MINIMISING ENERGY COST IN WATER AND WASTEWATER NETWORK OPERATIONS

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ABSTRACT

Hunter Water has saved millions of dollars in electricity expenses for water and wastewater network operations by paying attention to energy efficiency and energy management. The savings have arisen through: optimising pumping efficiency and specific energy consumption; scheduling pumping to avoid peak tariff periods; paying attention to the electricity retail market; and paying attention to billing details. Energy cost saving initiatives with short payback periods have been possible in all of these categories, including for initiatives requiring capital upgrades.

1.0 INTRODUCTION

Hunter Water serves over half a million people in the Lower Hunter region of New South Wales. With almost 5,000 kilometres of water mains and a similar length of sewer mains, a considerable amount of energy is consumed. Last year 78 GWh of electricity was needed to treat and transport the water and wastewater. This cost more than $11 million. Minimising electricity cost is an important objective for Hunter Water, particularly as energy costs have trended upwards in recent years.

Approximately half of the electricity consumed is used in treatment. Treatment operations has been contracted out to a third party (currently Veolia), who also pays for the electricity. This paper explains energy cost saving initiatives in water and wastewater network operations. Over a million dollars per year is saved from the electricity budget for the water and wastewater networks. This keeps water rates for Hunter Water's customers among the lowest nation-wide.

In broad terms, energy savings initiatives started with a desktop analysis to identify the biggest contributors to energy cost in water and wastewater transport. Hunter Water has close to 500 wastewater pump stations but only 124 water pump stations. There are a few large water pump stations that consume a significant proportion of total pumping energy. Energy consumption in the water network is around double that for the wastewater network, primarily because wastewater networks are designed to use gravity as much as possible. However, cost is approximately equal between water transport and wastewater transport. Unit cost (per kWh) is approximately double for wastewater pump stations because of their smaller relative size and because their load is more irregular (in terms of average electrical load to peak electrical load).

Once the overall consumption and cost breakdown and drivers were understood, focused attention was possible in a number of different areas and on sites or classes of sites contributing most to energy cost. The focus areas are detailed as follows.

2.0 DISCUSSION

2.1 Energy Efficient Pumping

There are a number of elements to ensuring energy efficient pumping, including:

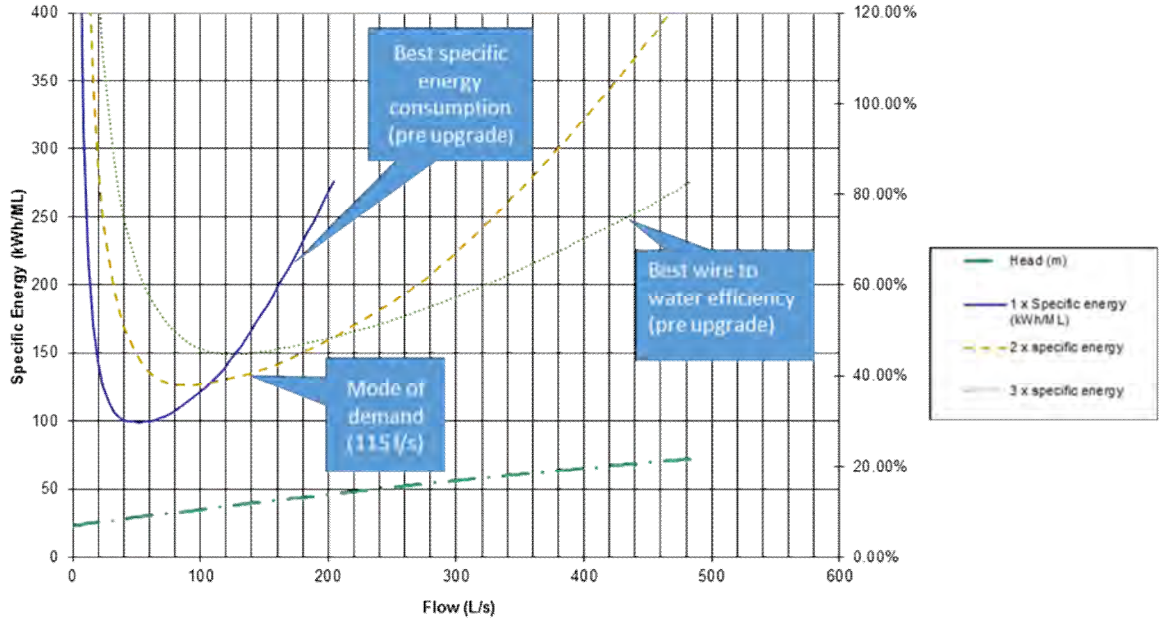
- Overall hydraulic design to minimize static and friction head;

- Correctly choosing pumps with appropriate curves for the most common duties as well as the peak duty (instead of just the peak duty);
- Ensuring that all required rates of flow are achieved through pump combinations that ensure optimal efficiency;
- Where friction head is significant, pumping at the lowest flows possible to achieve required volume transfer (possibly through use of variable speed drives or jockey pumps for optimal efficiency);
- Ensuring system efficiency by coordinating pumping across stations (e.g., it is usually more energy efficient to pump simultaneously at stations where the suction of one is fed from the delivery of the other);
- Choosing energy efficient motors; and
- Regular maintenance and overhauls of pumps and motors.

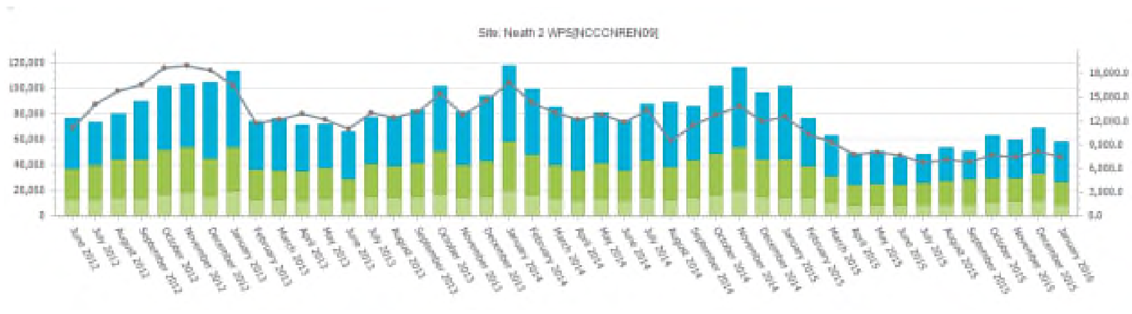
To measure efficiency it is beneficial to pay attention to both wire to water efficiency (kWh/ML/m) and specific energy consumption (kWh/ML). The former can easily identify poor performers but the latter is better for optimizing operations at a particular pumping station. Good performance monitoring requires good data collection for flow, pressure and energy.

Neath 2 WPS provides an example of where kWh/ML can be more instructive when analysing an individual station. The pumps at Neath 2 WPS were originally selected when the pumped pressures were higher. Amplification of the trunk mains meant that the pumps were no longer seeing the duty they were selected for. This meant that the best wire to water efficiency was achieved with three pumps running but the lowest energy mode of running the station was for one pump to operate. Specific energy analysis showed that installation of variable speed drives was a good option for this station.

Figure 1 shows the specific energy pre upgrade, while Figure 2 shows the energy costs pre and post upgrade. Installation of variable speeds saved around 370 MWh per year by allowing the station to pump at lower flows, reducing friction head.



<u>Figure 1:</u> ***Specific Energy Consumption Analysis Reveals the Opportunities for Savings and Guides how to Operate the Station***



<u>Figure 2:</u> ***Energy Bill Data Showing the Savings from Upgrading Neath2 WPS (commissioning completed March 2015)***

2.2 Scheduling Pumping

While energy efficiency is optimized by continual low-flow pumping, cost efficiency may be lead to pumping as much volume as possible overnight during off peak electricity tariff periods. Larger storage enables more pumping to be shifted to off peak periods. This is generally only possible in the water network, although large tunnels may sometimes provide wastewater storage opportunities. Hunter Water investigated this possibility for the Interceptor tunnel supplying Burwood Beach WWTW but in the end did not take up this opportunity due to asset maintenance risks that would be introduced.

In the water network, it is possible to use the storage capacity of reservoirs during periods of low demand (such as winter) to intelligently preferentially schedule pumping outside of high tariff periods. Hunter Water is doing this at Wallsend and Beresfield WPSs. But there is opportunity to intelligently control automated pump scheduling across the water network saving in excess of $100,000 per year in addition to the existing load shifting savings (which are an order of magnitude lower). The proposed initiative also has additional benefits through taking advantage of increasing suction pressure for downstream stations when pumping is synchronous between stations. Improving specific energy consumption under this proposed initiative may have savings of a similar order of magnitude to that achieved through load shifting. And a third category of savings (again of a similar order of magnitude) is possible under this proposed initiative through management of peak capacity charges.

2.3 Managing Peak Capacity

The local electricity network service provider for Hunter Water, Ausgrid, applies a Capacity Charge to large sites. Capacity charges are applied to the maximum half hourly kW or kVA power reading that occurred at a customer’s connection point over the 12 months prior to the bill being calculated. The chargeable kW or kVA reading can only occur in peak times which are from 2pm to 8pm on working weekdays.

In the past, Hunter Water has operated assets with no regard for this charge. Recent operator mindfulness of this charge has saved tens of thousands of dollars per year at some assets. So there are significant cost savings to be achieved through limiting pumping during this network peak window in addition to the above load shifting benefit.

Hunter Water has a bulk water supply at Tomago where a number of large pumping loads plus a private industrial load are fed from a single purchase point. This presents an opportunity to manage the capacity charge at that point by avoiding instances where all the loads are high at the same time.

One particular opportunity recently identified lies in the regularity of the industrial load. It can be counted on to drop by 1 MW by 4pm (the end of shift). Hunter Water will set up an automatic control to drop out two pumps at the Balickera WPS (approx. 1.1MVA) between 2pm and 4pm weekdays. This targeted load drop will give the benefit of a 1 MVA reduction in the peak capacity whilst only restricting load for two hours (rather than six hours). In most cases the sacrificed pumping capacity will be compensated for by extra pumping outside of peak times.

Peak capacity cost can also be reduced by knowing when to request capacity resets via the electricity retailer. These may be justified after peak loads due to events beyond the control of the customer (e.g., exceptional weather or electricity network events). Capacity resets have saved Hunter Water hundreds of thousands of dollars over recent years.

There is also similar related opportunity for demand side response, where retailers (or network providers) provide incentive to drop load during periods of high electricity demand. Such opportunities arise usually at quite short notice – i.e. hours. Hunter Water has investigated but not yet taken advantage of this type of energy cost saving initiative.

2.4 Renewable Energy and Storage

Wastewater pumping stations may use significantly more power during wet weather than during dry weather. An example of this effect is at Windale 3 WWPS. This station benefited from the addition of variable speed drives to reduce total energy consumption significantly by running pumps at lower speeds. However, during peak wet weather flows all pumps are required. The resulting peak capacity charge at Windale 3 WWPS dominates the electricity bills so that the reduced energy consumption has not led to as significant cost reduction at that site.

Additional storage of wastewater at the site to delay pumping at high power until after the network peak tariff period is not an option due to the prohibitive capital cost of the necessary civil works. But storing energy at the site is being considered through alternative fuels and/or batteries.

Downward price pressure on large scale energy storage means that onsite storage may replace onsite generators as the most cost effective option for security of supply. Zinc bromine flow batteries (for example) may be particularly suited to replacing generators, as the liquid reagent may in the future be able to be changed out on the fly to quickly restore a full charge state (the equivalent of delivering diesel to a gen set). Higher initial costs can be offset by daily load shifting and peak shaving; even demand side management. Readiness to run when required is confirmed through the activity of daily use.

This is an emerging technology that has not yet reached maturity at Hunter Water, or possibly anywhere. Hunter Water is also monitoring the increasing possibility to use renewable energy sources combined with storage too, to reduce the negative impact of intermittency of solar and wind generation, for example.

2.5 Energy Contract Management

By paying attention to what the wholesale energy market is doing before choosing when (and how) to negotiate new contracts, Hunter Water has saved millions of dollars.

Another way to pay less for electricity is to check for billing errors. Hunter Water finds enough savings through checking electricity bills to more than cover the cost of putting bill data management and validation systems in place.

2.6 Network Tariff Optimisation

Another way to pay less is to regularly review which network tariff is being applied to sites. There may be more than one network tariff that a site may be eligible for, and the selected tariff is not always in the best interests of the customer. For Hunter Water, with over 600 sites, regular tariff review saves over a hundred thousand dollars each year.

2.7 Return on Investment in Energy Management

Hunter Water has identified about 30 different pump stations with worthwhile energy efficiency initiatives, most of which have already been implemented.

These initiatives have been identified through a combination of:

- Paretto analysis to focus attention on a just a few likely candidates;
- Use of a meta-audit approach, knowing what types of things to look for (e.g., in the above categories);
- Systematic audit of WWPSs for potential for variable speed drives; and
- Keeping abreast of other upgrades and piggybacking energy efficiency onto it.

The great majority of energy efficiency measures at Hunter Water have not been dedicated energy efficiency projects. Instead most measures have conformed to one of two models:

- A Paretto/meta-audit has identified an opportunity for energy savings but the measure has been put on hold until an upgrade of the site for other reasons (e.g., replacing outdated electrical equipment, or station amplification projects due to growth). When combined with other operational imperatives the energy efficiency measure almost always is the lowest life cycle option.
- Hunter Water’s energy team has been able to reactively engage with a capital works program to identify the most energy efficient solutions, which again are often the lowest whole of life cost. This includes capital works at treatment plants and pump stations, both greenfield and brownfield.

The categories of energy saving initiatives most likely to have return on investment on their own are simple control changes and contract changes. If hardware needs upgrading, the cheapest types (in order of increasing cost) tend to be power factor correction, installation of variable speed drives, motor replacement, etc.

Energy efficiency opportunities were not always deemed by water utilities to be worth pursuing immediately, for example:

- When considered in isolation, individual pump station optimisation may lead to sub-optimal whole-of-system outcomes;
- The high value placed on security of water supply (quantity and quality) may lead to acceptance of less efficient operating regimes; and
- Consideration of capital cost or life cycle cost may make a delayed integrated planning asset upgrade more attractive than pursuing an energy efficiency upgrade in isolation.

The Neath 2 WPS upgrade is an example of how the regular capital program caused a delay in implementing an efficiency upgrade (retrofitting variable speed drives). The station was slated to be replaced with a new asset to resolve growth requirements and aging infrastructure. The planned life of the existing assets was too short to be sure of a worthwhile payback on the energy saving initiative investment. At the same time, the high cost of the planned new asset countered any ability for the energy savings to bring the upgrade forward. However, growth projections dropped off, while the imperative to retire aging electrical equipment remained. In response, the existing pump station was slated for an electrical upgrade only. The option to install variable speed drives not only had the advantage of reducing operating costs, but also allowed the design of the electrical upgrade to future-proof the station against growth. The adopted design included a designed pathway to augment the existing station, whilst retaining existing pumps, made possible by the variable speed drives. The efficiency gains at Neath 2 WPS are saving around 370 MWh per year or $55,000 per year at current pricing.

Energy efficiency initiatives often have multiplier effects with additional benefits such as better process control or monitoring, longer asset life, and better capital utility.

An energy efficiency upgrade at Schroder WPS provides an example of better capital utility. For all pumping stations there has been a tyrannical design constraint around fixed speed pumps. When meeting peak flows with a battery of pumps, the duty that the pumps see at low flows is usually quite different to the duty at full flow. Most designers elect to optimize pump selection for the full flow duty, but this means that the motor and associated power supply will be large as a consequence to manage the high-flow high-power duty that individual pumps see when operating singly.

A trade-off is always required with fixed speed pumping. Not so with variable speed pumping, where the speed control can be used to pull back the flow and power when a pump is pumping on its own. This allows the motors to be sized correctly for the highest station flow, such that when the station is operating at capacity, all elements of the station are operating at capacity. This feature was designed into the upgrade of Schroder WPS. Now at Schroder the station is capable of delivering 311 ML/d reliably, compared to the pre-upgrade figure of 267 ML/d. When high flow is required, the new control scheme runs pumps at the right speeds for the respective pumps such that all pumps are contributing flow to the safe limit of their individual power rating. (Schroder pump station is a battery of three pairs of pumps with each pair being physically different to the other pairs.) Retrofitting variable speed drives to the Schroder pump station is currently tracking to save 1,300 MWh per year reducing the electricity spend by around $100,000 per year.

Adding to the business case for energy efficiency or renewable energy projects is government funding through energy savings certificates and renewable energy certificates. Hunter Water has used both to further improve the return on investment for energy saving initiatives.

3.0 CONCLUSION

Through paying attention to a wide variety of factors that impact on energy costs, Hunter Water has been able to make a significant return on investment in pursuing initiatives to reduce energy costs. Many of these initiatives may also be applicable to other water industry operators.