strategies and programs that will help make Sydney Water an international leader in energy management and the generation of renewable energy from waste. Phil has lead the development of Sydney Water's Energy Master Plan, which sets the vision and goals to 2030 and beyond. He seeks to turn Sydney Water from a major energy user to an energy generator and a key player in the management of organic waste across the city.

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