Australian Government
Australian Renewable Energy Agency

ARENA

Unitywater

Final and project failure report

Project title:	A feasibility study to undertake an assessment of the commercial viability of a waste to energy project at Unitywater's sewage treatment plant
Project reference:	G00866
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Executive Summary

This report provides the final summary and project failure reporting for ARENA project G00866 - A feasibility study to undertake an assessment of the commercial viability of a waste to energy project at Unitywater's sewage treatment plant.

With Unitywater's Kawana sewage treatment plant (STP) as an example site, Unitywater identified that the addition of liquid wastes in the form of fats, oils and greases utilised latent capacity in the anaerobic digester on site, increasing biogas production. This increased biogas productions results in a decrease in fossil fuel usage for the plant, and presents a positive energy returned on energy invested (EROEI) ratio. The feasibility assessment included the design of unloading facilities, receival facilities and equipment for the introduction of additional waste feedstocks into anaerobic digestion.

Through the feasibility assessment, Unitywater identified that securing a consistent supply of waste feedstock and the value of the waste disposal gate fee received are critical to the commercial viability of a waste to energy project. The ease of disposal, availability and logistical efficiency of the disposal facility were key determinants in both defining the gate fee and ensuring consistency of waste supply. It was found that uncertainty in the waste disposal industry due to potential legislation changes in the End of Waste Code reduced the willingness of waste disposal companies to enter into agreements for the supply of these wastes.

On completion of these studies, Unitywater developed a knowledge sharing report, presented to ARENA. In this, Unitywater's investigations in waste to energy at Kawana sewage treatment plant are intended as a checklist for small scale anaerobic co-digestion and cogeneration throughout the Australian water industry. Through presenting the lessons learned from each stage of the assessment, Unitywater has provided a basis of the considerations required to enable a project of this type.

Additionally, Unitywater developed an internal database of all 17 of its sewage treatment plants, including influent and effluent characterisation. This database collated a broad set of information to enable Unitywater to investigate opportunities to achieve energy neutrality. It was intended that this dataset would be used to prepare a set of business cases for energy neutrality at 9 Unitywater STPs.

Due to internal changes in strategic direction, Unitywater recognised that it would be unable to deliver the intended scope of these business cases in the available timeframe. As a result, Unitywater applied for a variation to time for the final milestone. At this point in time Unitywater and ARENA proceeded to mutual termination of the project. The following report summarises the project, outcomes delivered, and the lessons learned.

Project Overview

Project summary

Unitywater is a statutory authority that provides water and sewerage services to the Moreton Bay, Sunshine Coast and Noosa local authority areas on behalf of their citizens. In September 2016 Unitywater was awarded grant funding from the Australian Renewable Energy Agency (ARENA) to perform a desktop study and analysis as defined in the project scope. This project delivered an assessment of the technical and economic feasibility of converting Unitywater's Kawana sewage treatment plant to produce biogas through anaerobic co-digestion of sewage sludge with additional feedstocks. It is anticipated that the facility would have the ability to reduce the total electricity requirements of the Kawana STP by over 30% and has the capacity to be expanded and commercialised over time. Further to this, milestones that would develop commercial business cases for technology solutions that deliver energy neutrality at smaller scale sewage treatment plants were included. These business cases were to be presented to Unitywater's Investment Steering Committee for consideration. The project was to be delivered in four milestones:

- Milestone 1: the development of a risk register for the project, independent laboratory testing of potential co-digestion feedstocks and a liquid waste feedstock market assessment.
- Milestone 2: A case study of the implementation of a waste to energy facility at Unitywater's Kawana sewage treatment plant.
- Milestone 3: provision of a report containing influent and effluent data for at least nine STPs and provision of a database which would form the basis for Milestone four.
- Milestone 4: Provision of a final report for the Activity and an energy neutrality plan for at least nine STPs including:
    - An outline of the scale and scope of energy neutrality opportunities
    - A business case for two to three STPs

A knowledge sharing report was developed by Unitywater at the completion of Milestone 2 which demonstrated the intricacies of the technical, commercial and economic viability of a waste to energy co-digestion plant of this scale. By assessing the feasibility of a project of this type at a smaller scale than that currently used throughout Australia, Unitywater provided a case study of the benefits and challenges of co-digestion at this scale. Presenting this information is intended as guidance to organisations managing waste water treatment at facilities of a similar size in Queensland. Unitywater then completed Milestone 3, presenting to ARENA an internally developed database including influent and effluent data for its 17 STPs, as well as additional data to facilitate development of energy neutrality plans in Milestone 4.

Project scope

The Desktop Study and Analysis, titled *A feasibility study to undertake an assessment of the commercial viability of a waste to energy project at Unitywater's sewage treatment plant,* considers the technical and economic feasibility of converting an existing waste water treatment facility to produce biogas and electricity from waste water effluent with additional co-digestion feedstock, utilising anaerobic digestion infrastructure as part of the process. The Activity will identify technology solutions that could deliver energy neutrality at smaller scale sewage treatment plants, resulting in a series of commercial business cases to be produced and presented to Unitywater's Investment Steering Committee for consideration.

The Activity would deliver:

(a) The Feasibility Study: a comprehensive report and document for Unitywater's purpose to support their internal investment case for capital expenditure associated with converting one of the organisation's existing waste water treatment facility to produce biogas and electricity from waste water effluent with additional co-digestion feedstock; and

(b) A Knowledge Report for public dissemination. The Knowledge Report would act as a 'checklist' for other project proponents to understand the intricacies for establishing such a project, reduce risk profile and remove a key barrier to the entry of this technology within Australia. The Knowledge Report would be primarily targeted at small to medium scale waste water treatment facility operators in Australia.

The Activity would deliver 4 milestones, as below:

Milestone	Details
1.	1.1 Provision to ARENA of a certified Risk Management Plan by an appropriately qualified person. 1.2 Provision to ARENA scoping and engagement documents for all third-party service providers who will be retained as part of the Activity. 1.3 Evidence that all deliverables for the Activity are addressed via third party service provider scope of work or internal expertise from Unitywater. 1.4 Provision to ARENA of laboratory testing results including feasibility assessment of converting waste samples to biogas. Testing report to include: • Sources and types of waste feedstock samples analysed; • Descriptions of tests carried out; and • Feasibility assessment based on data collected. 1.6 Provision to ARENA of the Liquid Waste Feedstock Market Assessment to include sources, volumes and cost (including transport cost) of waste feedstocks within a defined radius.

Milestone	Details
2.	2.1 Provision to ARENA of the Feasibility Report including: 2.1.1 Biogas plant design: • Detailed mass and energy balances on feedstock, products, chemicals and waste streams; • Life Cycle Assessment from feedstock to energy output in order to determine the GHG footprint and energy returned on energy-invested ratio (ERoEI); • Process Design Drawings of equipment, processes, piping and instrumentations; High level process flow diagram (otherwise confidential); • Costing of equipment, construction, utilities, infrastructure, communications and civil works; and • Projected staffing (operational, technical, administration and management). 2.1.2 Business case: • Detailed financial model and supporting information for adopted assumptions; confidential • Summary of capital equipment suppliers • Feedstock position and contract status • Offtake position and contract status • Financing options and analysis • Use of funds • Outline of expected project returns. 2.2 Provision to ARENA of a Knowledge Report. 2.3 Provision to ARENA of an independently prepared report detailing outcomes of stratification tests.
3.	3.1 Provision of a report containing influent and effluent data for at least nine STPs. 3.2 Provision of a database (containing with 2017-18 data sets and any available historic data) which includes: • STP size in equivalent persons units and average dry weather flow units • Process flow diagrams • Characterisation of plant influent and effluent • Installed renewable energy technologies • Power consumption and load profiling data • Tariff profiles • Electrical synchronisation data • Capacities of the backup generators • Potential revenue stream (from by-products) • Additional technical information obtained from the feasibility study.

Milestone	Details
4.	4.1 Provision of an Energy Neutrality Plan for at least nine STPs including: 4.1.1 An outline of the scale and scope of energy neutrality opportunities. 4.1.2 A business case for two to three STPs, which includes: • Capital costs • Operation and Management • Payback period • Mass, energy and carbon balances • Risk management plan. 4.3 Provision to ARENA of the Final Report for the Activity (in accordance with requirements in item 3 of Schedule 3).

Project background

A ARENA is undertaking the Advancing Renewables Programme (**Programme**) to provide funding for activities involving renewable energy technology, including desktop studies and analysis that support the Programme Outcomes.

B The Recipient applied for funding through the Programme to undertake the Activity.

C ARENA is required by law to ensure accountability for the funding and accordingly the Recipient is required to be accountable for all funding received.

D ARENA has agreed to provide funding to the Recipient for the purposes of the Activity, subject to the terms and conditions of Agreement G00866.

E The Recipient accepts the funding for the purposes of the Activity, and subject to the terms and conditions of Agreement G00866.

Failure

In February of 2019, Unitywater applied for a variation to time in Milestone 4 of the Agreement as Unitywater's approved Corporate Plan adapted as a result of the adoption of a goal for a fleet of self-sustaining STPs by 2027. This variation for time reflected Unitywater's increasing focus on energy neutrality and the changes in Corporate Strategy necessary to enable this goal. Following this application for a variation, Unitywater and ARENA proceeded to termination of the Funding Agreement by mutual agreement. Following this termination, Unitywater has accepted that progress was not made towards Milestone 4 of the Activity at the point that Unitywater and ARENA moved to a mutual termination of the project, as executed on 4 July 2019.

Project outcomes

Milestone 1:

- A Risk Management Plan, certified by Geoffrey Raymond, Associate Director at Broadleaf Capital International Pty. Ltd.
- Scoping and engagement of appropriately qualified external experts in Risk Management and Waste Feedstocks.
- A summary feedstock assessment, characterisation and feasibility including:
    - A description of tests carried out;
    - A report of feedstock characterisation by the University of Queensland Advanced Water Management Centre (AWMC);
    - The sources and types of waste feedstocks analysed; and
    - A feasibility assessment based on data collected (included in Liquid Waste Feedstock Market Assessment).
- A Liquid Waste Feedstock Market Assessment, including sources, volumes and cost of waste feedstocks within a defined radius.

Milestone 2:

Presentation of a feasibility study considering the technical and economic feasibility of converting an existing waste water treatment facility to produce biogas and electricity from waste water effluent with additional co-digestion feedstock at Unitywater's Kawana sewage treatment plant, including:

- Biogas Plant design
    - Process Design Drawings
    - Mass and Energy Balances
    - Life Cycle Analysis
    - Costing of equipment
    - Projected staffing.
- Independent reports of Liquid Waste Feedstocks conducted by Griffith University, including:
    - Bio-methane potential and stratification testing
    - Stratification.

- Development of a business case for presentation internally, detailing:
    - A summary of capital equipment suppliers
    - Feedstock position and contract status
    - Offtake position and contract status
    - Financing options and analysis
    - Use of funds
    - Financial modelling and supporting information for adopted assumptions
    - An outline of expected project returns.

- Presentation of the feasibility study and knowledge sharing report detailing:
    - The availability, quality, variability and material handling requirements of feedstocks
    - Transportation of feedstocks and gate fees
    - Receival facility design and layout
    - The incorporation of feedstocks into the anaerobic digestion
    - Licencing requirements of a co-digestion facility
    - Regulatory and policy impacts
    - Community engagement
    - Stakeholder relations
    - Financial and economic feasibility
    - Life cycle assessment of greenhouse gas emissions
    - Health, safety and environmental impacts
    - Project delivery timeframes.

Milestone 3:

- Provision of a report containing influent and effluent characterisation for Unitywater's 17 sewage treatment plants (included in the Unitywater Database), performed by an external National Association of Testing Authorities (NATA) accredited institution, the University of Queensland's Advanced Water Management Centre.
- Provision of a database of 2017-18 datasets and any available historic data, including:
    - STP size in equivalent persons units and dry weather flow units
    - Process flow diagrams
    - Characterisation of plant influent and effluent
    - Installed renewable energy technologies
    - Power consumption and load profiling data
    - Tariff profiles
    - Electrical synchronisation data
    - Capacities of the backup generators
    - Potential revenue from by-products
    - Additional technical information obtained from the feasibility study.

Key learning/s

Milestone 1:

- Key risks that were identified in the risk management process in accordance with *Australian Standard for Risk Management AS/NZS ISO 31000:2009*:
    - Certainty of the supply of waste feedstocks from the market to the waste to energy facility. Securing these feedstocks is critically important and advance procurement and Memoranda of Understanding will be required.
    - A high degree of variability in the availability, volume, strength and quality of additional waste feedstocks.
    - Delays in completion of Kawana upgrade project could delay implementation of waste to energy facility.
- Sampling and characterisation of various anaerobic co-digestion feedstocks by the University of Queensland (UQs) Advanced Water Management Centre (AWMC) indicated that:
    - Fats, Oils and Greases (FOGs) were found to have the highest biomethane potential when compared to other potential feedstocks including vegetable waste and dairy effluent.
    - Although FOG feedstocks had inconsistent quality, but despite this present the best opportunity for energy recovery due to the high availability of compounds that can be converted to methane through anaerobic digestion.
    - FOGs were found to have low sulphur, nitrogen and phosphorous content compared to other feedstocks sampled. The low concentration of these compounds in FOGs reduces the risk of process upset and/or equipment corrosion in the anaerobic digestion process.
- The Liquid Waste Feedstock assessment:
    - Identified and interviewed potential feedstock suppliers within a certain radius of the Kawana sewage treatment plant. It was found that waste companies who collect and dispose of FOG wastes in this region would be attracted to use the waste to energy facility at Kawana sewage treatment plant if it delivers logistical efficiency, good access and allows quick unloading of wastes.
    - Key requirements for these FOG feedstock suppliers included weighbridges and/or flowmeter measurement, reduced unloaded times compared to those used currently, broad range of opening hours (including limited after hours and Saturday availability) and availability of appropriate wash down facilities.

Milestone 2:

- Life Cycle Assessment and Mass and Energy Balances:
    - It was identified that the addition of FOGs made beneficial use of the latent capacity of the digester at Kawana sewage treatment plant at the commissioning phase through increased biogas production.
    - The reuse of heat energy from the co-generation engine provides the heat energy to maintain the temperature of the digester, which accounts for more than 50% of the greenhouse gas emissions.
    - A reduction in fossil fuel usage and depletion was noted with the use of co-digestion and co-generation.

    - Towards reaching the design capacity of the digester, the environmental benefits are reduced, with the benefits of co-digestion limited by the design capacity of the digester and co-generation unit.
    - There is an opportunity to utilise recuperative thickening to improve the performance of the digester, by allowing the digester to operate at longer detention times, without increasing the digester volume, effectively increasing the biogas production in the digester.
    - Electricity production is also limited by co-generation engine size. An increase in size of the engine increases the volume of biogas that can pe processed into electricity.
    - Energy returned on Energy Invested (EROEI) was overall net positive, demonstrating the efficiency of co-generation with co-digestion.
- FOG Bio-methane potential testing:
    - The study of bio-methane potential performed by researchers at Griffith University assessed 8 different sources of FOGs from a region surrounding the Kawana sewage treatment plant. Chemical analysis of these wastes revealed that they are highly dilute and rich in organic matter, with a high bio-methane potential.
    - Hydrolysis was shown to be the rate limiting step during the anaerobic digestion of these FOGs, with a lag phase of 5-12 days.
    - The FOGs as substrates in co-digestion should represent 5-10% of the sewage sludge on a volatile solids basis to enhance solids and FOG destruction and their conversion to biogas.
    - A recommendation was made that further study of semi-continuous anaerobic digestion (as opposed to batch anaerobic digestion used) would be required to more deeply understand process performance, inhibition and stability of the process. Additionally, a study of this kind could contribute to the identification of optimum organic loading rate of FOGs.
- FOG Stratification Testing:
    - Due to the variance in physio-chemical properties of FOG feedstocks it was identified that a preliminary receival tank was required to keep solids in incoming feedstocks in suspension and to homogenise the incoming feed, reducing shock on the anaerobic digestion process.
    - Settling velocity of FOGs is a function of solids concentration, floc density, shape and size of particles.
    - The receival tank design would include a vertical mixer arrangement to avoid stratification of FOG feedstocks.
    - It was decided that for ease of operation and maintenance recirculation equipment would be located outside of the receival tank as opposed to the internal vertical shaft mixer design.
- Bio-gas plant design:
    - Plant design requires consideration of the introduction of FOG feedstocks, unloading facilities, receival facilities and introduction of additional waste feedstocks into anaerobic digestion.
    - As noted previously, this requires consideration of the quantity of FOGs introduced, ensuring homogeneity of FOG feedstocks introduced to the

anaerobic digester and consideration of screening, mixing and heating requirements.

- Feasibility Study and Knowledge Sharing Report:

  The key findings of the feasibility study in a waste to energy facility were:

  - Fees received for waste disposal in the form of a gate fee can be a determining factor in the financial viability of a waste to energy facility.
  - Implementation of levies on waste disposal can have a positive impact on waste to energy facilities economic viability.
  - Waste disposal companies were not willing to enter into Memoranda of Understanding and advanced procurement at the completion of Milestone 2 for various reasons, including uncertainty around waste disposal in Queensland with the potential introduction of the End of Waste Code.
  - Technical feasibility is impacted by the investigations conducted under Milestone 2, as above.
  - While Kawana sewage treatment plant can be used as a case study for anaerobic co-digestion and co-generation to produce biogas, it is essential to recognise that every site and model will differ technically and economically depending on site layout, the feedstocks characteristics and the associated sewage treatment plants process configuration (especially in anerobic digestion).
  - As a result, the Kawana sewage treatment plant case study Knowledge Sharing report is intended to be used a checklist of considerations when designing a waste to energy plant, including regulatory, health and safety, technical, economics and supply chain.

Milestone 3:

- Chemical characterisation of sewage treatment plant influent and effluent performed by UQs AWMC:
  - Acts as an enabler for Unitywater, presenting a comprehensive dataset of influent, effluent and WAS characteristics.
  - Characteristics of each stream is variable from plant to plant, indicating the importance of comprehensive sampling to enable effective decision making to contribute to energy neutrality.
  - Decisions on the sampling period should be made to avoid sampling during high rainfall periods, reducing the impact of inflow and infiltration on samples. By avoiding sampling in times where infiltration and inflow is higher a more representative picture of the base flow sewage characteristics is achieved
- Development of an internal database:
  - The development of the internal database collated a broad range of information available internally in a central reference point. Collating data in this way allows for a central point of truth to provide data for decision making.
  - By leveraging existing internal databases Unitywater was able to achieve a centralisation of datasets in a central point of truth, reducing the need to access multiple platforms to retrieve this information.

Implications for future projects

Unitywater is committed to contributing to the development of innovations in renewable energy, improving the efficiency of our operations and maintaining a good working relationship with ARENA in the future. Through Unitywater's Self Sustaining Sewage Treatment Plants strategic goal we are committed to progressing our sewage treatment plants to incorporate technologies that generate electricity, heat and gas from our operations. These initiatives aim to utilise available resources from our sewage treatment plants to reduce our costs, emissions and grid reliance. Through our strategic plan, we are progressing a program of works that align to this intent, including:

- The development of a regional resource recovery facility for biosolids, energy and organic waste, in collaboration with other waste creating industries
- Efficient management of our biosolids to create opportunities for energy production and the beneficial reuse of biosolids
- Reduction of our reliance on grid energy by generating energy from STP waste streams, including the innovative use of solar to support these projects.

To support these programs, and the growth in projects as Unitywater progresses to Self-Sustaining STPs, Unitywater is aware that it is essential that this program is led by an individual with an appropriate skillset. Unitywater is actively recruiting for an individual with the skills required to lead these projects into the future, increasing our ability to effectively deliver these projects, with the appropriate resources. Through our participation in knowledge sharing initiatives in the water industry, Unitywater will continue to share our experiences and knowledge in these initiatives. Knowledge sharing in this way is a cornerstone of the water industry, enabling the collective development of water utilities across Australia. As Unitywater continues to develop solutions in renewable energy, we look forward to the opportunity to collaborate with ARENA.

Knowledge sharing objectives

As an active industry participant, Unitywater is continues to share the knowledge that is developed through projects that intend to incorporate renewable energy technologies into our operations. Throughout the project, Unitywater has engaged in knowledge sharing activities and press releases, as below.

Site Visits

- A site visit was hosted by Unitywater for two key ARENA staff to the Maroochydore STP and the Kawana STP on Tuesday 27 September 2016.
- A site visit was hosted by Unitywater for ARENA staff member Ms Young Lee to the Maroochydore STP on Wednesday 2 August 2017.

Knowledge Sharing

- A Knowledge Sharing session was held on Thursday 3rd August 2017 with a theme of "*Funding Opportunities for Converting Waste to Energy in Queensland*". Approximately 60 people attended the session held at QUT.
- The Queensland Chapter of Engineers Australia hosted a forum through their Electric Energy Society of Australia on 23 August 2017 in Queensland at which Wade Lewis and Heather Bone spoke to a wide audience on "*Waste to Energy at a Sewage Treatment Plant*".
- Unitywater representatives Rob Dowling and Heather Bone welcomed the opportunity to host a stand at ARENA's "*Innovating Energy Summit: Powering Australia's Future*" on 14 August 2017.
- Unitywater hosted Ambassador Fraser (Australian Embassy - Federated States of Micronesia, Republic of the Marshall Islands and Republic of Palau) at their Caboolture facility on 1 September 2017 for a discussion relating to the learnings of the feasibility study.

Press

- A media statement was released on 15 November 2016 and is attached at https://www.unitywater.com/newsroom/Unitywater-and-ARENA-investigate-the-hidden-power-of-waste-in-an-Australian-first
- A formal announcement of the project was made by ARENA at the Bioenergy Australia Conference on Monday 14 November 2016.
- The press release resulted in extensive coverage, a selection of which can be found at: https://arena.gov.au/project/unitywater-sewage-waste-energy-feasibility-study/
- http://reneweconomy.com.au/unitywater-arena-investigate-hidden-power-waste-australian-first-52690/
- http://www.australianmanufacturing.com.au/41731/unitywater-and-arena-launch-waste-to-energy-feasibility-study
- http://www.utilitymagazine.com.au/turning-sewage-into-renewable-energy/
- http://www.sustainabilitymatters.net.au/content/waste/news/renewable-energy-from-several-waste-streams-535159569
- http://www.psnews.com.au/aps/531/news/sewerage-energy-plan-flush-with-funds

- http://www.innovatorsmag.com/creating-renewable-energy-from-your-local-cafe/
- http://twitter.com/hashtag/ARENAIES17?src=hash&lang=en
- http://www.australianmanufacturing.com.au/41731/unitywater-and-arena-launch-waste-to-energy-feasibility-study
- https://www.unitywater.com/newsroom/Unitywater-and-ARENA-investigate-the-hidden-power-of-waste-in-an-Australian-first
- https://www.unitywater.com/about-us/projects-in-your-area/major-projects/kawana-sewage-treatment-plant-upgrade

Financial Compliance Report

A final financial audit was disclosed to ARENA on 18 April 2019 to meet the requirements of clause 2.2 of the Funding Agreement.

Recommendations

Unitywater has appreciated the opportunity to collaborate with ARENA throughout the Activity. Unitywater has gained an increased understanding of the benefits and challenges presented by both anaerobic co-digestion and resource recovery throughout the project. As well as this, Unitywater has had the opportunity to share this understanding with industry broadly, increasing the knowledge base of small-scale wastewater treatment anaerobic co-digestion to simplify the analysis of similar projects throughout Australia. A major learning for Unitywater in this process has been the need for effective project management through the duration of the project. Unitywater aims to continue to work with ARENA in the future in order to contribute to the effective implementation of renewable energy in the Australian economy.

Funding agreement compliance (Activity Failure Report)

Funding agreement compliance, Schedule 3, item 5: Activity Failure report	**Evidence**
In the event of Activity Failure, the Recipient must, within 60 Business Days after the Activity Failure, provide a report to ARENA for public release explaining the reasons for the failure and the Activity Lessons Learnt.	This report