By Simon Bunn

GET PUMPED

Maximizing energy efficiency and minimizing the carbon footprint in potable water pumping

Figure 1. Operating Characteristics of a Large Potable Water Pump

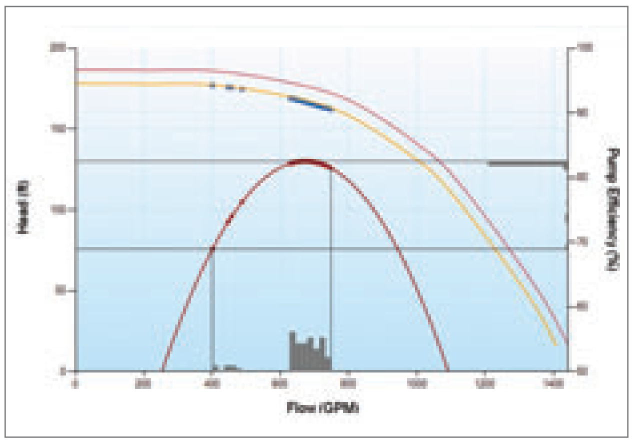
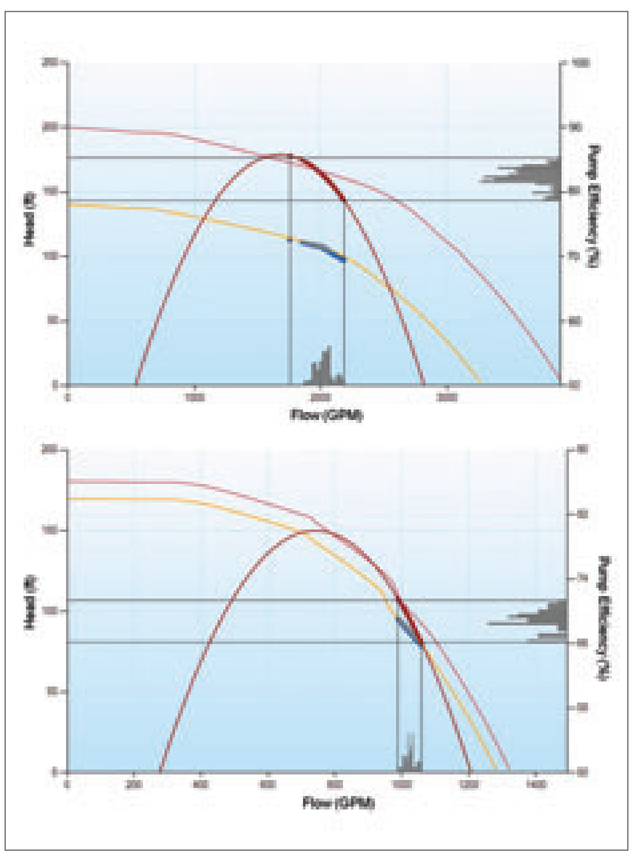


Figure 2. A Pump Station with Two Pumps



- Scheduled Operations
- Efficiency Points
- Pump Curve
- Manufacturers
- Efficiency Curve Fit

Electricity consumption by water and wastewater utilities accounts for 3% of all electrical energy consumption in the U.S.[1] This represents net annual consumption of 75 billion kWh in the U.S. and is currently worth $4 billion.

Between 90% and 95% of the electricity purchased is used for pumping.[2] It therefore follows that there should be considerable benefits from ensuring the pumps are well matched to their duty requirements and operating at efficiencies at the top end of the manufacturer's performance ranges. This involves specifying the right pump for the duty requirements and monitoring performance over the economic life of the pump. Energy efficiency investments can yield excellent returns of 5% to more than 25% efficiency improvements, with consequential energy cost reductions, in addition to other benefits such as reducing the greenhouse gas footprint of utilities.

While significant progress has been made in analyzing individual pumps and matching characteristics to specific duty requirements, these have relied on assuming each pump runs at a single pressure and flow operating point. Pump operating requirements for water utilities are subject to widely variable seasonal and diurnal water demand fluctuations, making it impossible to cover all operating contingencies.

Pump Efficiency

Given the benefits and potential for rapid payback, it would seem that pump efficiency is an obvious subject for investigation and remediation by water utilities. Until recently, however, energy has been relatively cheap and cost-saving efforts have focused elsewhere. While there appears to be only sporadic investigation work into this area in the U.S., Europe has made great progress in analyzing potable water systems.

A major study of pumps was commissioned by the European Commission in 2001.[3] The study recommended three key steps to improving pump operating efficiency:

1) Match pump characteristics to duty;
2) Counter efficiency deterioration through reconditioning pumps; and
3) Operate pumps at their best efficiency point.

Where water utilities have tackled pump reconditioning, the results have led to paybacks measured in months rather than years. Recently, the New York State Energy Research and Development Authority sponsored the Monroe County Water Authority (MCWA) to test pumps and then apply various coatings to large pumps during refurbishment programs. MCWA found during testing that some pumps were more than 20% below manufacturers' efficiency curves and was surprised to report substantial improvements after coating—in some cases, almost back to the manufacturers' curves. Payback for the entire refurbishment cost was less than a year.

Software Solutions

Improving the pump efficiency through replacement or refurbishment is useful as long as the pump is actually operating close to the peak of the efficiency curve. As discussed previously, potable water distribution systems often see a wide range of operating head across a pump.

In Figure 1, a plot of the operating characteristics of a large potable water pump has been generated through an innovative real-time reporting tool. The pump is almost brand new, evident by the only very small drop in measured performance versus the manufacturer's curve. Typically, the pump is delivering 750 gal per minute (gpm) at 175-ft discharge pressure, and it does this with an efficiency of 83%. Note, however, that even a slight increase in discharge pressure to 180 ft causes the pump's efficiency to drop below 70%, indicating that possibly a different pump should be run.

In Figure 2, a pump station is shown with two pumps. When purchased, these were specified as a 2,000-gpm pump and a smaller 800-gpm pump. Here, it is interesting to see that the 2,000-gpm pump is well worn, as indicated by the fact that the current measured pump curve (shown in yellow) is more than 25% lower than the original manufacturer's curve (shown in red). It is interesting to note that this pump achieves a very good average efficiency of 88%; in this example, the reduced flow as a result of the worn pump impeller actually helps move the operating point high on the efficiency curve.

Also note that the second pump, while almost new as indicated by the very similar manufacturer's and actual pump curve, is not operating as efficiently. The 800 gpm is seeing only 80 to 95 ft of total dynamic head, which is approximately 25% less than the ideal 125 ft of differential pressure it needs to operate at the top of its efficiency curve.

Table 1. Greenhouse Gas Reductions for Four U.S. Case Study Systems

Customer System	Average MWh per Year	Average Efficiency Gain Under Aquadapt	EPA eGRID 2004 CO_2 Emissions (tons/MWh)	Extrapolated CO_2 Reduction per Year (tons)
East Bay MUD, Calif.	26,000	6.1%	0.502	800
Washington Surburban, Md.	7,000	8.4%	0.515	300
WaterOne, Ks.	99,000	8.3%	0.547	4,500
EMWD, Calif.	94,000	6.0%	0.845	4,800

Case Studies

What is required, therefore, is a tool to select the right pump or combination of pumps at the right time of the day to maximize efficiency. Eastern Municipal Water District (EMWD) of Perris Valley, Calif., implemented the Aquadapt software package from Derceto, Inc., in 2006. The software reduced energy costs by more than 13% and improved efficiency by 8.4%. EMWD received the California/Nevada American Water Works Association Outstanding Energy Management Award in 2007 for this project.

Table 1 lists EWMD with three additional case study systems, noting the effect Aquadapt had on their greenhouse gas emissions. California has made a commitment to greenhouse gas reduction at the state level in Assembly Bill 32. With 19% of the state's energy use going to transporting both raw and potable water, this has led to a focus on energy-efficiency improvements in the water sector.[4]

The Potential of Optimizing

Traditional methods for improving pump efficiency have concentrated on the static process of carrying out a pump curve calibration, assuming operating point and then either replacing, modifying, machining, polishing or coating the pump surfaces. While these measures have been shown to be beneficial, they do not take into account the dynamic nature of the pump's actual operating range.

The ability to optimize pumps in real time against dynamic changes in water demand has achieved reductions in energy consumption of 6% to 8.4% for four large water utilities. This has reduced the carbon footprint for these utilities by the same percentages, adding up to thousands of tons of CO_2 per year. If this was applied to the all U.S. water and wastewater pumping networks—using an average greenhouse gas value of 0.668 short tons CO_2 per MWh of electricity production[5]— between 3 and 4 million tons of CO_2 emissions could be saved annually. WWD

References

1 Electric Power Research Institute. "Energy Audit Manual for Water/Wastewater Facilities." Palo Alto: Electric Power Research Institute, 1999.
2 Denig-Chakroff, David. "Reducing Electricity Used for Water Production." National Regulatory Research Institute. June 13, 2008, p. 5.
3 David Reeves, ETSU, CETIM, Darmstadt University of Technology. "Study on improving the energy efficiency of pumps." European Commission, 2001. AEAT-6559/ v 5.1.
4 California Energy Commission. "California's Water-Energy Relationship. Sacramento." California Energy Commission, 2005. CEC-700-2005-011-SF.
5 U.S. Department of Energy. "Updated State-level Greenhouse Gas Emission Coefficients for Electricity Generation." Office of Integrated Analysis and Forecasting, U.S. Department of Energy, 2002.

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