Smart Pumping: A New Way to Address the Worldwide Water Distribution Crisis

by Hussain Ahmed

Executive summary

Global water shortages, the growth in urban population, environmental regulations, and process inefficiencies are all contributing to a crisis in the water / wastewater industry. In fact, it is estimated that the amount of energy wasted as a result of traditional methods of water processing and delivery can be cut by up to 25%. This paper describes how migration to new "smart pumping / intelligent pumping" approaches can help water / wastewater organizations address these challenges.

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Introduction

Current methods for managing and allocating global water supplies are becoming obsolete. Symptoms of outdated water management infrastructure include inconsistent water supply, poor water sanitation, and substandard drainage. These problems, unfortunately, will continue to increase as more users come online. According to the United Nations, the urban population of the world is forecast to grow from 3.4 to 6.3 billion people in 2050[1].

Water / wastewater utilities and service providers working with local and national governments will bear the responsibility of addressing this challenge and will need to cost-effectively modernize their infrastructures in order to cope with the surging demand. This is especially true in the new megacities that are popping up across the globe. This rapid urbanization is occurring because of the attraction of higher paying jobs and because rural dwellers hope that cities can provide them with improved living conditions and enhanced services.

Fortunately, billions of dollars in water / wastewater research and development investment is helping to fuel the availability of new technologies. These technological advancements improve the efficiency of key processes such as water extraction, purification, and transportation. The water management process is tightly linked to energy, as energy is the lifeblood that runs the operational equipment of the entire water delivery ecosystem.

The treatment of wastewater alone, for example, requires significant amounts of energy. **Table 1** illustrates how much more energy is required to pump and process groundwater (e.g. from aquifers) as opposed to fresh water present at the surface.[2] As more demand is placed on the “easy to get to” water resources, the need to process groundwater, brackish water, and seawater will continue to increase.

Table 1
Amount of energy required to extract and treat water from various sources

	Source / treatment type	Energy use (kW hr / million L)
Water	Surface water	60
	Groundwater	160
	Brackish groundwater	1,000 – 2,600
	Seawater	2,600 – 4,400
Wastewater	Trickling filter	250
	Activated sludge	340
	Advanced treatment without nitrification	400
	Advanced treatment with nitrification	500

In water / wastewater operations, energy is utilized for the purposes of extraction (surface water, groundwater), transformation (treatment to drinking water standards, desalination), water resource delivery (municipal, industrial and agricultural supply), reconditioning (wastewater treatment) and release. For example, it is estimated that 7% to 8% of the energy that is produced globally is used to lift groundwater and pump it through pipes, and to treat

[1] Managing Water under Uncertainty and Risk, The United Nations World Water Development Report 4, VOLUME 1, 2012, page 19

[2] CEC 2005, EPRI 2002, Stillwell et. al. 2010b, 2011, Stillwell 2010c

both groundwater and wastewater. This figure rises to around 40% in developed countries.[3] The demand for energy to enable wastewater treatment is expected to rise globally by 44% between 2006 and 2030.[4]

The Electric Power Research Institute (EPRI) estimates that 2-4% of total US electricity consumption is used for water provision at water and wastewater treatment plants.[5] Including end-uses, the national US energy consumption for water is approximately 10%. Energy requirements for surface water pumping are generally 30% lower than for groundwater pumping.[6] It can be expected that groundwater will become increasingly energy intensive as water tables fall. Therefore strategies for controlling energy consumption are a must in order to cut costs.

The new water / wastewater infrastructure solutions are designed to enable rapid commissioning, safe and efficient operation, and simplified maintenance. This paper analyzes critical components within the water resource delivery chain such as pumps, variable speed drives (VSD) and sensor and software-driven monitoring. Recommendations are provided for how to integrate and deploy these new, digitized "smart" components.

Why pumping infrastructure matters

Over 24% percent of energy consumed by industrial motors is consumed by pumps (see **Figure 1**).[7] This represents a major driver for the development of a new generation of energy efficient pumps. Government agencies and regulatory bodies (like the European Commission) are defining standards to help ensure the development of energy efficient pumps.

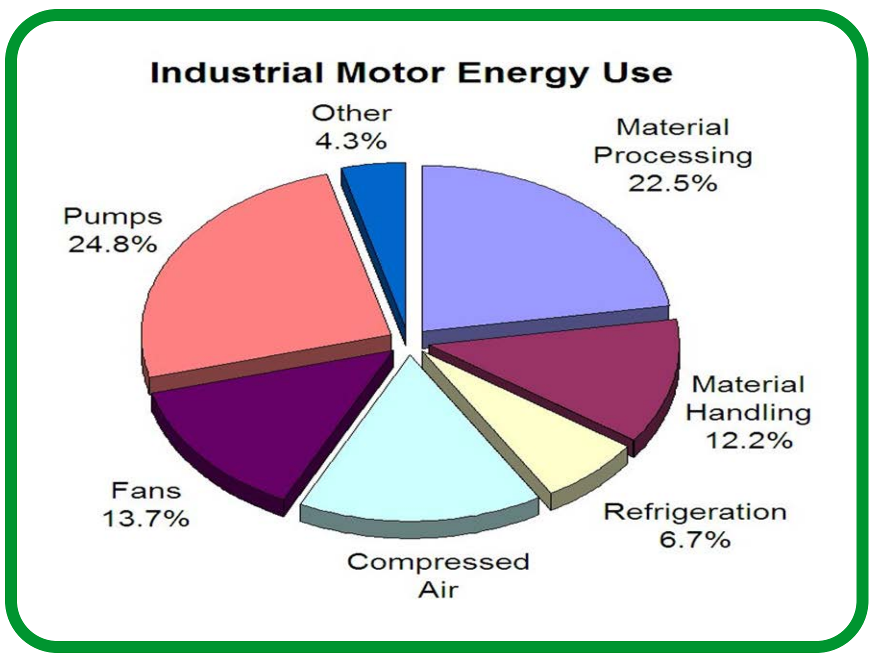


Figure 1
Pumps represent a major segment of the energy consumption pie

[3] WEF (World Economic Forum). 2009. Energy Vision Update 2009: Thirsty Energy: Water and Energy in the 21st Century. Geneva/Englewood, Colo., WEF/Cambridge Energy Research Associates. http://www.weforum.org/reports/thirsty-energy-water-and-energy-21st-century?fo=1 (Accessed 30 April 2011.)

[4] IEA (International Energy Agency). 2006. World Energy Outlook 2006. Paris, IEA. 2007. World Energy Outlook 2007. Paris, IEA.

[5] EPRI (Electric Power Research Institute). 2002. Water and Sustainability (Volume 4): U.S. Electricity Consumption for Water Supply and Treatment – The Next Half Century. Palo Alto, Calif., EPRI. http://www.circleofblue.org/waternews/ wp-content/uploads/2010/08/EPRI-Volume-4.pdf (Accessed 2 May 2011.)

[6] Ibid.

[7] DOE Office of Industrial Technology

Regulations are becoming more strict over time as evidenced by some of the following provisions:

- In 2011, the use of IE2 class motors was prescribed by law
- From 1 January 2015 on, energy efficiency class IE3 will be mandatory for motors from 7.5 kW to 375 kW
- From 1 January 2017 on, energy efficiency class IE3 will apply to motors from 0,75 kW to 375 kW

European Commission legislation has introduced the concept of an eco-design for pumping systems. According to EU Regulation No. 547/2012, eco-design requirements suggest that a pumping system consisting of the combination of pumps, drives, controlling systems and electrical systems be considered for efficiency measurement (as opposed to the older system of evaluating only the separate components).

Figure 2 illustrates this “extended product” approach. This will result in a potential savings of 30% compared to 3.6% with the current “pump only” approach.

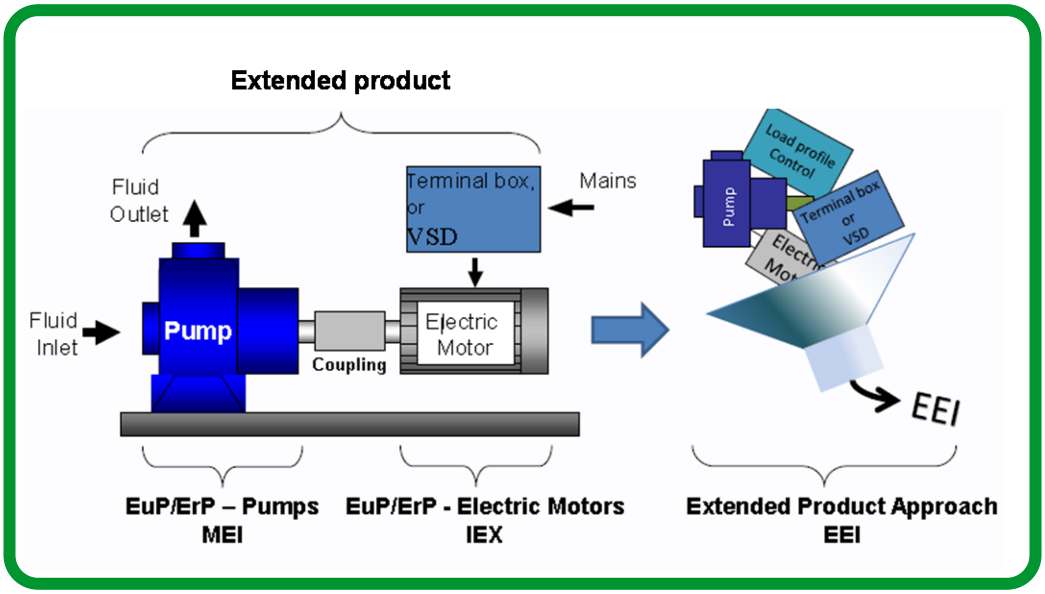


Figure 2
The extended product approach as presented by Europump, an association of pump manufacturers

The marketplace is now shifting in order to accommodate these more stringent efficiency regulations. The concept of the "Smart Pumping" which is also termed as “intelligent” pumping system combines higher efficiencies with sensor and software driven ability to regulate and control flow or pressure. This approach results in energy savings, increased equipment lifetime, and maintenance cost reductions.

In order to better understand how this concept of eco-design for pumping systems works we need to define some of the terminology presented in **Figure 2**.

- EuP – Energy using product: products which are dependent of energy input (such as electricity)
- ErP – Energy related product: products that use energy, or that do not use energy but have an indirect impact on energy consumption (such as water use devices, building insulation products, windows)
- MEI - The Minimum Energy Index: this is the minimum allowable level of efficiency of a pump

- IEX - Standard IEC 60034-30 defines the energy efficiency classes for asynchronous motors. Regulations (EC) 640/2009 and 04/2014 establish the conditions for the conversion to the new energy-efficient technology.
- EEI – The Energy Efficiency Index: this is utilized to determine the energy footprint of the pump under different load conditions
- BEP - Best efficiency point: Most of the pumps are not operating in this point.

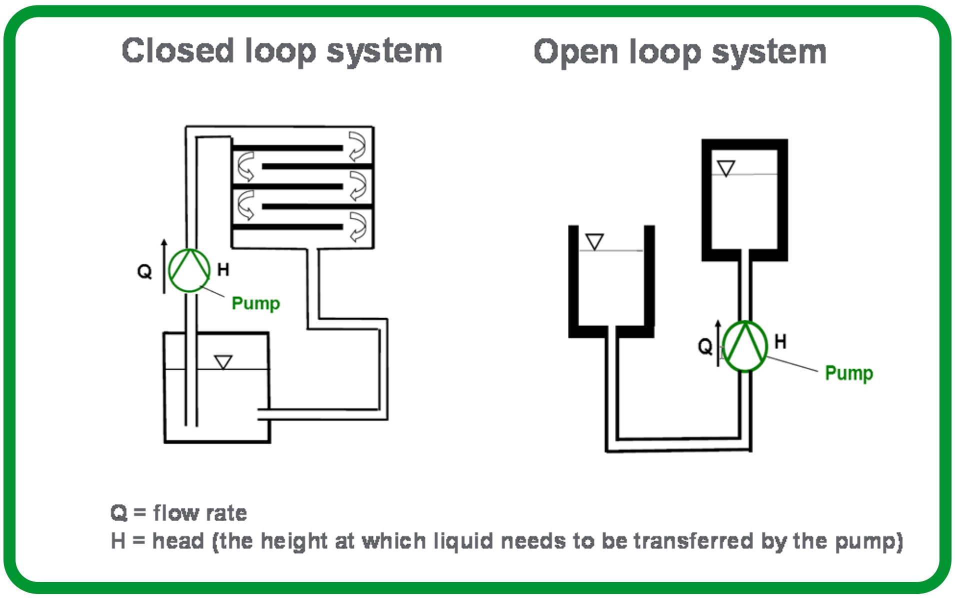
Manufacturers provide efficiency data for pumps. Terms like BEP (Best efficiency point) are utilized but most pumps are not operating anywhere near their BEP. Most pumps, in fact, operate between MEI and BEP. It is estimated that 75% of pump systems are oversized, many by more than 20%.[8] Also the efficiency of a pump is determined by whether or not the pump is being operated at partial load (not efficient), near full load (good efficiency), or at overload (not efficient).

However, pumps, as an isolated component within the larger physical infrastructure of a pumping operation, are just part of the picture. Electric motors and drives have to be factored in, so that a foundation for true efficiency gains can be enabled. This trio of components (pump+ drive + motor) is known as a complete drive module (CDM).

An important distinction between traditional systems and new "smart" systems is how all of these components interact with each other and automatically share vital information. For example the variable speed drive can recognize the levels activity of both motors and pumps (from idle to partial load conditions, to full capacity, to overload) and automatically makes the proper adjustments so that the pump operates as close to BEP as possible and for the motor to run as efficiently as possible.

A CDM works in "smart" mode for both open loop and closed loop pumping systems. An open loop system refers to a pumping system in which liquid is pumped from an open source to a tank. In a closed loop system the liquid circulates in a self contained system (see **Figure 3**).

Figure 3
Closed and open loop systems share different efficiency characteristics



[8] US Department of Energy, "Variable Speed Pumping — A Guide To Successful Applications", 2004, page 10.

In a "smart pumping" environment, the ability to determine, monitor and even to take corrective measures can be programmed into the CDM solution. This enables the users to run the pumps at near BEP throughout the life cycle of pumping systems.

Table 2 compares traditional pumping system performance to the smart system approach in several key areas. The "smart pumping" approach, if properly implemented, will enable improvements in pump efficiency, energy efficiency, and ease of maintenance.

Table 2
Comparison of traditional smart pumping systems

System attribute	Traditional system	Consequence	Smart system
Energy Efficiency	Lack of capability in components for monitoring consumption	Higher operating costs	Allows users to get much closer to optimal energy consumption operating points
Programming & controller	Non-standard programming practices	Longer start up times, more time to trouble shoot issues	• Pre-coded libraries allow of system standardization • Object oriented programming allows for rapid trouble shooting
HMI	Use of lights for indicating alarms	More time to trouble shoot issues	Optimized screens and detailed alarms provide better maintenance
Drives	Switching on pumps with on / off contactors	Less protection of the pumps because of more shocks to the mechanical systems	Though initial costs increase, drives provides higher energy efficiency and more pump protection against electric surges and also cyber attacks as latest control system have intelligence to provide firewall against attacks
Cabling	Hardwired systems	Longer start up times, more time to trouble shoot issues	Use of field bus in the control system reduces start up time and enables better maintenance
Remote monitoring	No possibility of accessing online data	Impossible to identify the history and causes of past events Therefore, preventive maintenance is not possible	Remote monitoring allows operators to better analyze conditions and to plan preventive maintenance strategies

Today, pumping systems account for nearly 20% of the world's energy usage. In industrial facilities motors can consume between 25 and 50% of total electrical usage. Therefore, a huge opportunity exists for reducing these energy consumption numbers.

Figure 4[9] provides insights as to where additional energy savings can be made if smart pumping practices are embraced. (The numbers in **Figure 4** are derived from a study conducted by AHR and Europumps and was validated by the US Department of Energy).

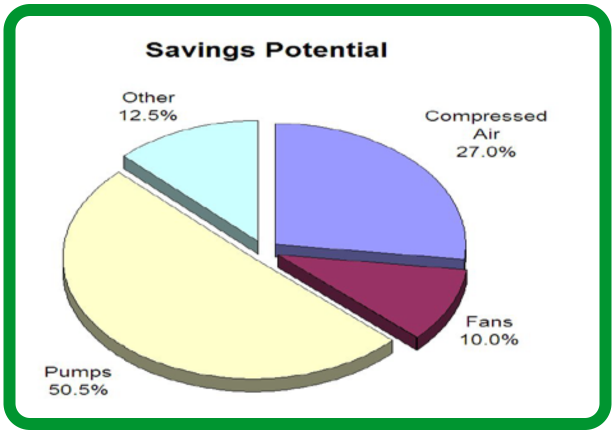


Figure 4
Energy efficiency saving potentials in pumping systems

Conclusion

The transition to smart pumping will be a major step forward in addressing the challenges of global water / wastewater management. Both private and municipally-managed facilities can no longer afford inefficient high cost operations that require high maintenance.

In order to enable this transition the following steps should be considered:

1. Introduce energy consumption measurement devices into the water / wastewater architecture. Data from energy meters enable improvements in energy efficiency (you can't manage what you don't measure) and also allows operators to perform pro-active, low cost maintenance.
2. Deploy modern controllers with high intelligence for improved security, reduced commissioning time, and better regulation compliance.
3. Replace fixed-speed pumps with variable speed pumps (enabled by variable speed drives).
4. Enable "smart" visibly into the network of pumping systems through the deployment of remote monitoring. This reduces both maintenance and energy costs.

About the author

Hussain Ahmed is Program Manager in Schneider within the Industry Division's OEM Segment team. Since 1994 he has focused on automation and commissioning projects, as well as global software and architecture development. Mr. Ahmed holds Bachelor's degree in Electronic Engineering. He joined Schneider Electric in 2006 and has executed several roles including marketing, business development, and software development /commissioning.

9 https://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/variable_speed_pumping.pdf