PROCESS INSTRUMENTATION

Smart savings - **Using pumping strategies to reduce electricity costs and carbon footprint**

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The estimated electricity consumption by US water and wastewater treatment plants is over 82 terawatt hours per year. This is a huge and almost incomprehensible number. To put it in perspective, 1,000 watts equal 1 kilowatt hour (KWh). And a terawatt is a billion kilowatts. Thus, 82 terawatts equal 82 billion kilowatts or 82,000,000,000,000 watts hour of electricity. This is just approximately 2% of the total electricity generated in 2021 (per the US Energy Information Administration, 4.11 trillion KWh were generated in the US in 2021). Put another way, this is about the electricity needed to power Denmark, Ireland or Morocco. It's no wonder then that energy reduction goals are becoming more prevalent in efforts to not only reduce the carbon footprint, but also to combat the increasing price of electricity.

Energy saving comes in many forms, such as better lighting strategies, using smart motors, and maintaining equipment in top condition. It also includes using pumping strategies that align well with ToU (Time of Use), also known as off-peak and peak-hours. With respect to pumping strategies, water pumps represent 40 to 60% of the energy usage at W&WTP, which accounts for a major expenditure in the water treatment process. Thus, implementing smart pumping routines can aid in the realization of real savings.

Energy cost saving measures at a water and wastewater treatment plant can start by evaluating pumps, blowers, and the sludge treatment process. Some of the recommendations to improve efficiency include the installation of variable frequency drives, SCADA systems, and replacing inefficient motors and blowers. However, replacing equipment requires a good assessment of the return on investment. The above possible areas of improvement are mostly geared for equipment inside the fence. What about equipment improvements away from the main treatment plants?

Siemens SITRANS HydroRanger controller and SITRANS LR120 radar level measurement.

It is estimated that 20% to 30% of the operational cost associated with electricity cost is due to water pumps moving water across a vast network outside the fence. For instance, evaluating pumps that may not be handling their expected load efficiently may present a great opportunity to reduce energy consumption.

Here is an example on how much a city saved by replacing an underperforming pump. A group of engineers evaluated the efficiency of a sewage pumping station and determined that an existing pump needed to be replaced by a new and more efficient pump. This resulted in about $2,500 per year in energy savings. Could there be additional actions that can lead to further savings?

Ten years ago, the California Public Utilities Commission estimated that of the approximately 176 Gigawatts (or 176,000,000, KWh) used in the water sector, 42% was due to residential use, which meant that a large amount of clean and dirty water must be managed by water and wastewater treatment plants. The real-time cost associated with the supply of electricity is linked to the demand. Usually, the demand goes up late in the afternoon into early evening hours. This is when residential water consumption goes up, when people return home from work and go on with their busy lives doing laundry, cooking, showering, etc. Although the electricity rates for residential customers are higher than for the commercial sector and municipalities, municipalities too must pay more during on-peak hours. An increase of 3%, 15%, 50% or more per KWh during high electricity demand can add up when considering the elevated volume of water collected in lift stations and the power needed to move it from point to point until it reaches the water treatment plant.

Whether inside the fence or within the water treatment plant, some plant operators have and are often finding ways to mitigate energy use and costs. Also, water treatment is a continuous process and plant operators must run their systems regardless of what the electricity price per KWh is at any given hour. But outside the fence across the collection systems in towns or cities there is room for flexibility on how to manage the operation of sewage lift stations.

A great number of lift stations have in place level and pump controllers to monitor the level and sequence of the various pumping cycles. Some of these level and pump controllers have energy saving pumping routines with built-in functions to schedule pumps to run when electricity is less costly or during off-peak electricity tariff rates. However, these features often go unused. Investing on these types of level and pump controllers is a practical solution to aid with the stewardship goals with respect to the reduction of the carbon footprint. The good news is that this feature is straightforward enough that no specific expertise with the instrument is required.

Here is another example. (See Figure 1 below.) Hourly pump down cycle times and duration vary based on the inflow rates. Also, the larger the pump, the longer the pump cycle is recommended. In some areas the electricity peak hour rates start early in the morning and in the early hours of the evening. Typical peak hours are from 6:00 a.m. to 9:00 a.m. and from 4:00 p.m. to 7.00 p.m. and this does not apply to weekends. In this example, it is estimated that the daily total pump operating hours is 8.5. Thus, running two 50-HP pumps with a 0.95 efficiency factor and 0.65 load factor for 5 hours a day at a rate of 5 cents per KWh will cost $12.76. The yearly costs for only the 5 hours at the off peak of electricity is $4,658.

Considering the additional 3.5 hours at the peak rate of electricity of 6.5 cent per KWh on weekdays, and at the off-peak rates of 5 cents per KWh on weekends, the costs are $3,019 and $938 respectively. This results in an estimated operation cost of $8,615 for 2 pumps. If both

Number of days	Running hours	KWh of-peak rate	KWh on-peak rate	Yearly costs	Comments
365	5	$0.05		$4,658	Weekly
260	3.5		$0.07	$3,019	weekday
105	3.5	$0.05		$938	Weekend
				$8,615	
365	8.5	$0.05		**$7,918**	Weekly

Fig. 1. On-and-off-peak rates of electricity cost calculations

pumps were to run the estimated 8.5 hours per day at the off-peak rate, the operating cost would be $7,918. Thus, the high peak rate represents an increase of roughly $700 a year for two pumps. What if there are 10 pumps, 50 or 100 pumps in network serving the local population? The total operating cost quickly escalates, i.e., 100, 50-HP pumps will amount to about $430,750 in electricity costs. Of course, not all wet-wells require 50-HP pumps. Also, some areas offer rate of consumption schemes to leverage reduced tariff rates but charge more when the agreed KWh is exceeded.

Considering the two examples, the yearly savings are not negligible for either case. In the example where a new pump was replaced, the overall investment was over $12,000. However, the cost for a level and pump controller that can manage up to 6 pumps using radar sensors hovers around $2,000. By simply reducing 1.5 hours off during the on-peak rate, 35% of the initial instrument cost can be achieved in the first year. Better yet, if level controllers with economy pumping capabilities are already in place and are not being used to do the priming of wet-wells or collection systems to take higher volumes of water and sewage during on-peak demand, then all is required is the setup of a few parameters. The implementation is simple. It is just a matter of determining the local times for the off-and-on peak demand rates. From there, setup up to 5 different schedules to reduce operation costs. It is worth noting that these pump routines do not sacrifice safety. What this means is that if the maximum level in a well is reached, the pump(s) will turn on and stay on to bring the well down to a safe level.

Electricity consumption reduction goals can be reached by varied paths or by a combination of paths. By using the examples above and combining the two approaches, that is replacing inefficient pumps and reducing the operation of pumps during high energy peak rates, savings can be even more sizeable. If there are budget limitations, the savings realized by a level controller can, in a few years, be re-invested to purchase more efficient pumps. Either way, it is a win-win scenario.

By the numbers:

It is estimated that there are over 16,000 water treatment plants and about 2 million sewage lift stations in the US. If we take only 1.5 million pumps and assume a motor rating of 50-HP, we can do some general estimates. But first, the economy pumping strategy requires priming down the wet-wells prior to the high peak period to allow them to receive more water and sewage before the higher cost of electricity begins. If out of the 6 on-peak potential hours per weekday, 3.5 hours are pump on-time hours, and economy pumping can be used to run them only for 2 hours, then the total kilowatts reduction would make a small dent on the astronomical 82 terawatts hours cited above. The 1.5-hour operation reduction results in an aggregated dollar amount of $498 per pump comes up to approximately $746.5 million per year. Just running an extra hour during peak demand, that is a total of 2.5 hours, increases electricity costs to $1,244 million. This is an additional cost of $497.6 million. Savings of this magnitude cannot be ignored. From the Energy Information Administration's Electric Power Monthly report, the price of electricity in November 2022 for the industrial sector ranged from an average of 6.03 cents per KWh all the way up to 18.4 cents per KWh across the contiguous 48 states. Good stewardship toward the environment and municipal budgets should drive an interest in running pumps more economically and thereby reducing operational costs. Consider the number of pumps in your network and the local applicable off-and-on peak electricity rates, and with little effort substantial savings can be realized year after year.

If you have any questions please feel free to reach out to me.

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