OPPORTUNITIES FOR RENEWABLE ENERGY IN THE NEW ZEALAND WATER SECTOR

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ABSTRACT

The New Zealand water industry is trying to cope with a rapidly growing population, the most significant in Auckland. Consequently there is significant ongoing investment in water, wastewater and transmission assets. With increasing industry-wide interest in achieving carbon neutrality, there is an opportunity for renewable energy to play an integral part in reducing water sector energy costs and providing off grid renewable energy solutions.

In 2015 Beca was commissioned by the Australian Renewable Energy Agency (ARENA) to undertake a study to investigate the opportunities and barriers of implementing renewable energy solutions in the Australian water industry. The Australian water sector is a significant consumer of energy.

To identify renewable energy priority areas, a staged investigation methodology was employed consisting of literature reviews, stakeholder engagement initiatives and multiple-criteria analysis to evaluate opportunities to overcome barriers to improve renewable energy use.

As a result of the ARENA study, the four priority areas that were identified are: renewables in water pumping and irrigation, bioenergy in wastewater treatment, energy storage technologies and demand management, and water specific renewables including mini-hydro, floating solar and small scale renewable desalination.

This paper will discuss these four priority areas and how renewable energy technologies identified as part of the study rank at an Australian and international water sector level, and how the New Zealand water sector could potentially benefit from these opportunities.

KEYWORDS

Renewable energy, energy neutral, biogas

1 INTRODUCTION

The Australian Renewable Energy Agency (ARENA) was established by the Australian Government to promote the use of renewable energy in Australia. In 2015 ARENA employed Beca to undertake a study to investigate the opportunities for and barriers to the use of renewable energy in the Australian water sector.

The study methodology involved an extensive literature review and a broad stakeholder engagement process. The information gathered from these processes was then analysed in order to identify possible renewable energy opportunities, which were tested and analysed in relation to ARENA's objectives and the specific needs of the water sector. The general investigation process is illustrated in Figure 1.

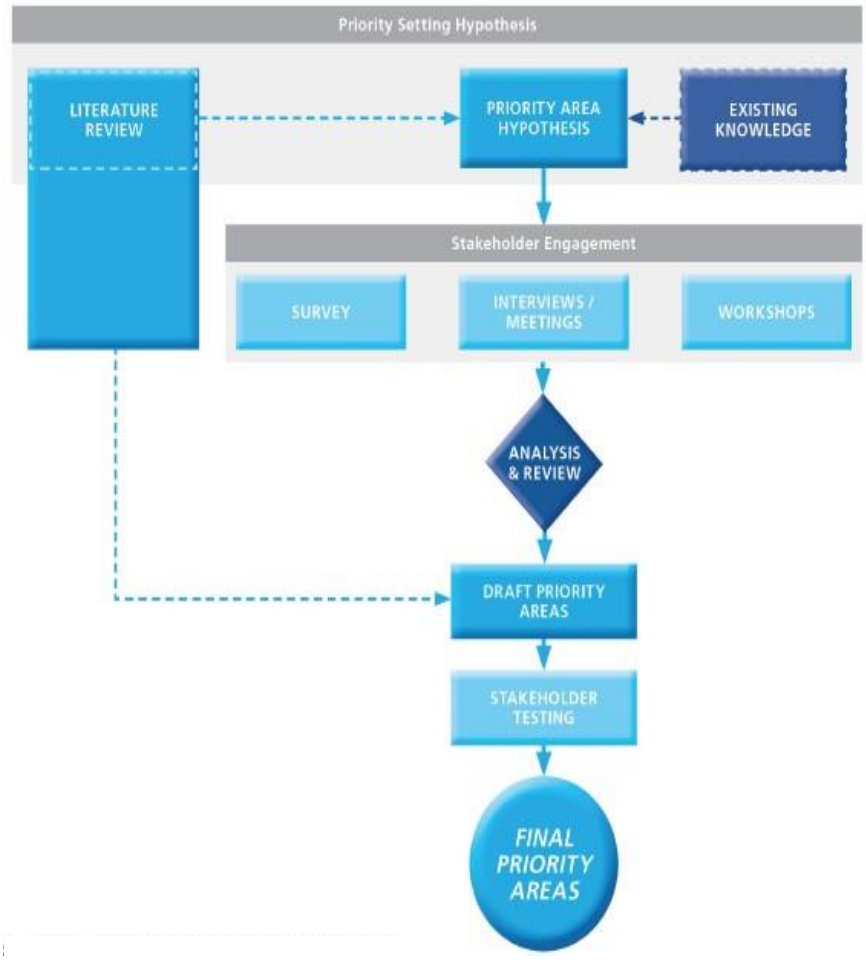

Figure 1: Flow diagram of the overall study methodology

This paper describes the methodology and principal findings of the ARENA study, with the objective of provoking discussion on how New Zealand might exploit similar opportunities that might exist in our own water sector.

2 LITERATURE REVIEW

The literature review covered renewable energy exploitation trends in Australian and international water management systems. The objective was to identify and compare patterns in energy usage, current levels of renewable energy use, the already identified opportunities for development, and industry trends and practices.

The findings were used to identify the areas where Australia has not already pioneered or followed international practice. The comparison took the form of a modified and consolidated Technology Maturity Level (TML) rating scale, based on the globally accepted Technology Readiness Level (TRL) benchmarking tool and the Commercial Readiness Index (CRI) developed by ARENA.

The relationship between the TML rating scale and the TRL and CRI rating scales is illustrated in Figure 2.

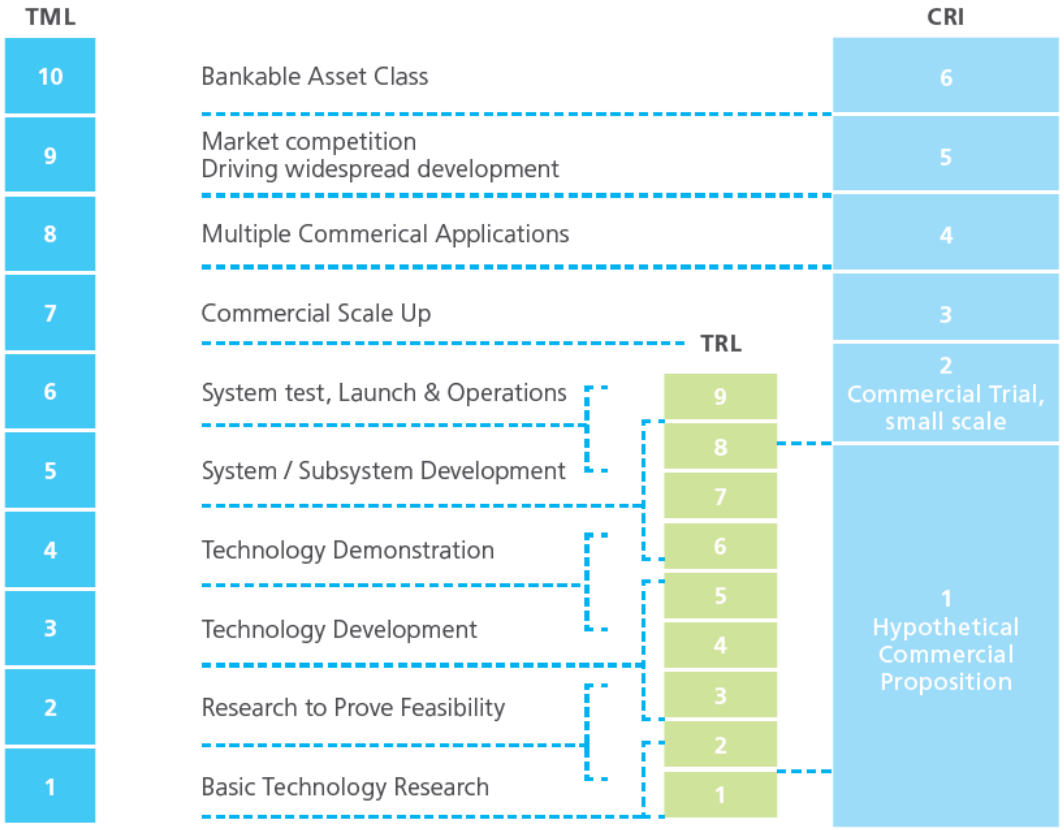

Figure 2: Graphical overview of TML rating scale and relationship with the TRL and CRI rating scales

The key results of the literature review and the outcomes of the gap analysis are summarised in Table 1.

Table 1: Summary of Literature Review Findings

	Water Market	
Water Subsector	**International**	**Australia**
Raw Water	▪ Significant large-scale hydroelectric power facilities ▪ Growing trend in use of floating solar PV	▪ Most large-scale hydroelectric power opportunities already exploited with limited new opportunities for large-scale hydro ▪ Existing hydroelectric generation heavily dependent upon rainfall and significantly affected during periods of drought ▪ Growing interest in floating solar PV technology, including pilot scale deployment
Desalination	▪ Growing development of direct solar PV powered large-scale desalination facilities ▪ Growing interest in direct thermal desalination including solar thermal and geothermal ▪ Approximately 1% of global desalination supplied by renewable energy sources	▪ Limited expected medium term development of large-scale desalination facilities ▪ The energy usage of existing desalination facilities is largely offset by grid supplied renewable energy ▪ Increasing viability of small-scale desalination facilities as an alternative water source for farming
Water Distribution	▪ Growing use of small-scale hydro for energy recovery	▪ Growing use of small-scale hydro for energy recovery
Wastewater	▪ Wide use of biogas facilities with many facilities becoming net energy neutral or even positive ▪ Growing use of biogas as a transport and pipeline gas fuel ▪ Growing use of latent heat in sewage systems for heating of buildings	▪ Approximately 34 MW of biogas electricity generation facilities at urban wastewater treatment plants ▪ Growing research and interest in algae as an alternative wastewater treatment process ▪ Growing interest in co-digestion as a means to boost biogas production, particularly for small wastewater facilities
Water Recycling	▪ Increasing use of water recycling and alternative water treatment methods	▪ Increasing use of water recycling as an alternative water treatment process. No direct renewable energy application.

	Water Market	
Water Subsector	**International**	**Australia**
Irrigation & Agriculture	▪ Significant potential for increased use of remote renewable pumping technologies in off-grid areas ▪ Growing use of bioenergy resource through utilisation of crop waste as feedstock	▪ Largest consumer of freshwater in Australia ▪ Strongly seasonal water usage trends a profiles depending upon crop and livestock farming practices ▪ High cost of electricity and/or diesel for off-grid and fringe of grid locations for water pumping activities ▪ Significant existing use of bagasse fired biomass power generation facilities in both NSW and QLD

3 STAKEHOLDER ENGAGEMENT

Informed by the preliminary findings of the literature review, a broad stakeholder engagement process was conducted across a range of forums. The main focus and aims of the stakeholder engagement process was to seek the input of affected participants and test the findings of the literature review, as well as facilitate knowledge sharing and consultation.

Through the initial findings of the literature review it became evident that the energy practices and organisational requirements of participants across the full array of water subsectors varied significantly, depending upon whether the participant was active in the urban water or the agricultural sectors. Regardless, all sectors were able to participate and were equally represented.

A summary of the stakeholder engagement activities and participation levels is provided in Table 2.

Table 2: Summary of Stakeholder Engagement Activities

Activity	Overview	Participation
Online Survey	Online survey distributed using direct email, social media and through water sector industry bodies.	121 responses
Interviews and Presentation	Face-to-face and phone interviews with individual stakeholders as well as presentation to industry groups and committees.	10 one-on-one interviews Presentation to National Irrigators Council (Energy Subcommittee) and International water Association (Energy & Greenhouse Special interest Group).
Workshops	Two stakeholder engagement and knowledge sharing workshops conducted in Sydney and Melbourne using face-to-face and webinar delivery.	24 in person attendees and 6 webinar participants.

Stakeholder MCA Participation	Independent stakeholder participation in completion of Multiple-criteria analysis (MCA) using developed MCA assessment matrix.	5 participants in face-to-face format.

The results from the stakeholder engagement activities were then analysed according to the responses from both the urban water and agricultural sectors with a view to identifying barriers, opportunities and perceptions in the industry in order to gauge the likely success of any ARENA investment. A summary of the key findings and outcomes of the aggregated stakeholder engagement results is provided in Table 3.

Table 3: Summary of Stakeholder Engagement Key Findings

Technology	Urban Water Stakeholders	Agricultural Stakeholders
Solar PV	High interest in solar PV technology, with a significant uptake in conventional solar PV applications including rooftop and ground mount. There is a significant interest in floating solar applications, however with very limited uptake besides one installation in Jamestown, SA. Stakeholder feedback suggests that little information is known about the technical performance and benefits of floating solar making feasibility assessment difficult. There is limited interest in solar/diesel hybrid options, likely due to easier access to the electricity grid.	High interest in conventional solar PV technology, however with a much lower installation rate compared to the urban water sector. Typically the cost of electricity is higher for the agricultural sector than that of the urban water sector. Uptake is expected to be limited. There is limited interest in both floating solar applications and solar/diesel hybrids, with the vast majority of respondents never considering these technologies. This is expected to be primarily due to lack of knowledge of technology as well as lower applicability due to the absence of existing infrastructure such as dams or diesel generating sets.
Bioenergy	High interest in biogas with a high uptake of cogeneration and direct heating applications. Applications involving co-digestion and biogas storage have lower uptake. Despite moderate interest in biofuel and algal technologies, uptake is still low and primarily limited to research and trials to prove the economic viability.	Low interest in bioenergy technologies with no examples of use from survey respondents, the vast majority of whom have not even considered it. Agricultural interest in bioenergy is predominantly limited to waste streams associated with high density livestock or consolidated crop wastes.

Technology	Urban Water Stakeholders	Agricultural Stakeholders
Hydroelectric	High interest and moderate uptake in small- scale hydro. Highest interest in in-conduit hydro, correlating with lowest uptake suggesting that this is an emerging area of interest to water utilities. Low interest in larger scale hydro (>1 MW) suggesting that fewer larger hydro opportunities exist within the market with most of the economically viable ones having already been realised.	Low interest in hydro opportunities with majority of respondents indicating that the technology is not applicable to their business. Hydro applications limited primarily to large scale irrigation systems.
Wind	High interest in small-scale wind but with very low uptake with cost, regulatory and performance barriers noted as main reasons. Low interest in large-scale and wind/diesel hybrid technologies.	Low interest in electricity generating wind technologies overall. Moderate uptake of direct windmill applications for pumping. Technical/performance issues noted as primary barrier, suggesting that challenges may lie with technology knowledge and also intermittency of the motive force.
Geothermal / Ocean / Biomass	Low interest and activity in geothermal, ocean and biomass energy technologies. None of the technologies are expected to present any significant opportunities for the water sector.	Low interest and activity in geothermal, ocean and biomass energy technologies. Geothermal and ocean technologies not expected to present any significant opportunities for this sector. Availability of biomass from crop waste and use of energy crops may present some potential for the agricultural sector, however respondents indicated little interest or activity in this area.
Storage	High perceived benefit of battery storage and moderate perceived benefit of both biogas and pumped hydro storage.	High perceived benefit of battery storage and moderate perceived benefit of pumped hydro storage. Benefit of storage technologies/ applications viewed as important in overcoming intermittency and infrequency of many seasonal irrigation systems.

4 MULTIPLE-CRITERIA ANALYSIS

In order to evaluate the potential that ARENA may have to influence the improvement of renewable energy use within the water sector, a multiple-criteria analysis was undertaken to provide a comparative assessment of the possible investment priority areas.

A total of 31 different technologies and associated practices were selected for assessment based upon those opportunities identified during the literature review and stakeholder engagement stages. In order to provide a structured framework for assessment of the selected technologies, an assessment criteria was selected based upon ARENA's investment funding criteria with associated criteria weightings outlined as follows:

- Likely Scale by 20130-40 (22.5% weighting)
- Potential for Growth (22.5% weighting)
- ARENA Investment Influence (22.5% weighting)
- Fit with ARENA Portfolio (22.5% weighting)
- Other (10% weighting)

In order to simplify the ranking of the various criteria, a qualitative ranking system was assigned based upon a scale of 'None', 'Low', 'Medium' and 'High' in order to determine the ranking of opportunities relative to each other. Individual criterion rankings were then scaled based upon the nominated criteria weightings to develop a scaled overall ranking for each opportunity as either 'Very Low', 'Low', 'Low/Medium', 'Medium', 'Medium/High', 'High' and 'Very High' in order to identify those opportunities which represent the best overall alignment with ARENA's objectives.

The multi-criteria analysis was conducted initially in-house with participation from ARENA, to provide an independent evaluation based upon an internal assessment. The process was then repeated with representative water sector stakeholders to provide a comparison between industry perceptions and the in-house assessment.

In general, good correlation was found between the outcomes of the in-house and stakeholder multi-criteria analysis taking into consideration the significantly different energy challenges from the urban water and agricultural sector participants. In reviewing the outcomes of the multi-criteria analysis for those opportunities whose overall ranking was rated as 'High' and 'Medium/High', the highest ranked opportunities were noted to generally fall into five main renewable categories as summarised in Table 4.

Table 4: Summary of Multi-Criteria Analysis Highest Ranked Opportunities

Opportunity Category	Overall Ranking	Technology/Practice
Renewable Pumping	High	Renewable Pumping
Bioenergy	High	Anaerobic Co-digestion
	Medium/High	Biogas Cogeneration
	Medium/High	Biogas Storage
	Medium/High	Biomethane (Pipeline)
	Medium/High	Algal Biofuel
	Medium/High	Biomass Gasification
Storage/Demand Management	Medium/High	Battery Storage
	Medium/High	Pumped Storage
	Medium/High	Demand Management
	Medium/High	Biogas Storage
Solar PV	Medium/High	Floating Solar PV
	Medium/High	Rooftop Solar PV
	Medium/High	Ground Mount Solar PV
Mini-Hydro	Medium/High	Mini-Hydro

The highest ranked priorities were then reviewed in the context of emerging trends and commercial readiness of each technology, so as to determine those opportunities that would likely benefit from ARENA support.

5 OUTCOMES

Four priority areas for renewable energy development were proposed for ARENA's consideration:

a. **Renewables in Water Pumping and Irrigation**
   Renewable energy technologies, or applications of technologies and/or processes, for water pumping and irrigation purposes.

b. **Bioenergy in Wastewater Treatment**
   Improved utilisation and generation of bioenergy in wastewater treatment applications.

c. **Storage technologies and Demand Management**
   Improved use of energy storage technologies and practices to increase renewable energy use in water pumping applications.

d. **Water Specific Renewables**
   Focus on understanding and supporting renewable energy technologies that have distinct advantages or opportunities within the water sector including: mini-hydro, floating solar PV and small-scale renewable desalination.

The success and impact of ARENA activities to support renewable energy within the Australian water sector remains highly dependent upon interest, participation and contribution of water sector stakeholders. Feedback is currently being sought on the completed report.

6 APPLICATIONS FOR NEW ZEALAND

6.1 HYDRO AND SOLAR ELECTRICITY GENERATION

For hydro electricity generating potential to be realised, one needs two fundamental ingredients – water supply (i.e. volume) and head (i.e. potential energy able to be released through gravity). In general the larger the hydro generating scheme the higher yield per invested capital expenditure dollar. Small schemes tend to be expensive when assessed on an installed $/kW basis.

The physical differences in the respective Australian and New Zealand climate, topographies and energy sources make-up may explain why hydro generation in the water sector in Australia has had a moderate degree of uptake compared to New Zealand, where uptake has been low. The energy savings to be realised by installing small hydro in New Zealand are not likely to result in savings in cost, since in most cases it is cheaper to import power from the (large scale hydro-dominated) grid.

The economics of pump storage (pumping water uphill during periods of the day when power cost is low, generating power at high-cost periods) is similarly marginal in the New Zealand grid, where we currently have more generating capacity than we need.

For solar PV electricity generating potential to be realised, one needs high year-round incident solar energy and lots of available space. At the moment there are very few regions in New Zealand where the rate of return on investment is sufficient to invest in large-scale solar PV electricity generation.

In Australia, the government has put in place incentives to implement renewable generation, whereas in New Zealand we rely on the low marginal cost of renewable energy sources to provide a natural market advantage and a (light touch) emissions trading scheme. The water industry is exempt from the New Zealand Emissions Trading Scheme, so the drivers for adoption of renewable electricity generating technologies in this sector are largely financial. At the moment, the economic drivers just aren't there.

6.2 BIOGAS FOR COGENERATION

To Beca's knowledge, the only significant current application of renewable energy technology in New Zealand is in bioenergy.

According to the Bioenergy Association (www.bioenergy.org.nz), more than 10 percent of New Zealand's energy currently comes from biological sources such as wastewater, landfills and bioenergy crops. It is estimated that bioenergy could supply 25 percent of New Zealand's energy needs by 2040, including 30 percent of our transport fuel. Bioenergy has the potential to add revenue of $6 billion per year to the country's economy.

Raw biogas derived from wastewater is a very versatile fuel that can be used in many different applications. The most common is use as renewable electricity in Combined Heat and Power (Cogen) plants, as is currently done at numerous wastewater treatment plants in New Zealand.

For example, in 2013 Beca was involved in the investigation, specification, integration design and installation of a biogas co-generation engine at the Christchurch Wastewater Treatment Plant (CWTP).

In 2014 Beca prepared a sludge management strategy for Palmerston North City Council to evaluate new technologies for sludge treatment. A part of the review, Beca considered the WWTP digester loadings and performance, estimates of the methane production, cogeneration of electrical power generation and heat output for use in the sludge drying options.

6.3 COMPRESSED BIOGAS AS A VEHICLE FUEL

Due to long-term fuel supply and environmental concerns, there is also increasing interest worldwide in the development of renewable, sustainable vehicle fuel technologies. Technologies for upgrading the biogas produced in anaerobic digestion are well established and operational over a wide range of production rates. Vehicle fleets are being successfully run on Compressed Bio-Gas (CBG) in many countries, particularly in Europe.

However, implementation of CBG schemes is primarily driven by economics – the relative commodity values of vehicle fuel and electricity and the existence of established markets for them. This can be purely market driven, or influenced by Government legislation such as feed-in tariffs for electricity generated by renewable sources. In our case, our 'Biofuel Bill' incentivizes CBG production by requiring fuel retailers to sell a certain percentage of fuel from renewable sources.

Beca undertook a feasibility study for Watercare in 2008 to assess the economic feasibility of using some of the bio-gas generated at the Mangere WWTP to make CBG, either for use in Watercare vehicles or to sell to fuel retailers. While it did not prove to be economically attractive back then, market conditions and our Paris Accord commitments may now justify revisiting the findings.

It is also interesting to note that Christchurch City Council ran a small fleet of vehicles on compressed biogas (from the CWTP digesters) during the energy crisis in the 1970s.

7 CONCLUSIONS

As one might expect given the political and physical Australian environments, water utilities in Australia have high interest in solar PV, hydro and wind generation with high uptake of solar PV, moderate uptake of hydro and low uptake of wind.

As in New Zealand, there is high interest and uptake of biogas cogeneration in Australia.

In New Zealand, there appears to be little interest or uptake in solar PV, hydro or wind power generation in the water sector, given relatively poor financial incentives. We have been unable to find any specific research related to the technical viability of these technologies, other than for solar PV domestic applications.

Financial incentives could improve with the introduction of a more meaningful emissions trading scheme that is also applied to the Water Industry, an upwards change in the price of electricity, or significantly lower $/kW installed costs for energy storage or renewable generation technologies.