OPPORTUNITIES FOR EMBEDDING CIRCULAR ECONOMY PRINCIPLES IN THE AUSTRALIAN WATER SECTOR

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EXECUTIVE SUMMARY (100 words maximum)

The Australian Water Sector has long been operating under a 'take-make-consume-dispose' model and the need to shift to a circular economy is rapidly becoming apparent with the impending challenges of climate change, population growth and increased costs. Radical solutions are necessary to facilitate this transition. .

This paper explores specific ways in which the Australian water sector can start making this transition and through using anaerobic digestion, explores how value can be derived from the whole value chain of wastewater. Some of the key opportunities include carbon sequestration through biochar, embedding hydrogen technology and market based solutions where the water sector can partner up with industry and agriculture to create a regional methane economy.

INTRODUCTION

The term Circular Economy is rapidly sweeping the water sector but ideas for embedding these principles are still lacking maturity. It is therefore urgent to begin exploring ways in which the water sector can play a role in transforming the 'take-make'consume and dispose' model of growth towards sustainable development and help realise some of the key economic benefits that are characteristic for a circular economy.

A recent review breaks down the circular economy as it relates to the water sector into three interrelated pathways: the water pathway; the material pathway and the energy pathway (IWA 2016). While Ausralia has made some head road into closing the water loop there is still much to be done with regards to closing the energy and material loops and these need to be included should the water sector truly move towards a circular economy.

This paper explores specific innovative ways in which the water sector can embed circular economy principles into its operations to help "close the loops" for water, nutrients, soil fertility, climate and energy - collectively and with easily manageable and proven methodology.

METHODOLOGY/ PROCESS

Integrated biogas systems closing the material and energy loop

Anaerobic digestion (AD) is globally recognised as an important cornerstone technology for a future circular economy (IEA Bioenergy Task 37). Biosolids produced in municipal wastewater treatment present a key opportunity for closing out the energy, soil fertility and material pathways in wastewater treatment. The UN World Water Development report described Wastewater as one of the worlds largest untapped resources and through anaerobic digestion Australia could help close out the energy and material pathways and maintain economic sustainability. This is therefore a key avenue to embed circular economy principles into the water sector in Australia.

Figure 1 shows the mechanism under which anaerobic digester facilities (biogas plant) could support a circular economy, though it will be site specific. Specifically co-digestion of sewage sludge and regionally specific organic waste streams will be a common theme in all sites (Thiele 2018) which can help increase recovery of biofuels, bioplastics, biochar, enzymes, water and nutrient concentrates through digestates, processed digestates, carbon storage materials and value added fertilizers.

OUTCOMES

Soil fertility programs

Table 1 describes the value potential that wastewater and thus sewage sludge has on its own. When considered with co-digestion this is likely to increase significantly. The synergies with local agriculture and industry cannot be ignored should the water sector want to embed circular economy principles. Digestate from trade waste co-digestion produces improved organic fertilizers thereby reducing environmental and carbon footprints and supporting local industry through reduced costs of fertilizer application (Thiele 2018).

Carbon capture and sequestration (CCS)

All climate model to date have highlight the important role of CCS for stabilisation of the world climate at average temperatures of < 2^o C above pre-industrial global temperatures. The challenge is to achieve this at least cost and in an economically sustainable way. Biochar production from processed biosolids and cultivation of dedicated CCS energy crops with nutrient rich filtrates can play a dual role for CCS and soil fertility when the carbon price is expected to exceed about $A 100/t CO_2-e (around 2030). The commercial opportunities for the water industry in Australia are then nearly unlimited.

A regional methane economy

A large part of circular economies is about regionalisation of materials streams. Production of 3-5 fold increased amounts of low cost biomethane (biogas) from co-processing organic waste in municipal WWTPs (Thiele 2018) lends itself to cost effective decarbonisation of public transport and corporate fleets (transport energy from carbon neutral biomethane fuel).

Optimising and sharing existing assets

A key element of the circular economy will be opportunities for improved utilisation of existing water sector assets and the extension of their asset life and this can be achieved through integrated biogas systems and co-digestion. Specifically recuperative thickening helps double digester biofuel production capacity and substantially improves organic waste co-digestion business cases.

Other opportunities include photovoltaics and mini-hydro within existing water and wastewater infrastructure. Specifically mini-hydro by generating electricity from water, and floating solar by being able to reduce evaporative water losses whilst simultaneously improving electricity generation efficiency from solar PV panels

Closing the energy loop with Hydrogen

Hydrogen is being recognised for its properties as a long-term energy storage medium and renewable energy carrier for decarbonising multiple industry sectors. These properties along with the fact that recycled wastewater and biogas can be used in the production of Hydrogen (H2) means that it is relevant in a circular water sector. Waste CO2 can also be used in combination with H2 to create value-added products such as biomethane and biomethanol.

Biogas from the water sector can be used as alternative CH_4 source to produce H2 and can significantly reduce greenhouse gas emissions. Within this context, the integration of biogas reforming processes and the activation of proton exchange membrane (PEM) electrolysers using bioenergy represent an important route for generating clean energy, with added high-energy efficiency. From H2, electricity can also be generated through microturbines and fuel cells thereby providing energy to the adjacent plant in lieu of grid-connected electricity along with additional thermal energy for heating and cooling. This H2 can also be used as an additional revenue stream via sale to fleet such as buses and passenger vehicles whilst the associated PEM electrolysers can also be used to generate significant revenue from sale of demand response (DR) and frequency control ancilliary services (FCAS) to the local electricity network operator.

CONCLUSION

A key to seeing the water sector transition to a circular economy is the need to adopt new business models. Traditionally the water sector has been singly focused on producing water that is fit for purpose. However embedding the circular economy through integrated biogas systems, carbon capture and embedding hydrogen present new opportunities for fully integrated systems and the associated market uptake. Such approaches will require the embedding of technological, organisational and social innovation through the whole value chain of water while exploring synergies with other sectors.

Figures and Tables

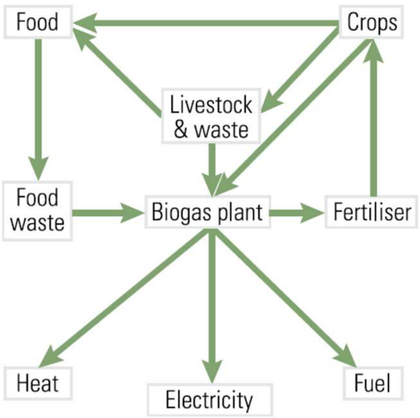

Figure 1: Closing the energy and material flow through anaerobic digestion

Table 1: Resource Recovery Potential of Municipal Wastewater without ACD[1]

Wastewater Target Components	Amount per kL of wastewater
Water	1 m^3
Nitrogen	0.04 kg
Methane	0.14 m^3
Organic Fertiliser	0.10 kg
Phosphorus	0.01 kg

[1] Calibre, 2018. Calibre Submission Re: Low Emissions Economy DRAFT Report *https://www.productivity.govt.nz/view/submissions/3254*

[2] Wastewater – An Untapped Resource – Australian Academy of Technological Sciences and Engineering (ATSE), 2015