PATHWAYS TO A CARBON NEUTRAL WATER INDUSTRY

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KEYWORDS

Circular economy, GHG emissions, renewable, wastewater, industrial, biosolids, recuperative

EXECUTIVE SUMMARY (100 words maximum)

Simple, proven and affordable decarbonisation tools for the water industry are important to address the rapidly growing challenges of climate change. Using the New Zealand water industry and municipal WWTPs as examples, this paper demonstrates a range of modern waste to energy solutions that render municipal treatment plants energy self sufficient, have rapid financial payback and ultimately achieve nett zero carbon emission performance for the water industry (= carbon neutrality). We show the results of model calculations and implementation scenarios to demonstrate the pathways. Typical investment payback periods at current carbon prices are less than 4 years.

INTRODUCTION

Anaerobic digestion (AD) is globally recognised as a cornerstone technology for a future circular economy (IEA, 2018). AD with recuperative thickening (RT-digesters) is a recent, cost effective biosolids treatment innovation coming out of the Australasian water industry. It is based on use of a (specifically designed) anaerobic sludge recovery step that is added to proven conventional anaerobic sludge digesters. Subject to regular access to adequate amounts of digester feedstocks, the innovative process typically doubles the sludge treatment capacity (within the existing footprint) and the daily biogas output with 50 % reduced biogas production costs. Treatment plants with RT-digesters can meet all WWTP energy (electricity) requirements from on-site power. In addition, they create significant greenhouse gas (GHG) off-sets and emission reduction opportunities. On-site co-processing of site biosolids and/or local trade waste, industrial by-products and commercial food waste (co-digestion) is an effective use of RT-digesters in a municipal WWTP setting (see Palmerston North WWTP, NZ). 10 RT-digesters operate presently in New Zealand and Australia.

The New Zealand Productivity Commission released recently (August 2018) its recommendations on practical measures that support a gradual transition into a future low emissions economy. In section 15 (Waste), the report recommends the systematic use of municipal RT-digesters in the wastewater treatment and waste sector. This paper here provides the quantitative and peer reviewed energy and GHG emission calculation results that underpin these recommendations. A full report about the study is available on the website of the Bioenergy Association of New Zealand (https://www.bioenergy.org.nz/).

HIGHLIGHTS

- A water industry pathway to reduce GHG emission by 50 % by 2030 is technically feasible
- The pathway will lead to carbon neutral water industry operations by 2050
- An accelerated pathway doubling carbon offsets is also achievable

METHODOLOGY

The Bioenergy Association of New Zealand conducted recently a nationwide New Zealand study using the NZ water industry WWTP asset database information and compared 3 WWTP sludge digestion scenarios (Thiele 2018): Business As Usual (BAU, existing assets, no RT-digesters); Scenario 1 (moderate RT-digester introduction for biosolids, industrial food processing waste and grease trap waste over 30 years); Scenario 2 (accelerated RT-digester introduction over 30 years adding dairy and meat industry WWTP sludge resource).. Statistical information about existing municipal WWTPs in New Zealand (Water NZ treatment plant database (2016 data) was calibrated with actual biosolids and trade waste co-digestion performance data in the PNCC and HCC WWTP digesters in New Zealand (published in AWA e-journal Vol 1, No 3, 2016). The calibrated results were scaled to NZ population growth forecast (Statistics NZ, 2016 – 2068) and current waste sector GHG emissions (NZ Greenhouse. Gas Inventory - May 2017). Gross GHG emissions from land filled biosolids and grease trap waste were corrected for average landfill gas capture efficiencies (68 %). Typical per capita urban grease trap waste and WWTP biosolids production and ICI food waste collection amounts were obtained from the technical literature. The available industrial processing waste (dairy processing, meat processing) was estimated based on industry sources. The digester process energy was subtracted from the estimated annual gross biogas production and the corrected total annual nett biogas production expressed as Peta Joules (PJ biogas, volume based on 65 % methane content). Biogas production was also converted into the corresponding avoided GHG emission (kt CO_2-e). based on NZ emission factors for natural gas use in the heat market in New Zealand.

RESULTS/ OUTCOMES

2018: The NZ water industry operates currently over 250 municipal WWTPs. 12 WWTPs operate conventional anaerobic digesters for biosolids stabilisation, 2 WWTPs operate RT-digesters for the same purpose incl. trade waste co-digestion. 53 % of the New Zealand population are connected to WWTPs with AD. The biogas is mainly used for on site power generation or is flared. The gross biogas production in the water industry is about 0.4 PJ/annum (Figure 1B), the current (biosolids and grease trap waste processing dependent) GHG emissions in the water industry are 250 kt CO_2-e/annum.

2030: Table 1 shows the expected WWTP capacity distribution in 2030 and the WWTP sites with AD after a completion of the gradual digester capacity upgrade program with recuperative thickening installations. Construction of 3 new sludge digester plants on existing WWTPs is also expected by 2030. 61 % of the population in 2030 will be connected to WWTP with AD. A moderate program considering the time frame of 12 years for the capacity upgrade. Using 17 WWTPs for trade waste co-digestion in 2030, the gross biogas production (Figure 1B) increases from 0.4 PJ/annum to 1.5 PJ/annum (scenario 1) or to 2 PJ/annum (scenario 2). This results in avoided water industry GHG emissions of 200 kt CO_2-e/annum (scenario 1) and up to 300 kt CO_2-e/annum (scenario 2). Given a technical life for RT installations of about 15 years, a good emission reduction benefit for a minor WWTP infrastructure effort. Payback of the investment is expected within 4 years.

2050: Table 2 shows the expected WWTP capacity distribution in 2050 and the WWTP sites with AD after a completion of the gradual digester capacity upgrade program with recuperative thickening installations. Construction of 9 new sludge digester plants on existing WWTPs is also expected by 2050. 70 % of the population in 2050 will be connected to WWTP with AD. Using trade waste co-digestion in these 26 RT-digester WWTPs (Figure 1B), the gross biogas production increases 5 fold from 0.4 PJ/annum (2018) to 1.9 PJ/annum (scenario 1) or 8-fold to 3.2 PJ/annum (scenario 2). At the same time, the resulting avoided water industry GHG emissions are 250 kt CO_2-e/annum (scenario 1) or 450 kt CO_2-e/annum (scenario 2). A major emission reduction benefit for a minor WWTP infrastructure upgrade effort. Payback is expected within 3-4 years.

CONCLUSION

A carbon neutral water industry is achievable under NZ conditions. Using scenario 1 and 2 as lower and upper boundaries, the presented scenario calculations show a carbon neutral water industry operation for the NZ water industry in 2050. Recent biosolids digester developments showed feasibility and good economic drivers for digestion plants in WWTP above 10,000 EP (under European conditions). The currently assumed economic size threshold for NZ and Australia should thus be reviewed and if necessary, reset to the new technology. RT-digester can be an important component for such a reset (as this paper has shown).The assumptions, calculations and data shown here are conservative, especially if one considers a potential carbon emissions price increase from $A 25/t CO_2-e (2018) to $A 100/t CO_2-e (2030) to $A 150/t CO_2-e (2050). The available resource feedstock potential for co-digestion in New Zealand (municipal and industrial) in 2050 is estimated to be sufficient for production of about 10 PJ biogas/annum.

A parallel similar investigation for Australia is highly recommended. Due to the higher power prices in Australia and the higher carbon content (> 80 %) in the power generation, we expect even better drivers for the Australian water industry to achieve carbon neutral status. The work shown here indicates one promising angle where to start.

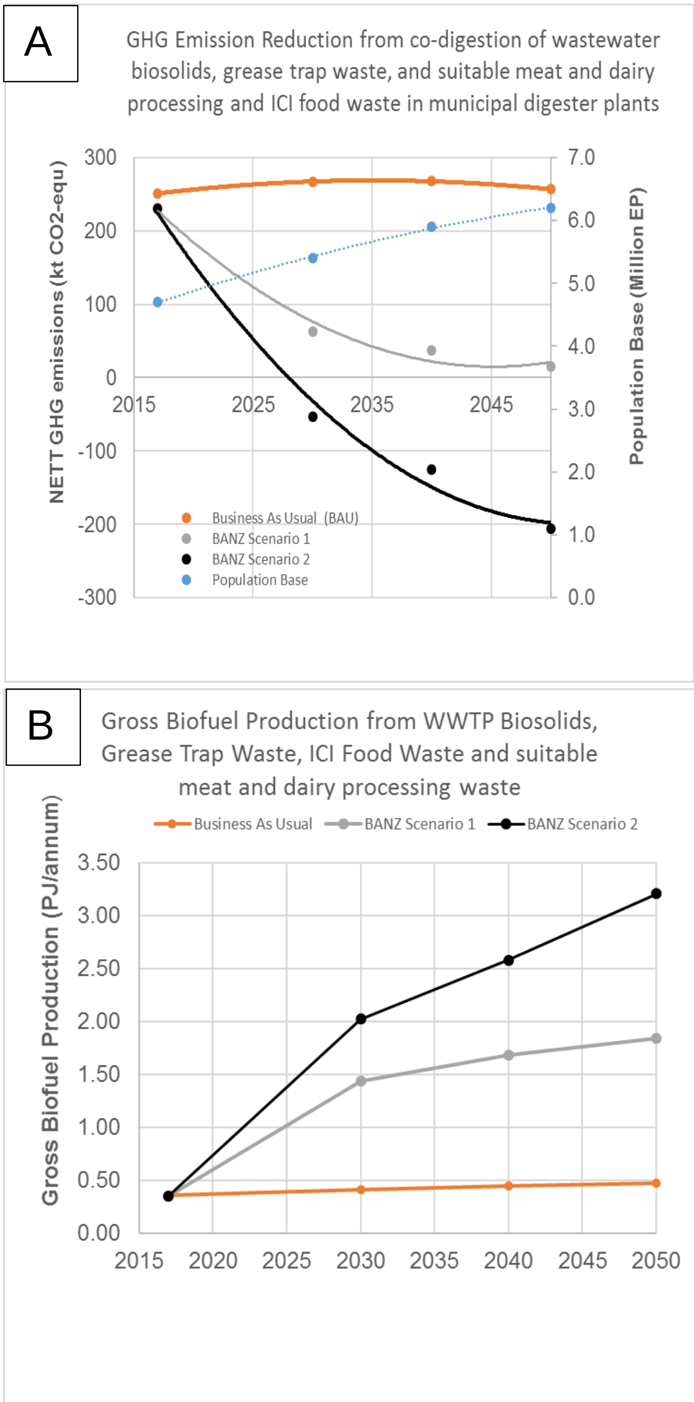

Figure 1:

Comparison of the projected annual GHG emission reduction (A) and biofuel production (B) for the three possible pathways modelled ("Do Nothing" = BAU scenario; "moderate" scenario1 and "more aggressive" scenario 2). Please note that all scenarios and GHG emission calculations are based on biogas use for onsite energy needs and surplus biogas exported to a wide range of co-existing options (industrial heat, natural gas (NG) vehicles, electric (EV) vehicles, hydrogen vehicles, hydrogen distribution grid) to replace natural gas/LPG use. Due to the high renewable energy content (84-86 %) in the New Zealand electricity market, dedicated power generation from the biogas will play a minor role. Please note that the moderate scenario 1 is mainly based on recuperative thickening installations with very few new digester plants. Upgraded digesters in scenario 1 process biosolids, ICI quality pre-consumer food waste and grease trap waste. The resulting annual GHG emission reduction is expected to "practically" offset the current and future GHG emissions from WWTP biosolids and GTW management. Please note that in scenario 2, co-digestion of 70 % of suitable meat and dairy processing industry waste material is added to scenario 1. Scenario 2 is expected to generate an additional GHG offset of about – 200 kt CO_2-equ/annum in 2050. Please note that in Figure 1 B the biogas production from waste to energy schemes in 2050 is 3 – 6 fold higher (in scenario 1 and 2) than in the BAU scenario. This demonstrates the extent of the circular economy benefits that the cost effective digester capacity upgrades at municipal WWTPs provide.

*Table 1: List of municipal wastewater treatment plants in New Zealand in **2030 in scenario 1 and 2**. All WWTP operations shown practice anaerobic co-digestion of municipal biosolids, trade waste co-digestion, food waste co-digestion and biogas is exported into a local biogas grid (gensets) associated with the wastewater treatment plant operations. WWTP with digesters shown in the list have adopted trade waste co-digestion (locally available sources, no industrial waste added in scenario 1 but industrial waste sources added in scenario 2).Three municipal WWTP operations in the Greater Wellington area follow Rosedale, Hamilton, Tauranga, Christchurch and Dunedin examples. Please note that the scenarios are based on the condition that 21 other WWTP of adequate size remain without biosolids digesters in NZ. The assumptions in the list below are conservative.*

Council, Name	**Proportion of NZ Population serviced (2030)**	**Wastewater Treatment Level**
Christchurch City Council, Bromley	8.0%	Tertiary
Dunedin City Council	1.7%	Tertiary
Dunedin City Council, Green Island	0.5%	Tertiary
Dunedin City Council, Mosgiel	0.2%	Tertiary
Hamilton City Council, Pukete WWTP	3.2%	Tertiary
Horowhenua District Council, Levin WWTP	0.4%	Tertiary
Invercargill City Council, Clifton WWTP	1.8%	Tertiary
Palmerston North, Totara Road WWTP	1.8%	Tertiary
South Waikato District Council,	0.3%	Tertiary
Taupo District Council, Taupo	0.5%	Tertiary
Tauranga City Council,	1.7%	Tertiary
Watercare, Rosedale WWTP	4.4%	Tertiary
Watercare, Mangere WWTP	26.9%	Tertiary
Whangarei District Council	1.2%	Tertiary
Manawatu District Council	0.3%	Tertiary
Hutt City Council, Seaview	2.8%	Tertiary
Porirua City Council, Porirua WWTP	1.3%	Tertiary
Wellington City Council, Moa Point	3.6%	Tertiary
Total:	61%	

Table 2: Inventory and status of municipal wastewater treatment plants in New Zealand ***in 2050 in scenario 1 and 2****. All WWTP operations shown practice anaerobic co-digestion of municipal biosolids with biogas capture, trade waste co-digestion, food waste co-digestion and biogas export into a local biogas grid (gensets) associated with the wastewater treatment plant operations. Improved "economy of scale" is achieved with added in industrial waste to fully utilise digester capacity incentivised by a low gate fee and a "carbon price" ($A 150/t CO_2-e). Scale and carbon price have incentivised seven plants (1/3rd of the remaining 21 plants in 2030) to add anaerobic co-digestion of industrial waste to their treatment process. There remain 14 other WWTP of sufficient scale but without biosolids digesters in 2050. The assumptions in the list below are conservative.*

Council, Name	Proportion of NZ Population serviced (2050)	Wastewater Treatment Level
Christchurch City Council, Bromley	8.0%	Tertiary
Dunedin City Council, Tahuna	1.7%	Tertiary
Dunedin City Council, Green Island	0.5%	Tertiary
Dunedin City Council, Mosgiel	0.2%	Tertiary
Hamilton City Council, Pukete WWTP	3.2%	Tertiary
Horowhenua District Council, Levin WWTP	0.4%	Tertiary
Invercargill City Council, Clifton WWTP	1.8%	Tertiary
Palmerston North, Totara Road WWTP	1.8%	Tertiary
South Waikato District Council	0.3%	Tertiary
Taupo District Council, Taupo	0.5%	Tertiary
Tauranga City Council, Chapel Street	1.7%	Tertiary
Watercare, Rosedale WWTP	4.4%	Tertiary
Watercare, Mangere WWTP	26.9%	Tertiary
Whangarei District Council	1.2%	Tertiary
Manawatu District Council	0.3%	Tertiary
Hutt City Council, Seaview	2.8%	Tertiary
Porirua City Council, Porirua WWTP	1.3%	Tertiary
Wellington City Council, Moa Point	3.6%	Tertiary
Hawkes Bay District Council	2.7%	Tertiary
Nelson City Council, Bells Island	1.1%	Tertiary
Nelson City Council, Nelson North	0.5%	Tertiary
New Plymouth	1.7%	Tertiary
Rotorua District Council	1.2%	Tertiary
Tauranga City Council, Te Maunga	0.7%	Tertiary
Timaru District Council, Industrial + Domestic	1.5%	Tertiary
Total:	70%	