LOW CARBON LIVING CRC

Operationalising Australian Energy Benchmarking for Efficient, Low-Carbon Wastewater Treatment

Final Report

Australian Government
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Acknowledgements

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The author(s) confirm(s) that this document has been reviewed and approved by the project's steering committee and by its program leader. These reviewers evaluated its:

- originality
- methodology
- rigour
- compliance with ethical guidelines
- conclusions against results
- conformity with the principles of the Australian Code for the Responsible Conduct of Research (NHMRC 2007),

and provided constructive feedback which was considered and addressed by the author(s).

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Acronyms

BEC tool – Benchmarking Energy and Carbon tool

BOD – biochemical oxygen demand

COD – chemical oxygen demand

KPI – key performance indicator

kWh – kilowatt hours

PE – population equivalent

TN – total nitrogen

WSAA – The Water Services Association of Australia

WWTP – wastewater treatment plant

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Executive Summary

Wastewater treatment plays a pivotal role in the protection of public and environmental health in urban precincts and in the recovery of scarce water and energy resources for an increasingly urban and growing global population. Yet wastewater treatment operations are among the most energy-intensive within urban precincts and so there is considerable scope to optimise wastewater treatment plants to improve their energy efficiency and reduce associated carbon emissions. One such approach used to realise energy efficiency savings is 'energy benchmarking' which is an approach whereby energy use key performance indicators are developed for a range of wastewater treatment plants and treatment processes and then used by industry to 'benchmark' current treatment process performance, and inform subsequent process optimisation requirements for future energy efficiency savings.

This project used a national wastewater treatment plant energy use dataset for some 244 treatment plants across Australia to develop a Benchmarking Energy and Carbon (BEC) tool, or data visualization dashboard for the Australian water industry to use in future energy efficiency assessments with the goal of driving future optimisation for energy and associated carbon emissions savings in the sector. The tool has been developed in the form of an intuitive internet-based Tableau dashboard, making it both highly accessible and user-friendly. At the expiry of this project, the tool currently exists in beta version format and further work will be undertaken by the project team to complete tool development activities and deliver it to the water industry's peak body association (The Water Services Association of Australia) for broader dissemination to its water industry stakeholders.

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Introduction

Wastewater treatment plays a pivotal role in the protection of public and environmental health in urban precincts and in the recovery of scarce water and energy resources for an increasingly urban and growing global population. Until recently, energy has been relatively inexpensive and many wastewater treatment facilities were simply not designed or operated with a goal to minimise energy consumption or maximise energy efficiency (NYSERDA, 2010). Moreover, the gradual progression from simple low-cost treatment processes, to more advanced highly engineered processes in order to meet increasingly stringent regulatory criteria has led to a progressive increase in the energy intensity of wastewater treatment over time. Today, wastewater treatment operations are among the most energy-intensive industrial activities within urban precincts, with wastewater treatment plants (WWTPs) often the single largest energy users within a municipality (Krampe, 2013). Accordingly, there is considerable scope within existing WWTPs for operational optimisation to improve their energy efficiency.

The application of 'energy benchmarking' methods presents opportunities for the water industry to reduce costs by enabling energy savings and energy recovery at WWTPs, whilst at the same time identifying operational issues for WWTP personnel to focus on to improve plant performance and future performance efficiency. Energy benchmarking is an approach whereby energy use key performance indicators (KPIs) are developed for a range of wastewater treatment operations and then used by industry to 'benchmark' current treatment process performance and inform subsequent process optimisation requirements for future energy efficiency savings (Krampe, 2013).

The basic premise of energy benchmarking is to collect operating energy consumption data from a given WWTP and then compare (benchmark) this performance level against industry performance benchmark values representing average (50th percentile) and best practice (10th or 20th percentile) energy efficiency performance. The difference between the actual energy use and benchmark performance value represents the potential saving to be realised through optimisation (see Figure 1). These 50th and 10th percentile benchmark values are specific to certain technology types (type classes) and sizes (size classes) of WWTPs to ensure proper 'like-for-like' comparisons.

Figure 1 Conceptual overview of WWTP energy benchmarking and efficiency savings
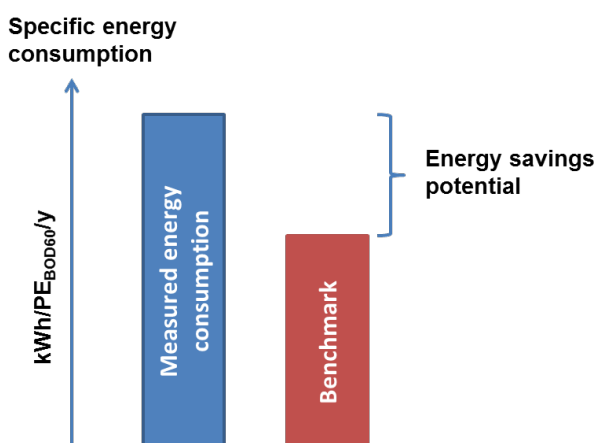
The approach was first developed in Europe in the 1990s and has recently (circa 2012) begun to be applied by Australian water utilities (Krampe, 2013), including two national benchmarking projects coordinated by the water industry's peak body—The Water Services Association of Australia (WSAA)—to date (GHD, 2014; GHD, 2017). These Australian benchmarking studies have resulted in the collection of a considerable data resource on the energy use profiles of some 244 WWTPs nationally – data that has so far sat underutilised and inaccessible in various industry reports (GHD, 2014; GHD, 2017).

The objective of CRC Utilisation Project RP2017u1 was to unlock the potential of this rich data resource for the full benefit of the Australian water industry through the development of an online benchmarking tool or data dashboard. The concept for the tool was to provide user access to the WSAA dataset for the purposes

of independent benchmarking investigations and further promote energy efficiency and CO_2 emissions reductions from wastewater treatment activities.

Project activity summary

The project commenced in January of Quarter 3 2017/18. Tool input was obtained by WSAA and underwent quality checking during both Quarters 3 and 4 2017/18. Prior to project commencement, the project leader was told by WSAA stakeholders that in-kind technical support would be available to the project early in Quarter 4 2017/18 for tool development. Due to complications with WSAA staffing arrangements during 2018, pledged project support from WSAA was not forthcoming until late in Quarter 2 2018/19. A project variation was granted during November 2018 to extend the project end date to April 30, 2019. Initial contingency plans to develop a MS Excel-based tool in the absence of successful development of an internet-based platform were abandoned after consultation with water industry stakeholders highlighting that such Excel-based tools invariably and quickly become outdated/forgotten and fall into a state of disuse due to lack of maintenance. In this regard, the project team elected to solely pursue the internet-based tool option.

In-kind technical support from WSAA stakeholders was made available during Quarter 3 2018/19 and the project had developed a functional Tableau beta version of the benchmarking tool for further development and refinement as of March 2019. The project team attended the WSAA offices in Melbourne during mid-April to further refine the beta version of the tool and these activities have been ongoing past the official project expiry date of April 30, 2019. The project team is continuing to work actively with WSAA for the remainder of 2019 to refine the tool (including adding more benchmark KPIs and enhancing tool functionality) and once finalised, to promote the tool to water industry end users. We have been advised by WSAA that they are unlikely to be able to release the tool before October 2019 as they will need to consult with relevant water industry stakeholders regarding tool data (de)identification at their September meeting of the Energy and Environment Group.

Description of the Benchmarking Energy and Carbon (BEC) tool

The benchmarking tool has been developed in the form of an online Tableau dashboard which allows users to explore the underpinning Australian wastewater treatment plant operational energy performance dataset from some 244 WWTPs nationally. Data can be sorted and interrogated according to a number of parameters such as water utility, wastewater treatment plant type and size class, energy performance percentile level (e.g. 20th or 50th percentile performance) which allows water industry professionals to rapidly assess (benchmark) their own wastewater treatment plant energy performance relative to that of the equivalent national sector performance benchmarks and identify to what extent the potential for energy efficiency optimisations are required.

Figure 2 shows a general layout overview of the tool's Tableau dashboard. Functionality of the tool includes the ability to filter the data by water utility (inset 1), filter by WWTP size class (inset 2), filter by WWTP plant type/sub-class (inset 3) and filter by threshold value for specific energy performance (inset 4). Percentile performance information (e.g. 20th or 50th percentile performance) of the filtered WWTPs are shown on the bottom left pane for rapid benchmarking assessment of industry average energy performance (50th percentile) and industry best practice performance (20th percentile) for a given data set. This enables tool users to very rapidly assess the performance of selected WWTPs against their peers within a particular size class and plant type. Other data display information in the beta version of the tool includes information on WWTP specific energy performance versus annual wastewater flow ("Wastewater flow vs total energy use per PE per year" – bottom right pane) which gives useful energy performance information when considered in the context of WWTP size class, and cumulative frequency distributions of KPI performance according to wastewater treatment plant and utility (top pane) or utility only ("Cumulative distribution by utility" – middle right pane). Figure 3 shows an example dashboard layout with a single water utility selected and filtered only to display the best performing WWTPs (below 20th percentile energy performance) which is done by clicking on the green bars in the lower left pane chart "Which Quartile?" Similar click-based filtering can be done to identify WWTPs performing above the 50th percentile, or between the 20th and 50th percentile range.

Figure 2 Layout of (beta version) Benchmarking Energy and Carbon (BEC) tool Tableau dashboard showing data filtering options (inset red; 1–4).
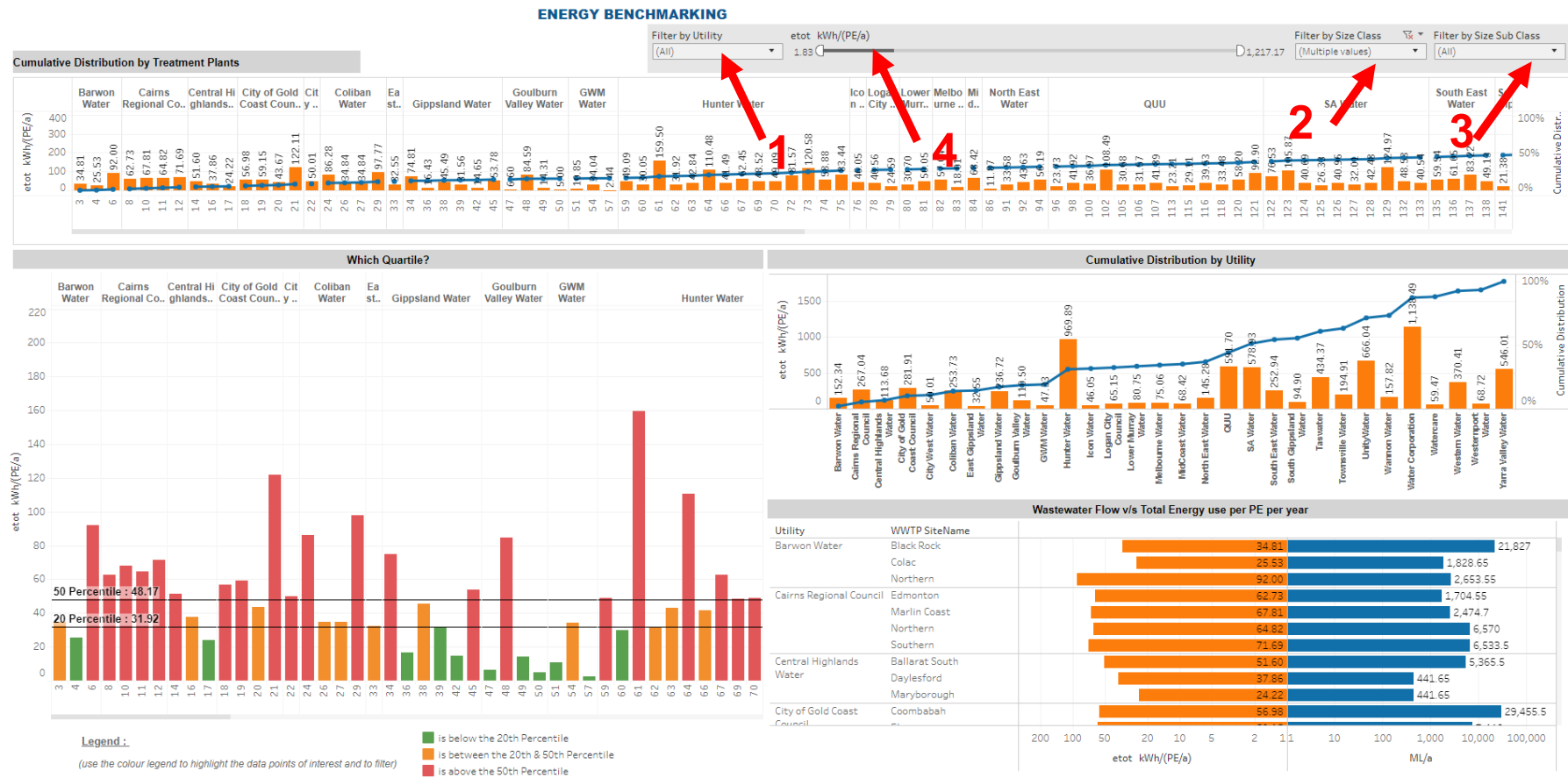
Figure 3 Layout of (beta version) Benchmarking Energy and Carbon (BEC) tool Tableau dashboard.

By necessity, development of the beta version focused on a single benchmarking KPI metric (energy use per connected population equivalent as commonly used by the water sector for energy benchmarking). This was done to simplify the initial development work and to expedite establishment of the basic tool framework. Now that the structure of the tool is developed and functional in beta version form, we will continue adding additional KPIs (including carbon emissions) such that the final suite of KPIs will include:

1. Electricity use per population equivalent (PE_{BOD60}) connected to treatment plant per year (kWh/PE/year);

2. Electricity use per volume of treated wastewater (kWh/m^3);

3. Electricity use per unit of organic load (chemical oxygen demand, COD; or biochemical oxygen demand BOD) removed (kWh/kg $COD_{removed}$; kWh/kg $BOD_{removed}$) and/or electricity use per unit of nutrient load removed (kWh/kg $TN_{removed}$);

4. Carbon dioxide equivalent emissions per connected population equivalent (kg CO_2-e/PE/y).

The final layout and functionality of the tool will most likely change slightly from that of the current beta version; however, the overall look and feel, and user functionality will be similar to that shown here. Once finalised, the Benchmarking Energy and Carbon (BEC) tool will be made available through WSAA to all of its 80 member utility organisations which collectively provide water supply and wastewater treatment services to over 20 million people, encompassing the vast majority (>80%) of water and wastewater services provision throughout Australia. The tool will be ready for water industry professionals to use for the purposes of rapid energy benchmarking and energy efficiency assessment and will be of value in helping water utilities in reducing energy use and associated carbon emissions. It is expected that the tool will be of particular value to smaller utilities which may not have sufficient resources to invest in in-house energy management personnel or tools.

Summary, challenges and industry utilisation

This project has used a comprehensive, national water industry dataset of some 244 wastewater treatment plants to develop an internet-based tool or data dashboard (in Tableau) which will enable water industry professionals to rapidly benchmark and understand their own WWTP energy performance relative to that of the equivalent national sector performance benchmarks (average and best practice performance percentiles). Once finalised, the BEC tool will be made available through WSAA to all of its 80 member utility organisations which collectively provide water supply and wastewater treatment services to over 20 million people, encompassing the vast majority (>80%) of water and wastewater services provision throughout Australia. The Tableau dashboard is extremely intuitive and user-friendly, which will allow even the least technically savvy wastewater plant operator to explore and understand the data, and to benchmark and understand their own system's energy (and ultimately carbon emissions) performance.

We experienced considerable challenges during this project in relation to accessing pledged in-kind project technical support for tool development, and this regrettably and substantially delayed project progress. However, we now have very good and active support from WSAA stakeholders and the project team are committed to delivering the BEC tool and disseminating to the water industry later in 2019 for utilisation thereafter. Consultations to date with water utility partners suggest that the tool will be useful for rapid energy benchmarking assessments, in particular for smaller utilities which often don't have their own internal energy management tools or specialist personnel. It is envisaged that once the BEC tool is finalised later this year, it will be handed over to WSAA for ongoing maintenance and updating as new data from future national WWTP energy efficiency assessments come to light.

References

GHD (2014) WWTP Energy Efficiency Benchmarking, Part 2 – Technical Report. Report for Water Services Association of Australia (WSAA) Ltd. by GHD, Melbourne, Australia.

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