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# Fluid PUMPING systems– low-hanging fruit for energy savings

## *Whole-systems approach, rather than components approach, saves most*

*Pumping systems account for about 20 percent of the energy electric motors use. Improvements such as integrated controls, as shown, represent a huge opportunity for savings. Photo courtesy of Armstrong Pumps Inc., Buffalo, N.Y.*

**By Brent Ross**

Pumping systems consume roughly 20 percent of the total electrical energy motors use in the U.S and worldwide, and 25 to 50 percent in certain industrial facilities. Clearly, pumping systems eat up a significant amount of electrical energy.

One could argue that upgrading the motor or variable-speed drive (VSD) alone would be sufficient, because these components represent the greatest opportunity for energy savings in a pumping system. Indeed, many established incentive programs today focus on component efficiency.

However, taking a component, rather than a whole-system, approach often saves far less energy than anticipated. Upgrading components individually saves up to just 28.7 percent:

- Motor–4.7%
- Drive–20 %
- Pump–4%
- Total savings–28.7%

A typical component approach starts with the motor. The average motor efficiency today is 89.5 percent, and there is an opportunity to gain 4.7 percent by switching to a high-efficiency motor (4.7 percentage points is the average efficiency gain for motors from the DOE's 1998 pre-Energy Policy Act (Epact) to the current NEMA standard [12-12], known as NEMA Premium® ).

Pump efficiency improvements since 1998 have been minimal, about 4 percent. A more efficient pump system alone could save energy by improving the pump operation—from the average 74 percent efficiency to 78 percent, which is a fairly aggressive efficiency gain.

When VFDs are simply installed in an existing pumping system, the energy savings is 20 percent, on average. This is based solely on the author's observation in the field.

This component approach yields a total energy efficiency gain of 28.7 percent. However, the opportunity exists to achieve a lot more—82 percent energy reduction—by taking a whole-system approach.

## Four Steps to a Whole-System Approach

Let's examine a typical secondary pumping system in a heating or cooling loop in a facility. If the pumping system was installed before 1995 (perhaps 50 percent of the installed base today), it probably is of the three-way, constant-flow type.

In one of these typical fluid pumping systems, 8 percent of the energy is wasted in the motor; about 29 percent is wasted in the piping that transfers the fluid to where it is needed; roughly 25 percent is wasted in throttling; and 20 percent is wasted in the pump. So the actual delivered energy is only 18 percent

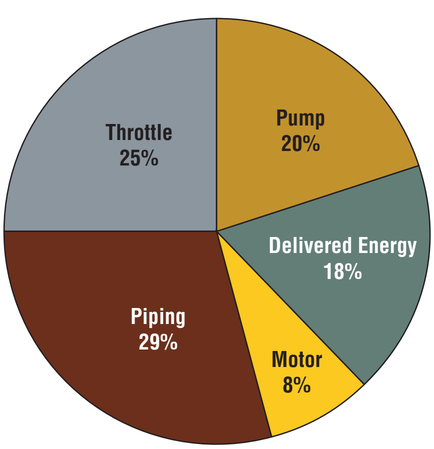


***Figure 1***

*In a typical fluid pumping system, the actual delivered energy is only 18 percent because power is lost in the pump, piping, throttle, and motor.*

> The opportunity exists to achieve 82 percent energy reduction by taking a whole-system approach.

(see **Figure 1**). That means there is an 82 percent opportunity to reduce energy usage in the average pumping system.

Energy efficiencies can be achieved in a typical closed-loop pumping system in the following areas:

**1. Variable-speed Drive.** Most constant-speed, constant-flow systems have a throttling device that is throttling 15 percent. They have a throttle valve somewhere that throttles the flow, and dissipates an estimated 15 percent of the pumping power. So the first area of opportunity is to install a VSD and open the throttling valve. Doing so improves efficiency by 15 percent (see **Figure 2**).

Many VSD systems operate today with the variable speed set at a constant reduced speed.

**2. Variable Flow.** Thirty years ago the standard pumping system for cooling was the constant-flow, constant-speed type. It was turned on and spent its entire life pumping away at the same flow and the same pressure. Three-way valves basically controlled the flow. Because the heat exchanger didn't need flow, fluid bypassed the heat exchanger, but the pumping system itself pumped merrily along.

For systems with three-way valves, the second opportunity to gain efficiency is to make them variable-flow systems. The easiest way to achieve that is to close the bypass, which changes the configuration into a two-way valve. In this mode, the pump "rides" its performance curve to provide the flow needed by the system.

This step should net another 29 percent savings.

**3. Flow Control.** Once a pump has been equipped with a VSD and an open-throttle valve, the next way to achieve energy savings is to control flow. Switching from constant speed to variable speed controls and maintains a constant pressure across the pump.

This is considered by the heating and cooling industry to be the easiest method for controlling a VSD in the pumping system, because the control sensors and wiring are all contained in the mechanical room. It is an easy system to install and troubleshoot. The pump delivers a constant pressure, although flow can vary. This realizes another 25 percent in energy savings.

**4. Integrated Control.** The fourth opportunity for improved energy efficiency is to have the pumping system attuned to the true flow requirements of the HVAC system. This can be done by either placing the control sensor into the system itself, which can raise the cost of the control system and make troubleshooting more difficult, or by using an integrated pump control available in the marketplace just in the last decade only. This type of control senses the true system requirements through electronics present in the pump itself. Another 20 percent energy savings can be achieved here.

Taking a whole system approach, and using all four of the efficiency strategies listed above can improve energy efficiency by 49 percent over a simple component-based approach

However, this does not allow for the power loss through the VSD control, although these devices are not 100 percent efficient even at full load and are less efficient at part-load and reduced speed. The same applies to motors because motor efficiency is reduced as it runs at reduced load and reduced speed.

In addition to these four areas, a

| | | Power | Energy Savings | |
|---|---|---|---|---|
| A | Constant speed throttled | 32.03 | Incremental | Cumulative |
| B | Reduced speed unthrottled - constant flow | 27.11 | 15% | 15% |
| C | Reduced constant speed - variable flow | 19.36 | 29% | 40% |
| D | Variable speed - variable flow - mechanical room sensor | 14.35 | 26% | 55% |
| E | Variable speed - variable flow - remote sensor | 7.32 | 49% | 77% |

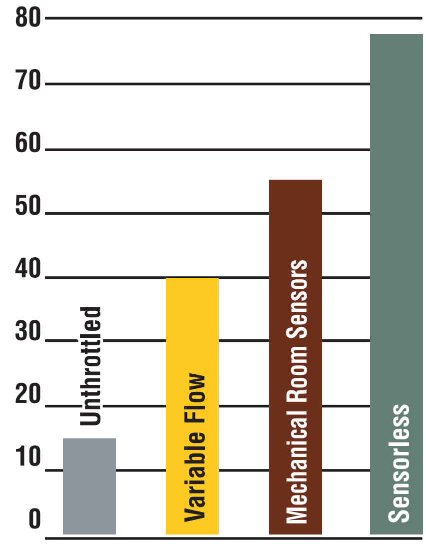


***Figure 2***

*The opportunity exists to improve pumping system efficiency by looking at the system as a whole instead of just its component parts.*

number of other energy-saving opportunities are available. Changing the motor to a higher-efficiency one, right-sizing the pump, and optimizing the selection against load profile also will gain efficiencies. In a retrofit installation, a pump upgrade can increase pump efficiency by an additional 1 to 5 percent.

### Incentives Needed

Only a small portion of the $6.2 billion in utility rebates can be applied to pumping systems. These incentives are needed to ensure the upgrade of pumping systems. Today's incentives from utilities breakdown mainly into two areas: prescriptive and custom. Most pumping systems today are directly rebated under the custom criteria, which is quite cumbersome. Prescriptive incentives applicable to pump systems have mostly been geared toward motors and VFDs, which encourage the component approach and save only a small percentage of the total savings available.

Prescriptive incentives could be in the form of rebates based on:

- Pumping system upgrade type on a per installed HP basis
- Before and after power meter comparisons
- Installation of pumps with integrated controls


Changing the motor to a higher-efficiency one, right-sizing the pump, and optimizing the selection against load profile also will gain efficiencies.


- Reduction of installed pumping horsepower
- Flat incentives per installed HP for impeller trimming, upgrading pump clearances, seal and bearing types
- Reduced discharge pressure

The combination of prescriptive incentives, measures, validation programs, and tools for pumping systems has the potential to reduce the electrical energy consumption in North America by 5 percent.


*Brent Ross is director of marketing for S. A. Armstrong Ltd., 23 Bertrand Ave., Toronto, ON M1L 2P3 Canada, 416-755-2291, www.armstrongpumps.com.*


## Pump Systems Efficiency Tools

A Hydraulic Institute (HI) and Pump Systems Matter (PSM) guidebook, *Optimizing Pumping Systems: A Guide for Improved Energy Efficiency, Reliability, and Profitability,* provides information on optimizing existing pumping systems and designing new pumping systems to run at optimum efficiency to reduce energy use.

PSM also offers a day-long course, *Pumping Systems Optimization*, on fundamentals of doing a basic pump system assessment.

For more information, visit **www.pumpsystemsmatter.org.**