Energy Management

“It is not about going to the gym”

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INTRODUCTION

Implementation of energy management is in many ways analogous to how people treat going to the gym.

We know it’s good for us, we know we should be doing it and we all have the best intentions to do it. Getting started is the hardest part. Organisations behave like people when it comes to energy management.

1. Some embrace it religiously as part of their life style;
2. Some start with a flurry then dabble with intermittent bursts of enthusiasm after a pang of conscience or a glace in the mirror;
3. Some avoid it all together, seeing it as of limited benefit, too much effort and assume things will take care of themselves through other means;
4. Some achieve positive results without the gym, through a common sense plan and a slight change in their day to day activities;

HWA has adopted the latter method for assisting organisations in implementing Energy Management. Many of the energy and monetary savings are achieved through taking a practical approach using experience and industry knowledge, involving staff at all levels, developing a plan, leveraging existing technology and implementing simple changes.

Typically regional water authorities and local government entities have fewer resources at their disposal for commitment to energy management implementation than their larger metropolitan counterparts. As a result the perception exists that implementation of a scheme requires substantial external expertise and internal resources.

This paper presents a strategy for the implementation of an energy optimisation plan for water and wastewater assets using current staff, simple methodologies, and innovative use of existing technology. A current project undertaken by the HWA for Eurobodalla Shire Council is examined as a case study, in addition the paper presents ideas and design philosophies for reducing energy use and cost .

PROJECT BACKGROUND

Eurobodalla Shire Council (ESC) provides a water and sewerage services to a population of over 35000 consumers over a large geographical area. Located on the South Coast of NSW, the Eurobodalla Shire Council is responsible for an area of 3,400 km, most of which is national park and state forest. Its main centres are Batemans Bay, Moruya and Narooma. HWA was engaged to assist ESC with implementation of an energy management strategy for their Water and Wastewater assets. The project involved review and operational and asset data to allow development of comprehensive plan for reducing energy use and costs for the water and wastewater system and development of project cost benefit estimates.
The ESC water and wastewater system comprised 115 Wastewater Pump stations, 5 Wastewater Treatment Plants, 23 Water Reservoirs , 22 Water pumping Assets all of which contributed to an annual energy bill of approximately ~ $1.8M

Figure 1. Highlights the council’s area of operation.

Figure 1: Eurobodalla Shire Council Area of Operation

Project Overview

Eurobodalla shire council was actively promoting energy management and greenhouse programs for the various areas within the organisation. The organisation had a target to reduce its overall carbon footprint.
The Water and Wastewater areas of the business were seen to be a key area for energy savings to be included the organisations Energy management initiative. HWA were engaged and using HWA’s broad industry knowledge and experience in operational systems the energy management project was managed and implemented.

The project covered a broad range of areas including organisation of teams, collecting and reviewing existing data, undertaking field audits and analysing collected data to develop an energy management plan and identify energy management projects.
HWA made significant use of the ESC SCADA system to gather historical and real time data which was used in the analysis of the system operation in conjunction with Electrical energy bills. The preliminary audits and system analysis have been completed and key energy and costs saving projects identified. The implementation of the energy management initiatives will begin in the new year .The projects include traditional power saving methods in addition to the use of the ESC SCADA system to provide efficient management of energy and operations.

The preliminary audit

Before the first kWh could be saved there were several tasks that need to be done, the majority of the work involved review of the ESC assets and associated power baseline usage. In conjunction with the information gained in the initial meeting HWA gathered and reviewed as much relevant asset information in the office as possible. This provided considerable savings in time and money for ESC.

The information gathered included

- Asset location
- Operator names, area of operation and contact numbers.
- The energy provider details and primary contact details.
- Electricity contact details, Power accounts (detailed) and tariff structures.
- Equipment list / Asset registers/ Maintenance records.
- Site plans and network reticulation drawings.
- Proposed asset augmentations or network expansion plans.
- Legislative & operational requirements that the organisation must meet e.g. Licensing
- SCADA historical data.

Historical SCADA data was used significantly to assist the field audit and ongoing performance monitoring. The implementation of any energy management scheme relies heavily on the historical information. The HWA understanding and use of SCADA systems historical data was an invaluable tool in analysing and implementing the scheme. The review and analysis of historical SCADA data in conjunction with the organisation’s power accounts assisted in determining how the assets and system actually operated. The information assisted in proving and disproving anecdotal information.

This information greatly assisted in prioritising the assets.

The Initial prioritisation included indemnification of sites with:

- High total Electricity use/cost

- Low power factor
- High proportion of usage in peak tariff periods

Using this information a plan of attack was developed to undertake the preliminary audit of the assets. For the purposes of site audits, target assets were grouped geographically not by type. (Water & Wastewater assets are typically dispersed so planning of routes can save time and money.)

The audits were conducted using HWA and ESC experienced personnel with operational experience.

Many organisations select the junior staff or consultants to undertake reviews and audits thinking that this will minimise costs. In short, it doesn't. HWA used experienced electrical personnel with field & installation experience to undertake the audits. Real savings were made through increases in the quantity and quality of data collected. Operational issues were able to be discussed with plant staff. Using experience personnel with 'Street Cred" assisted in breaking down barriers and getting vital undocumented information.

Taking this approach to staff selection for audits will reduce the number of repeat site visits. Not only can basic asset data be gathered but sites can be assessed for potential modification/upgrade work, asset conditions assessed and potential safety and operational problems identified.

What to look for

The principles that were used by HWA and ESC during the audits were very similar to those used in domestic energy saving initiatives. It comes down to the four 'R's:

Replace

Look for inefficient equipment and practices. Can we replace an old motor? Are drives and pipework correctly designed? What is the condition of the assets ? Has the equipment been maintained?

Reuse

Look for opportunities to reuse energy that would otherwise be wasted. Can the potential energy in reservoirs be used to generate energy? Can waste gas at a Waste Water Treatment Plant be reused for heating or electricity generation?

Reduce

Can equipment be used less or even turned off without affecting system operation or output quality? What equipment can be improved to reduce consumption & costs? Can the power factor or pump efficiency at the site be improved?

Installation of power factor correction equipment or variable speed drives (VSDs) can provide real savings. Take the time to do the evaluation, it will be worth the effort.

Reschedule

Do you have large volumes of storage available in your system? Does demand vary considerably from summer to winter? Do your treatment processes operate intermittently? What time of day is equipment being run and is there interoperability between assets?

Areas to Investigate for Energy and Cost Savings

Drive efficiency

The silent users of energy in most plants are drives that have been installed prior to the legislated requirement of high efficiency drives. Prior to 2001 low efficiency drives were used in most installations. In most cases these drives are still in use and may be running at 85-90% efficiency. Modern high efficiency drives that meet the Mandatory Energy Efficiency Performance Standards (MEPS) can achieve operating efficiencies of approximately 93%.

This may not sound much but on a large drive this may save thousands of dollars each year. Even on a small drive money can be saved if the drive is running often or even continuously. The final outlay for this project is generally low and with the amount of money saved the payback period can be 1-2 years in some cases. The reduction of CO^2 per annum is also highly attractive.

Typically the decision to rewind or replace a large old electric motor is based purely on the capital cost without considering the energy savings of a new high efficiency motor. When replacing equipment on older installations always consider the potential energy savings in the replace or repair equation.

As demonstrated in the example below, a 45kW aerator that runs approximately 10 hours per day will save $550 per annum and 6 tonnes of CO^2 if changed out to a high efficiency drive. For a small investment and little effort this project will be paid back in under 4 years.

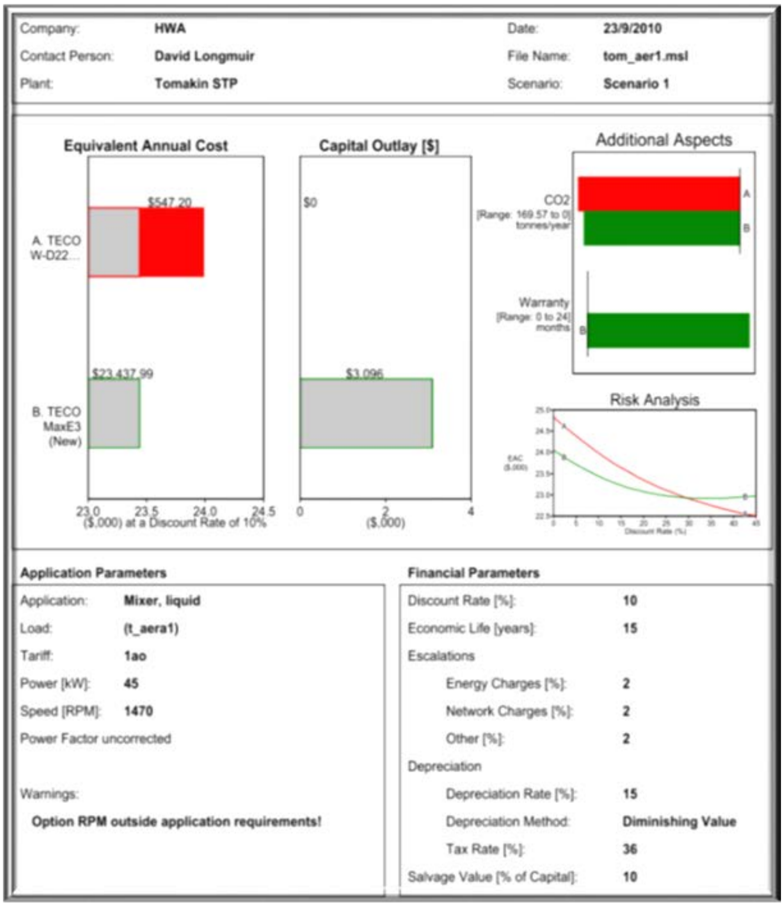


Figure 2 - Motor efficiency savings

Power Metering and SCADA

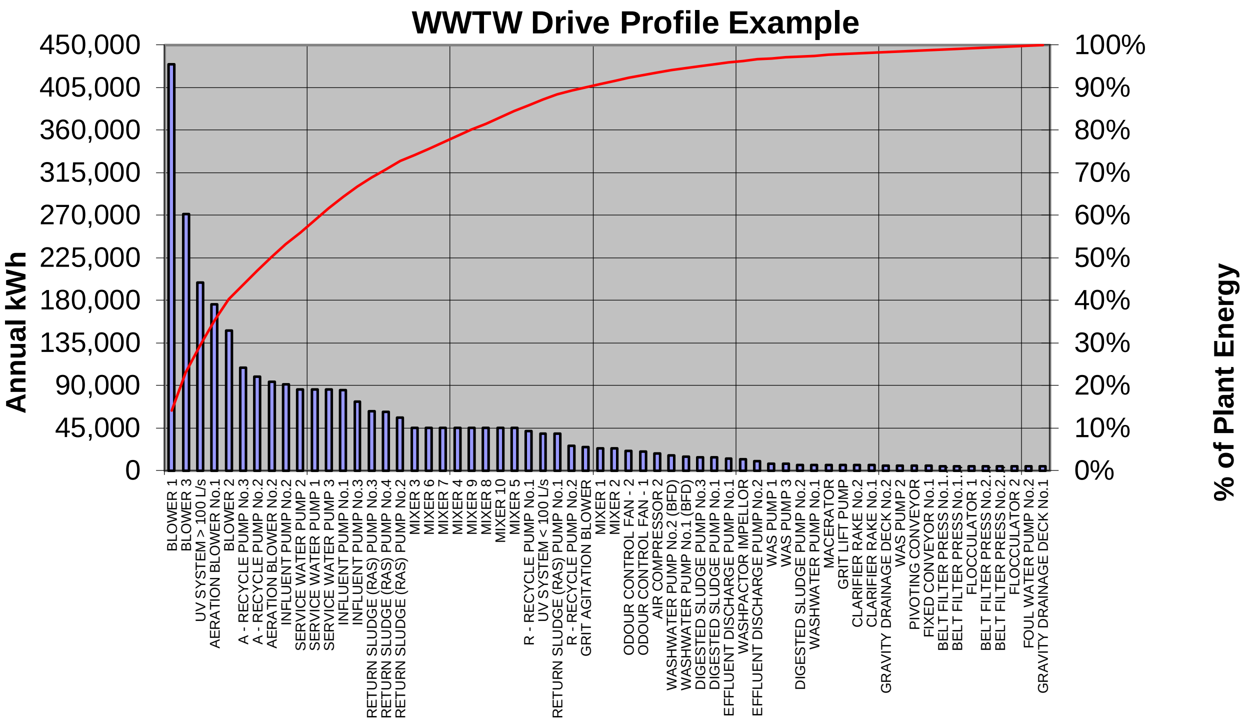
Without real time and historical trend information on energy plant usage, operators are unaware of the energy impacts their operational decisions make. In water and wastewater treatment the number one priority is water quality. However it is possible to maintain effluent quality or water quality and reduce the energy by providing operations staff with greater information on how and where energy is consumed by their plant.

Traditionally plant power consumption only appeared on the quarterly energy bill which was handled by the administration staff back in the office. The amount and cost was never a primary concern for the plant operations staff. They may have been aware of the annual consumption, they may have recorded the meter readings and passed them on to their supervisors but in most cases the information was not readily available.

In HWA’s experience plant operators take great pride in ensuring that their plant is providing the best water or effluent quality. Providing real time power consumption data to the operator provides another performance criterion that they embrace as a challenge.

As a minimum the real time energy consumption of a plant and tariff times should be displayed to allow plant operators to optimise their plants.

For existing modern advanced treatment plants displaying power data in hierarchical “SCADA dashboards” for each of the process areas, provides operators with the tools to tune their plants and save energy. This will require retrofitting power metering on primary equipment in various process areas of the treatment process .



Retrofitting of power equipment to all drives is not economical. Development of drive profile for a plant is necessary to determine which drives should have power metering installed. This is achieved using drive nameplate data and historical SCADA data to develop a kWh profile for all drives on the plant.

For new plants, inclusion of power sub metering and SCADA displays should be a mandatory part of the design. Power metering technology is now very affordable and can be provided on all drives for an incremental cost.

Many plants have been conservatively designed. This provides the opportunity to revise operational set points to decrease energy use.

For example, review of the current aeration cycles and times may be reduced without affecting the quality of effluent. With the installation of power meters in the plant, the operators can monitor and record energy usage of the plant and make adjustments based on energy usage. The power meters can be placed in sections such as aeration, WAS and RAS pumping, dewatering and inlet works.

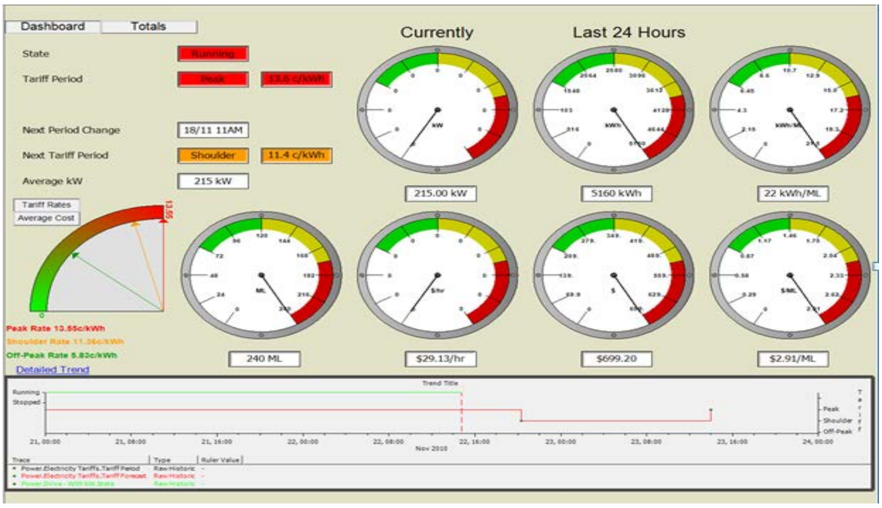


Figure 3 - SCADA based energy faceplate

This concept can be used in a system wide approach for i water or waste water systems. Data from each of these interconnected systems can by summarising to give a total kWh and electricity cost for a particular location, considering all pumping stations the product passes through. This information gives a total electricity use and cost rate for water supply zones and waste water catchment areas. This information is invaluable in justifying and targeting leak reduction or inflow and infiltration reduction programs.

Off peak pumping of water and sewerage assets

Electrical tariffs vary depending on the time of day, so to operate assets in off peak will save money for the organisation.
While rescheduling of loads and replacement of metering does not directly save energy it does save money, which may assist with the implementation of projects that do save energy.

All energy providers offer different tariffs depending on the site's usage. In the example below the asset is on a tariff that has two specific charge rates depending on the time of day.

FINANCIAL YEAR	PERIOD	RATES ($)		
		< 100MWh	> 100MWh	> 160MWh
2010-2011	Peak & Shoulder	0.105329	0.143769	0.036342
	Off-peak	0.054293	0.067727	0.021325

7:00am to 10:00pm peak & shoulder periods (5475 hours per year) ;
10:00pm to 7:00am off-peak period (3285 hours per year)

Water pumping is an area where an organisation can take advantage of off peak tariffs. Water pumping is typically controlled by the level of the associated reservoir. Operating limits are determined to ensure the reservoirs are near capacity, for example 90% cut in and 95% cut-out. While this philosophy ensures maximum security of the water supply it does not take into consideration energy costs.

Reservoirs provide energy storage. Reviewing a distribution system's operating limits and investigation of the system hydraulic requirements can reveal opportunities for alteration of reservoir operating limits and pumping times. Changing pumping profiles to move pumping periods from peak and shoulder tariffs periods to off peak periods will provide real savings.

To take full advantage of off-peak energy periods operating limits should be reviewed against the energy provider's energy tariff structure.

Leveraging the SCADA system to automatically revise operating limits to account for summer and winter or holiday period demands should be considered. While reservoir operating levels may need to be kept higher during summer, lower demands in winter may mean that all pumping can be done in off-peak tariff periods.

The SCADA and telemetry system can extend this from a single site approach to a system wide implementation leveraging interoperability over a number of system related assets. Pumping can then be scheduled based on the system demand profile rather than on level only. A system wide approach can also provide collateral operational benefits such as detection of main breaks and calculation of water loss for individual supply zones in addition to the system as a whole. Water quality benefits can also be realised as a result of increased reservoir turnover.

The following tables highlights the possible cost savings from moving to off peak tariff periods

Current pumping data based on 2010-2011 tariffs

Account Name	Peak $$$	Off-Peak $$$	Total Cost $$$
WPS 1	$36,507	$12,581	$49,088
WPS 2	$14,117	$4,267	$18,385
WPS 3	$12,940	$4,271	$17,211
WPS 4	$6,490	$2,236	$8,726
Aeration Shed	$13,806	$3,820	$17,626
WPS 5	$11,545	$2,115	$13,660
WPS 6	$2,967	$291	$3,259
WPS 7	$965	$140	$1,105
WPS 8	$299	$29	$328
			$129,388

Revised pumping based on 2010-2011 tariffs

Account Name	Peak $$$	Off-Peak $$$	Total Cost $$$	Total Savings $$$
WPS 1	$15,842	$24,707	$40,549	$8,539
WPS 2	$2,637	$11,004	$13,641	$4,744
WPS 3	$0	$11,864	$11,864	$5,347
WPS 4	$1,153	$5,368	$6,521	$2,205
Aeration Shed	$0	$10,324	$10,324	$7,302
WPS 5	$0	$7,554	$7,554	$6,106
WPS 6	$0	$1,821	$1,821	$1,438
WPS 7	$0	$638	$638	$468
WPS 8	$0	$183	$183	$145
			$93,094	$36,293

Peak demand Management

To help cover the cost of generation and transmission most energy providers will charge users for their peak power demands on the network. This charge will normally apply on larger sites that use more than 100MWh per annum. To do this the site is generally fitted with a smart meter. Peak power is measured in kVA (apparent power) and is greatly affected by the power factor at the site.

Once the organisation has installed power factor correction, the other way that peak demand charges can be reduced is to review the sites' starting patterns of it drives. If there are several large drives running at the same time power will accumulate and incur expensive peak demand charges. This is where the use of the SCADA historical information comes into play. Analysis will highlight times when several drives are running at the one time.

The implementation of a scheme to take advantage of savings in peak demand should carefully consider tariff structure. The demand charge is a network charge, simply explained, the structure and rate are controlled by the network provider not the retailer under a supply contract. This means the structure and rate of this tariff changes for different geographic areas and in many cases changes annually.

Following is an example of the saving that can be made. During the course of HWAs investigations it was found that a major water pump station with two 265kW high lift pumps and two 160kW low lift pumps had all four drives running at the one time, when only two or three are required for suitable operation.

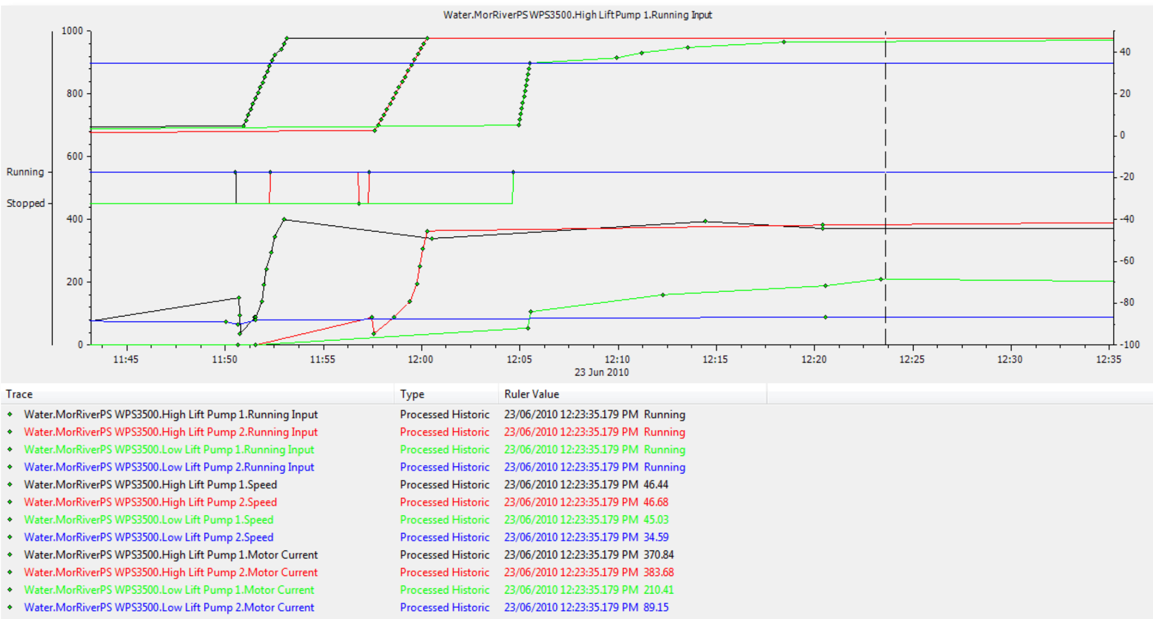


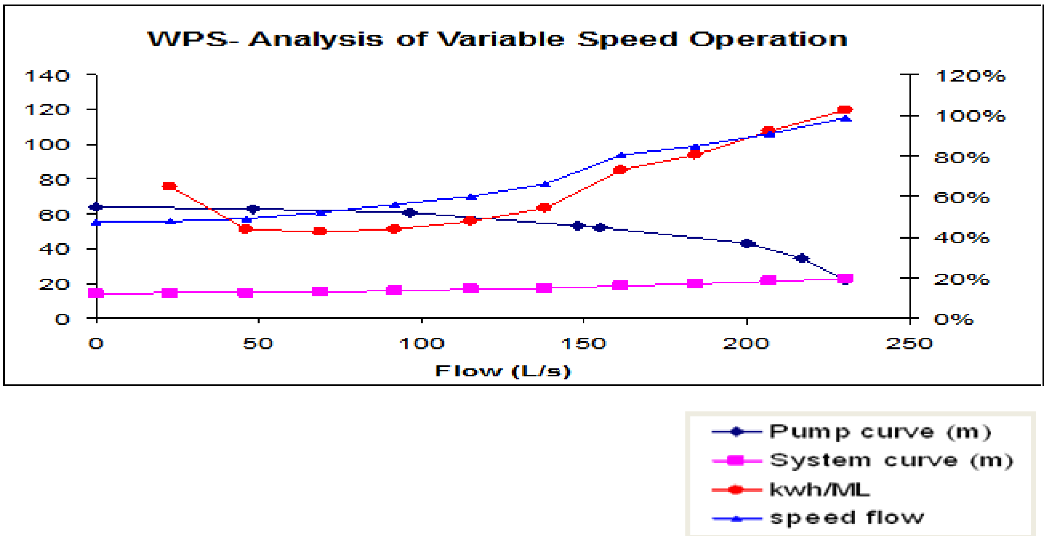
Figure 4 - Peak demand starting of WPS

Reducing peak demands can be an effective cost saving measure at treatment plants. Treatment plants often contain a large number of drives that run intermittently. Savings in peak charges can be achieved if the plant is controlled so that running large drives is delayed until other parts of the plant are idol.

Implementation of VSD control

Because of the vast array of sites and equipment throughout the organisation there are a number of opportunities for the installation of a Variable Speed Drive (VSD) to help in the reduction of energy. For example in most sewerage treatments plants the aerators are run continuously without any feedback or control. Using VSD drives and correctly installed dissolved oxygen probes the Aeration can be controlled using a dissolved oxygen setpoint by modifying the speed of the aerator drives. By operating at a lower speed of these times, less energy will be consumed.

Another opportunity would be where a WPS or a SPS pump is operating above the efficiency point of its pump curve. Water and waste water pumping systems are designed to meet peak demands which only occur occasionally, for a short period of time. By making use of existing VSDs or retrofitting VSDs to the existing system, savings can be made by pumping the most efficient point during non-peak periods. In the example below, slowing the pump down to 45% speed will allow water to be pumped at 50 kWh/ML, compared to 120 kWh/ML at 100% speed.



While the flow rate is 70L/s compared to the full speed flow rate of 230L/s, control code at the station can be modified to run the station at a lower speed for longer periods and ramp up only if demand exceeds the lower pumping rate. This type of scheme could also take advantage of a second redundant pump to use two pumps at their most efficient speed rather than running one at full speed.

Review of site tariffs

While reviewing the organisation's performance, billing and energy usage it was thought that some sites may be on incorrect tariffs, based on their usage. A theoretical model of the sites was created and sent to the energy provider for review. The initial investigations based on usage alone were promising, however once the sites peak demands and power factor were taken into consideration it was shown that the sites bills would have been more, based on the historic electrical data. Even though these investigations did not provide saving on the data presented, it did highlight that if power factor and peak demand was improved on the sites, there could be possible savings for the site if their tariff code was changed.

Demand Side Response

Contracts with energy retailers have the effect of shielding customers from the spot price of electricity on the national market. However, there are still opportunities to take advantage of spikes in the spot price to reduce discretionary electricity usage and be paid a bonus for doing so.

A number of companies now specialise in “Demand Side Response Aggregation”. These companies sign up a large number of customers and when the spot price spikes they contact these customers to reduce their electrical load voluntarily. They then sell this additional capacity back to the electricity companies and pass back a proportion of the earning to the customers that participated.

Utilising this type of service allows a risk free option to take advantage of spikes in the spot price and potentially reduce energy costs, as reaction to each event is optional. The use of SCADA dashboards to summarise and present information allows operators to quickly and confidently make decisions on whether to participate when opportunities arise.

Solar power installations

During the course of the site investigations all avenues for carbon reduction were investigated, even solar power. At the time the NSW government were supporting a solar power buy in tariff rate of 60 cents per kWh. However this rate was recently dropped to 20 cents per kWh, thus dramatically increasing the payback period of the project. The following results were found during the course of the investigation:

- It was better to invest into one large site (10kW maximum) rather than several smaller sites
- The solar installation had to be done on a site that had a energy usage of <160 MWh per annum
- Due to the high number of cells the site had to have a reasonable amount of available ground or roof space.
- Site security and costs associated with antitheft measures must be taken into account in evaluating the projects.

The table below indicates the various options that were investigated during the project, while the tariff was set at 60 cent per kWh.

Location	Installation Size (kW)	No. of Cells	Installation Cost ($)	Annual Return @ $0.60/kWh	Payback (Years)	CO2 Reduction (t/yr)
STW	2.04	12	$15,523	$1,689	6.58	3.63
	2.97	18	$21,845	$2,459	6.88	5.29
	2.97 (expandable)	18	$22,849	$2,459	7.29	5.29
	4.08	24	$28,771	$3,378	6.87	7.26
	4.95 (expandable)	30	$35,524	$4,089	7.20	8.81

Although the reductions in carbon emissions are substantial the investment costs are relatively high, making the payback period unattractive. However, if the goal is to reduce carbon not just save money, it should be considered.

Hydro power installations

Due to the undulating terrain within the Eurobodalla Shire significant energy is required to move water from the river systems to higher reservoirs. In some cases 100m or more of water head had to be overcome to supply reservoirs. The water is then gravity feed to other reservoirs within the network. In doing so large amounts of potential energy is stored in the reservoir but not used. Existing Pressure Reducing Valve (PRV) sites, or any location where valves are used to throttle flow, provide on ideal opportunity to install small hydro systems.

HWA investigated the possibility of installing small hydro power units that utilise this potential energy. Several sites had the potential to generate power; however HWA focused on the sites that were able to reduce carbon emissions by > 10 tonnes per annum. Eight sites were identified.

As detailed in the example below the possible carbon savings can be as much as 50 tonnes per annum. From a carbon reduction perspective the project had merit, however from an installation cost and energy saving perspective the project did not stack up. It was also found that the cost of installation was high $50K on average and that the buy in tariff rate for hydro power was very poor; only 4.2 cent per kWh.

Because the sites would be rated more than 10kW in most cases, the installation may have to be classified as a Renewable Energy Power Station (REPS). Although this would not affect the station operations, it would require a higher level of detail for the sites application and implementation.

As detailed below the site installation costs are high and the returns from the energy supplier are low, however the offset in carbon emissions are quite substantial. Changes in legislation, tariffs or technology may make it worthwhile to revisit these projects in the future.

Reservoir Name	**WR2510**	**WR2505**	**WRSR5530**	**WR5500**	**WR1525**	**WR3530**	**WPSR 3515**	**WR3510**
Total kWh per year	12938	15569	20833	23815	29731	31945	42759	47609
Total $$$ earned from power generation (at 4.2c/kWh)	$543.43	$653.91	$875.01	$1,000.23	$1,248.74	$1,341.71	$1,795.92	$1,999.60
Project cost $$$	$46,950.00	$46,950.00	$46,950.00	$46,950.00	$42,450.00	$46,950.00	$196,950.00	$46,950.00
Possible REC's (<6.4kw SGU)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REC $$$ per year (based on current price of $33 per REC)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Project payback period in years	123.2	133.0	139.4	86.9	70.0	72.3	56.8	46.0
Total reduction in carbon emissions per year (tonnes)	13.715	16.503	22.083	25.244	31.515	33.862	45.325	50.466

New Assets and Capital Works

For new infrastructure projects, ensure you have input into the designs, and demand an energy focus. Typically the electrical and SCADA systems are 10%~15% of the total project capital. Unfortunately because of the value, they are treated as a collateral activity in most projects. (Especially where the electrical & SCADA package is provided under a D&C arrangement)

The level of investment in the electrical & SCADA design has a major impact on the long term operation and energy consumption of the asset over its lifetime. Good designs which consider and embrace energy management and asset management principles will provide real ongoing long term savings. Inclusion in the initial construction phase is an incremental cost. Retrofitting after construction is expensive and time consuming. Take the time to think of the implications before letting your consultants and constructors take the easy option of D&C for the electrical package.

BENEFITS AND LESSONS LEARNT

For the Eurobodalla engagement HWA were able to identify 7 major energy saving areas that provided savings of approximately $165K pa. The payback period (based on 2010 carbon and energy costs if all projects were implemented) was 4 years, with a reduction in Carbon of 17%.

However if the Hydro Power projects are excluded the payback for the projects is less than 2 year based on current energy costs. The associated dollar savings are a reduction of 12.7% of the annual current energy costs.

Project	Total Project Cost $	Total CO2 Savings (t)	Total Cost Savings $	Cost/CO2 $/t
Replace motors	$45,774	100	$8,527	458
Installation of PFC	$96,500	748	$25,988	129
Off peak pumping	$32,500	0	$37,885	0
Installation of power meters	$60,630	56	$9,073	1,084
Reduction of peak demand	$15,000	0	$72,773	0
Solar installation	$28,771	7	$3,378	3,963
Hydro Installation > 25 kW systems	$380,250	158	$8,261	2,406
Totals	**$659,425**	**1070**	**$165,887**	

2009-2010 Baseline	Running cost	Total CO2 Cost (t)
	$1,234,484	6300
CO reductions (%)		17%
Total payback period (years)		4

During the course of the project Hunter Water Australia (HWA) had some big wins. However there were one or two areas that alternatively looked promising after more detailed investigation, did not deliver positive results. For example, HWA investigated the amount of financial savings that could be made if the sewage pump stations were to pump out prior to a peak energy period. Although it was estimated to save approximately $2,000 per annum for an average sized network branch, the cost to implement the change as a one off project was considered too high. However staged implementation during maintenance activities or inclusion in any future upgrades would be worth considering as the cost for inclusion would only be incremental. The other side effect to consider was the inrush of sewage in the treatment plant which may offset any gains.

HWA also investigated the possibility of well level manipulation for sewage pump stations to smooth flow through the STP's. Again even though it was found that savings could be made, the chance of higher odours and possible surcharges required further system analysis.

Energy providers don't necessarily help the process. There was reluctance by some energy providers to deliver the relevant information. This did delay the project and added to the costs. Preliminary audits indicated several sites which had the potential savings and were subsequently included detailed investigations .However once the current tariff structures and billing information was provided they were found to be unsuitable for peak demand savings due to the tariff structure. Lesson learnt; it is best to wait until all of the billing information is in before acting. Make sure your energy provider is onside and acting in your organisations best interest.

CONCLUSION

Investment in energy management and the associated monitoring systems is important. Build your system in a piecemeal fashion, with limited thought, on shoe string budget, and it will join the long list of fad systems that sit in every organisations storeroom gathering dust. (Just like that gym equipment in the garage.)

Developing your operational systems to use the data you collect and presenting the information in easily understood, practical formats will not only assist in reducing energy use and costs but will also assist in improving broader operational and maintenance decisions.

Effective monitoring of equipment, power consumption and performance will lead to the early detection of pending equipment failures. Similarly, encouraging a whole of system perspective on SCADA control will increase an operator's awareness, provide whole of system visibility on the impact of operational decisions and assist in overall efficient management of the Water & Wastewater systems, which will save energy and improve efficiency across the organisation. The indirect benefits of a reduction in maintenance and operations activities will also save energy.

Build the energy management systems correctly; work in conjunction with people with skills, knowledge and experience to implement practical solutions and this will ensure the organisation becomes more aware and reaps the long term benefits. Energy management will be embraced and become an integral part of the organisations culture. Just like the gym, take a practical long term approach and you will enjoy the benefits.

ACKNOWLEDGEMENTS

The author would like to thank the Eurobodalla Shire Council for permission to publish this paper.
The successful delivery of this project was a result of a collaborative team effort.
In this regard the author wishes to acknowledge the significant contributions of:

- Angus McLean, Manager Water & Wastewater Eurobodalla Shire Council
- Eurobodalla Shire Council Water & Wastewater Staff
- David Longmuir Project Manager Hunter Water Australia
- Steve Hopton Principal Automation & SCADA Engineer Hunter Water Australia

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