ISO 50001: SO WATTS IT ALL ABOUT?

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ABSTRACT
Allwater provide water and wastewater operational services to metropolitan Adelaide and energy is a large component of Allwater’s budget. Therefore, energy management is a key area to achieve both business and operational efficiencies, and address environmental responsibilities for customers and the community.

In May 2013, Allwater implemented the ISO 50001 Energy Management System to monitor energy savings. Full application and certification took just over 12 months resulting in Allwater becoming the first Australian water company to achieve the international standard.

Projects were instigated to meet energy management targets with the projected energy savings expected to outweigh the cost and resources to maintain the System.

INTRODUCTION
Allwater (a joint venture between Transfield Services, Suez Environnement and Degremont) commenced an Alliance agreement with SA Water on 1st July 2011 for the Operation and Maintenance of the Adelaide Metropolitan Water and Wastewater Supply Systems. An overview of the Alliance is shown in Figure 1.

Allwater serves approximately 1.3 million people and energy is the second highest component of its operational budget after labour. The majority of Allwater’s energy consumption is from key processes including:
- Treating raw source water to a drinking water standard
- Pumping drinking water through the distribution supply network
- Pumping wastewater (where required) through the sewer network and pumping recycled water, and
- Treating wastewater to a standard appropriate for discharge to receiving waters or for reuse.

Allwater also produces approximately 30% of its overall energy requirements through the anaerobic process at three Wastewater Treatment Plants (WWTPs): Bolivar, Glenelg and Christies Beach. The methane generated during the process is converted into electrical power and used on-site.

Power usage has increased in recent years due to stricter environmental regulation, higher water quality standards and increasing water network pumping. In addition, new high-tech treatment processes are resulting in higher quality effluent but are corresponding to increased energy consumption. For example, membrane bioreactors require increased aeration to prevent membrane fouling.

Allwater’s energy management objectives include optimising energy demand, consumption and costs and Allwater has a significant responsibility and driver to show leadership in how energy consumption can be reduced.

This paper describes the rationale and methodology for implementing the ISO 50001 Energy Management System and the progress made towards achieving energy performance targets.

IMPLEMENTING ISO 50001
SA Water is one of Australia’s top energy using corporations and has been an active participant of
the Australian Government’s Energy Efficiency Opportunities (EEO) Program since 2007. The EEO program was initiated in response to the Energy Opportunities Act (2006) to encourage large energy-using businesses to increase their energy efficiency by improving the identification, evaluation and implementation of worthwhile energy saving opportunities. Emphasis is on introducing potential change to improve energy performance with a payback period of four years or less.

Although the Act was repealed in June 2014, SA Water had previously identified and introduced the EEO as an ongoing program and together the Alliance is dedicated to realizing these initiatives.

In order to drive energy awareness and continuous improvement, Allwater developed an Energy Policy and instigated an Energy Management Planning process. The ISO 50001 framework was adopted to assist this process and to ensure on-going improvement. By implementing the framework, Allwater is able to show accountability and transparency of its energy objectives and targets, whilst reducing utilisation of energy resources. The Energy Management System (EnMS) Model is depicted in Figure 2.

The detailed methodology for implementing the system is described in the following sections. In summary, a total of approximately 120 days were spent incorporating the EnMS into Allwater’s operations. Figure 3a shows the breakdown of this time with the energy review and data collection being the areas needing the greatest effort; followed by developing procedures and documentation. The procedures and documentation were then incorporated into daily operations through training and awareness.

The number of days required for maintaining the ISO 5001 is estimated to reduce by half for maintaining the system and Figure 3b shows that the focus shifts towards checking the information is correct through rigorous internal audits.

**Implementing ISO 50001**

**Maintaining ISO 50001**

The energy review is still the largest component of required time to maintain the EnMS, but emphasis has shifted from developing the numbers and establishing baselines, to providing current and easily accessible energy performance information to Allwater personnel on a monthly basis. Implementation also included providing on-going training of Allwater’s workforce to ensure cultural change, knowledge and awareness.

The projected energy savings per year are expected to outweigh the costs and resources to develop and maintain the system and will result in a return on investment of less than one year.

**METHODOLOGY**

The implementation of ISO 50001 in Allwater consisted of seven key stages:

1. Identification of the scope and boundaries of the Energy Management System (EnMS) to ensure it covered the areas under Allwater’s operations.
responsibility, as Allwater is operating and maintaining SA Water’s assets.

2. Definition of the roles and responsibilities of the organisation from Network Technicians to the General Manager to drive a process of continual improvement.

3. Establishment of Allwater’s energy performance to allow energy targets to be developed, to measure continual improvement and show that energy efficiencies are being implemented. Allwater conducted an energy review to understand its energy profile, set performance targets and prioritise energy projects (discussed further in the next section).

4. Development of a monitoring and reviewing system in order to determine the progress of the performance targets, to disseminate information across the organisation and facilitate continuous improvement.

5. Development of a training strategy to communicate the EnMS throughout Allwater, build awareness and competence as energy awareness is important for all of the workforce. Utilisation of a staff-suggestion process was encouraged to motivate and empower the workforce to play their role in reducing energy consumption.

6. Integration of ISO 50001 into the existing Environmental Management and quality business systems to facilitate day-to-day operations.

7. Development of an Energy Opportunities Management model to ensure both EEO and ISO 50001 energy improvement initiatives were actioned. Once implemented the final step is verification of the energy savings and assessment of the outcome.

ALLWATER’S ENERGY PERFORMANCE

An energy review was undertaken to capture and define the significant areas of energy usage within Allwater’s operations. As part of this process, energy data from water and wastewater treatment plants together with major pumping stations were analysed. This allowed Allwater to understand and rank energy efficiency performance, highlight operational areas to focus resources and implement efficiency programmes. In addition, energy performance indicators (EnPIs) were identified and energy performance targets set.

Energy Baseline

Figure 4 depicts Allwater’s energy profile showing that 89% of energy is sourced from electricity; leading to this becoming the initial main focus of energy efficiency projects. Natural gas is used on site at Bolivar and Glenelg WWTP’s to supplement the generation of on-site power through biogas.

Biogas power generation has reduced Allwater’s overall external electricity requirement by 20%. This fact highlighted the significance of any major plant failures affecting on-site power generation, resulting in the highest level of ‘criticality’ given to preventative maintenance programs.

Figure 4: Energy consumption by source

Figure 5 depicts electricity usage by treatment group showing that the combined WWTP electrical meters account for 57% of Allwater’s power usage, followed by both water treatment and water pump stations.

Figure 5: Electricity consumption by treatment group

The consistently highest energy consumer within Allwater was found to be the Bolivar WWTP, which treats on average 150 MLD of raw sewage from 60% of Adelaide’s population. The power consumed at Bolivar WWTP is approximately 35% of Allwater’s total electricity usage.

Figure 6 shows an average distribution of the different areas within a WWTP that electrical power is used. Unsurprisingly, aeration has the highest usage with over 40% and is one of the critical processes impacting on operating costs.
**Energy Performance Indicators**

EnPIs are quantitative relationships between energy consumption and one or more relevant variables, such as the number of filters on-line to produce drinking water, or the number of pump run hours.

EnPIs can be used to:
- Establish baselines and track performance
- Identify best practices and set targets
- Identify potential savings
- Prioritise energy efficiency projects
- Identify performance problems

The consumption of all energy for a site should be a linear function of an EnPI. However, for the treatment plants, a proportion of the electricity usage will be fixed to some degree and will not vary with treatment flow. For example, in wastewater treatment the microorganisms within the aerobic zones of the bioreactors must be aerated to ensure nitrification and discharge compliance; the bioreactor contents must also be mixed regardless of the flow into the tanks; and membranes that require aeration to prevent fouling. Plus all treatment sites have attached offices which are powered and air conditioned regardless of occupancy and will be incorporated into the fixed electrical usage.

A number of ENPIs have been established in Allwater which are included in Table 1. Energy performance against the EnPIs is reviewed on an ongoing basis. From this it can be identified whether performance targets are on track.

**Energy Performance Targets**

In addition to EnPIs, Allwater developed the following energy performance targets to assist in driving the progression towards achieving the energy management objectives:
- Reducing electricity consumption across Allwater by 3% by Jul-16; targeting 1% by Jul-15
- Increasing biogas power generation by 5% by Jul-16; targeting 3% by Jul-14, and
- Implementing five employee energy initiatives by Jul-15.

![Figure 6: Power consumption by wastewater treatment process](image-url)
Table 1: Examples of Allwater’s Energy Performance Indicators

<table>
<thead>
<tr>
<th>Area of Business</th>
<th>Energy Performance Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water and Wastewater Treatment</td>
<td>kWh / ML treated</td>
</tr>
<tr>
<td>Plants</td>
<td>kWh / No. of filters online</td>
</tr>
<tr>
<td></td>
<td>kWh generated / m³ biogas produced</td>
</tr>
<tr>
<td></td>
<td>kWh / UV unit on-line</td>
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</tbody>
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ENERGY INITIATIVES
The energy review highlighted several areas where projects could be instigated at minimal cost to achieve power savings and meet the energy performance targets. Projects that have commenced include:
- Bolivar DAFF Fixed Energy Use
- Anoxic Zone Mixing Efficiency
- Glenelg WWTP Biogas Management
- Thickened Primary Sludge Pumps Upgrade
- Christies Beach WWTP Optimisation

These projects, in addition to a number of employee initiated projects, are described below.

Bolivar DAFF Fixed Energy Use
An opportunity to reduce the fixed consumption electricity usage at the Bolivar Dissolved Aeration Flotation and Filtration (DAFF) plant were investigated. Figure 7 shows the baseline value for the Bolivar DAFF plant which is the energy usage profile against ML/treated for a 24 month period. The graph shows that even when no reuse water is required that energy usage is still on average 82 MWh per month. By implementing strategies (i) to monitor and regulate the saturated water flow to individual filters, and (ii) reduce the recycle pump operation when not producing water for reuse, there is the potential to reduce energy use by approximately 30 MWh/month or a potential saving of 360 MW/annum.

Anoxic Zone Mixing
The goal of mixing in an anoxic zone at a WWTP is to keep the Mixed Liquor Solids (MLS) in suspension and in contact with primary effluent and Return Activated Sludge (RAS), while minimising surface turbulence that could transfer oxygen from the atmosphere.

The mixing of anoxic bioreactors was a priority area to improve due to relatively high-energy consumption. Currently the mixing in the anoxic zones is operated 24/7; however industry practice is trending towards allowing the operation of mixers in intermittent mode; with the set points determined by operators at each individual WWTP.

In order to achieve this, SCADA modifications were made to enable the operators to define the on and off period during normal operation for each mixer. In tanks where two or more mixers were installed the control system was changed to allow the mixers to operate alternately.

The intermittent mixing was successful during operational trials and the optimum on/off operation varied between seasons and between WWTPs. Intermittent mixing has been estimated to save at least 300 MWh /annum.

A solution to reduce energy consumption even further is the replacement of the existing mixers (mixer and motor) by equipment with motors utilising permanent-magnet technology. The measured energy savings between classic and permanent magnet technologies is 10 to 15%. Allwater is progressively replacing mixers with permanent-magnet technology as an on-going maintenance programme.

Glenelg WWTP Biogas Management
At Glenelg WWTP the efficiency of the on-site engines and biogas demand management through trade waste delivery can be optimized. Management of the biogas is important to reduce biogas wastage through flaring. Flaring has increased from an average of 0.3% to 1% due to the increased power generation from co-digestion with trade waste. By managing trade waste pumping into the digester this should reduce gas
flaring to under 0.75% which will save approximately 125 MWh/annum.

**Thickened Primary Sludge Pumps**
The completion of a SA Water funded project at Bolivar WWTP to upgrade the thickened primary sludge pumps should lead to increased power generation due to increased digester hydraulic retention time and solids concentration. It has been estimated that the thickened primary sludge should increase the HRT from 17 to over 20 days which will improve Volatile Solids Destruction (VSD) which could generate 200 MWh/annum.

**Christies Beach WWTP Optimisation**
The Christies Beach (CB) WWTP has recently completed a major upgrade with a 50% increase in plant capacity to allow for increased load from projected growth in the catchment area over the next 25 years. The basis of CBWWTP design was to provide capacity to treat an annual average flow (AAF) of 45 ML/d. The existing A and B Plants have design capacity to take half of this flow (22.5 ML/d) with the new C-Plant constructed to take the balance (22.5 ML/d). The upgrade was also to ensure the required effluent discharge target of 100 Tonnes / year of Total Nitrogen was met, assisted by forecast recycled water demand.

The existing A and B Plants are conventional Biological Nutrient removal (BNR) configurations with the additional capacity provided through the construction of C-Plant; a membrane bioreactor (MBR) in a four stage Bardenpho configuration. An overview of the site is shown in Figure 8.

As previously stated the MBR plant is an energy intensive process due to the aeration requirements of the membrane filtration process and increased mixed liquor concentration within the bioreactors; however the process ensures high quality effluent for both suspended solids and total nitrogen (TN) so SA Water’s EPA discharge obligations can be achieved.

The final completed plant saw electricity power usage double; however sewage flow to the plant was only 70% of design. To achieve the target TN discharge load and minimise energy consumption at CBWWTP a detailed investigation was undertaken to develop an operating strategy that considered the ideal flow distribution through Plants A, B and C.

The resulting study showed that during the summer months, when effluent reuse was highest and discharge to the Spencer Gulf was minimal, the design flow to A and B-plant could be maximised and one of C-plants bioreactors was taken offline. This strategy resulted in an effluent with higher nutrients of benefit to the local irrigators and lower energy use. During the winter months when effluent reuse is minimal, the flow split between C-plant and A/B plant can be adjusted to achieve the annual 100 ton limit for Nitrogen discharged to the sea, by utilising the higher standard of treatment through the C-plant MBR and operating the MBR at an energy efficient flow rate. This flexibility in operating strategy delivers an estimated energy saving of 700 MWh/annum (Dreyfus, J. 2014).

**Personnel Initiated Projects**
Allwater personnel initiated projects ensure active involvement in energy saving ideas allowing energy efficient practices to be integrated into daily operations. These projects include:

1. Reminder stickers being sent to all sites to be put on light switches asking people to turn the lights off when leaving an area
2. A more permanent solution that is being rolled out to all WTP’s is the installation of motion sensor-operated lighting throughout the WTPs. This would eliminate electricity wastage and would also improve safety by automatically turning on lighting whenever personnel enter an area
3. Creating an Energy Dashboard on the company intranet to incorporate current energy usage and circulate information on energy saving operational tips and projects
4. Developing an energy saving calculator to aid procurement of power rated equipment for operations
5. Development of a water pump efficiency tool to monitor and highlight a decrease in performance which may indicate the pump needs maintenance or replacement.
CONCLUSION
Allwater has implemented an ISO 50001 Energy Management System to support SA Water’s energy efficiency initiatives and drive further operational energy efficiency across its operations. This has resulted in greater access to energy usage information across Allwater and associated reporting systems have been developed to identify usage trends. From this improved understanding of energy usage, opportunities for energy efficiency have been identified and implemented.

Allwater has established its energy usage baselines and energy performance indicators and have committed to the following energy performance targets:
• Reduce electricity consumption across Allwater by 3% by Jul-16.
• Increase biogas power generation by 5% by Jul-16.
• Implement five employee initiated opportunities by Jul-15.
• Ensure energy efficient technologies are considered when acquiring new, replacing or retrofitting equipment.

In order to ensure efficient energy management, Allwater has developed an Energy Policy and implemented an Energy Management System in line with the ISO 50001: International Standard framework, and is continuing to work collaboratively with SA Water to deliver both EEO and ISO 50001 initiatives.

Overall, Allwater, SA Water, and its customers will benefit from these energy reductions identified and implemented with potential for further savings in the coming years as more energy efficient projects and initiatives are completed.

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REFERENCES