Three Steps for Reducing Total Cost of Ownership (TCO) in Pumping Systems

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(Adapted and revised for US readership by Tom Lowery and Jack Creamer)

Executive summary

Energy costs have become an increasing contributor to pumping systems Total Cost of Ownership (TCO). In fact, energy cost represents 40% of the TCO of a typical pump. It is possible to reduce the electrical consumption by at least 30% utilizing Variable Speed Drives while decreasing maintenance costs associated with the mechanical driven system. This paper explains how to reduce TCO with a limited investment focused on three key areas: energy efficiency management, asset management, and energy cost management.

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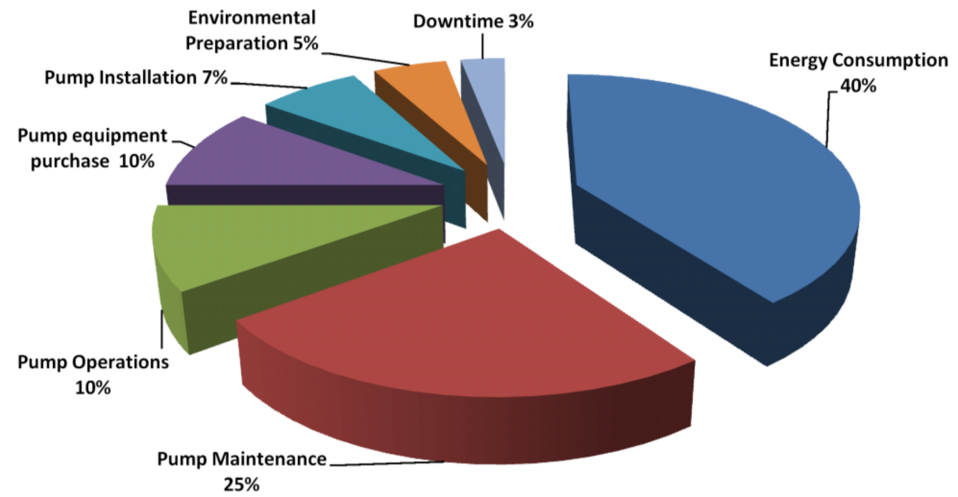
Introduction

Typical pumping systems are found in applications such as Building / HVAC, Water / Wastewater, Oil & Gas Extraction/Transportation and Irrigation – where energy makes up a significant portion of total pump cost. Electrical energy costs can represent 40% of the total cost of ownership (TCO) of pumping systems (see **Figure 1**). Despite this fact, many organizations fail to introduce the proper steps to leverage cost reduction through efficiency improvements. To solve this dilemma, the following major barriers need to be recognized and addressed:

- Energy efficiency has traditionally not been a primary focus used to assess system performance. In most organizations, energy utilization has only just been introduced as a corporate metric.
- A lack of awareness in overall pump system energy efficiency opportunities is prevalent and, as a result, potential savings and other benefits have been missed.
- Lack of funding has resulted in operations personnel struggling to present attractive large or even small investments to their senior management.

Figure 1

Typical pump life-cycle cost profile (Courtesy of Hydraulic Institute and Pump Systems Matter)



This paper illustrates how deployment of an energy management plan, with limited investment, can provide reductions in pumping systems TCO while maintaining sustainability objectives. Any sound energy plan should take into account the following three steps:

1. Energy efficiency management
2. Asset management
3. Energy cost management

For the purposes of this paper, the “Pumping System” is defined as encompassing all related components starting from the point of the electrical utility connection down to the point of end use. This paper will illustrate how energy management and system optimization can result in a 20% reduction in TCO and a return of investment (ROI) of less than 24 months.

Step 1: Energy efficiency management

Energy efficiency has become a global priority. Industry trade and governmental organizations such as the Department of Energy (DOE), the Air Conditioning, Heating, and Refrigeration Institute (AHRI), and the American Society of Heating, Refrigeration, Air Conditioning Engineers (ASHRAE) have introduced standards to mandate minimum efficiency requirements for motors and variable speed drives (VSDs). These standards impact pumping systems. DOE EPACT and ASHRAE 90.1 are examples of some of these standards. In addition, the DOE is currently developing minimum efficiency standards for pumping systems. Organizations such as Hydraulic Institute (HI) are representing the pumping industry to assist in the development of these standards.

Along with the industry and governmental organizations referenced above, numerous utilities have implemented rebate programs aimed at encouraging investment that will reduce energy consumption across all sectors including Irrigation, Industry and Buildings. The great majority of these programs focus on pumping applications and provide rebates that support using more efficient motors and VSDs to drive system optimization.

There is tremendous variation in pumping applications across water/wastewater, industry and buildings environments and this represents part of the energy management challenge. In addition, variables exist within process demand changes, weather conditions, and local regulations. As a result, plant and building operators need to understand how and when energy is used in order to minimize consumption and related costs.

The pump system energy management approach discussed in this paper reviews the nature of efficiency loss for individual components within the system, and also considers losses for the whole, integrated system entity when the various components are all operating together.

In pumping systems, most inefficiency comes from:

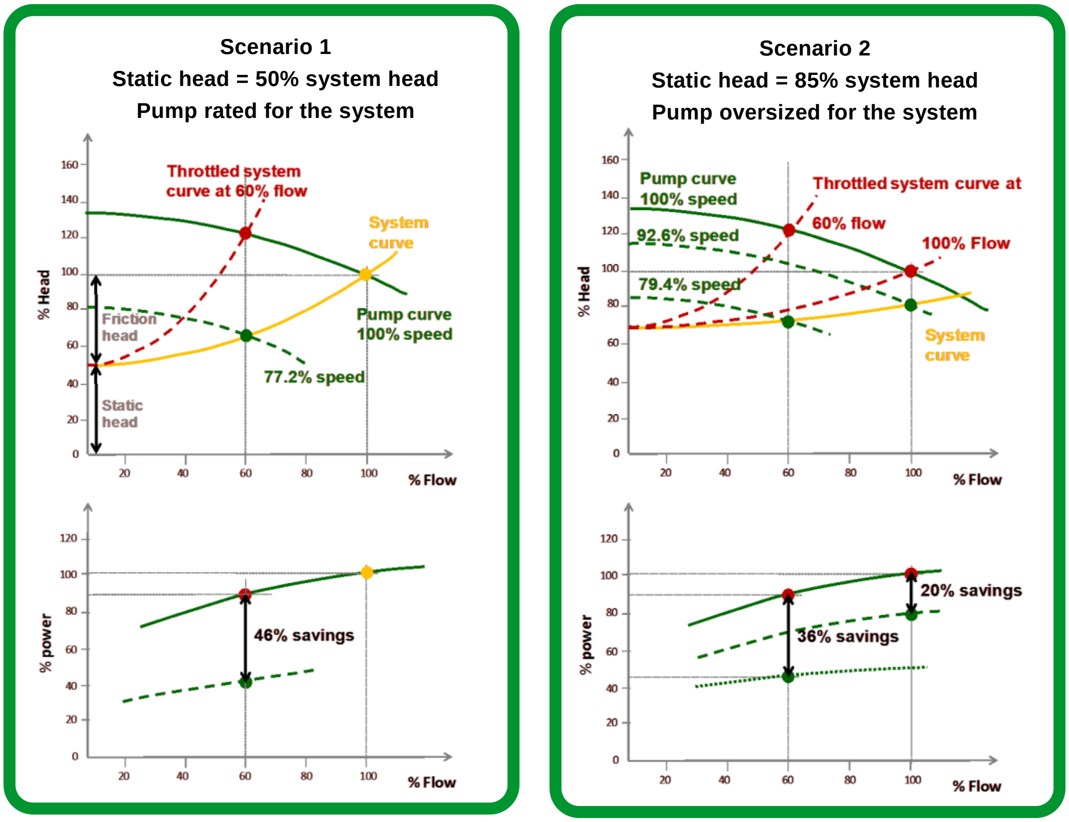
- A mismatch between the pump deployed and the actual system requirement (i.e., undersized or oversized)
- The improper use of throttling valves and flow-restriction technologies to control the volume and pressure of liquids

These two elements imply that the way pumping systems are controlled plays a major role regarding how efficiency can be improved. Control systems themselves are composed of both hardware and software components. On the hardware side, variable speed drives are a primary enabler of high efficiency performance.

The example in **Figure 2** compares two installations (one with a variable speed drive and one with a fixed drive throttled system) in which static heads (height difference between the source and the end use) are different.

- At fixed speed (in the throttled system example), it is necessary to add a throttle valve in the hydraulic circuit. This adjusts the flow by increasing or decreasing the flow resistance. This will modify the system curve. However, the speed remains the same so the pump curve does not change. The flow rate is matched but the head is much higher than required resulting in poor energy savings.

- If a variable speed drive is deployed, the system curve does not change. The pump curve is modified according to flow speed and affinity laws (rules of hydraulics that express the relationship between variables involved in pump performance such as head, volumetric flow rate, shaft speed, and power). Adjusting the speed matches the process requirement and results in significant energy savings.


Scenario 1
Static head = 50% system head
Pump rated for the system

Scenario 2
Static head = 85% system head
Pump oversized for the system

Figure 2

Energy saved with variable vs. fixed speed drives at 100% and 60% flow, according to the static head and pump sizing. The operating point is represented as the intersection of the pump curve with the system curve

Energy savings depend on the static head: the lower the static head, the bigger the energy savings (and speed variation range). In order for a pumping action to occur, it is necessary to generate enough power to overcome the static head. The friction head is the amount of head required to push the liquid through the pipe and fittings. It depends on flow rate, pipe size, pipe length, and viscosity.

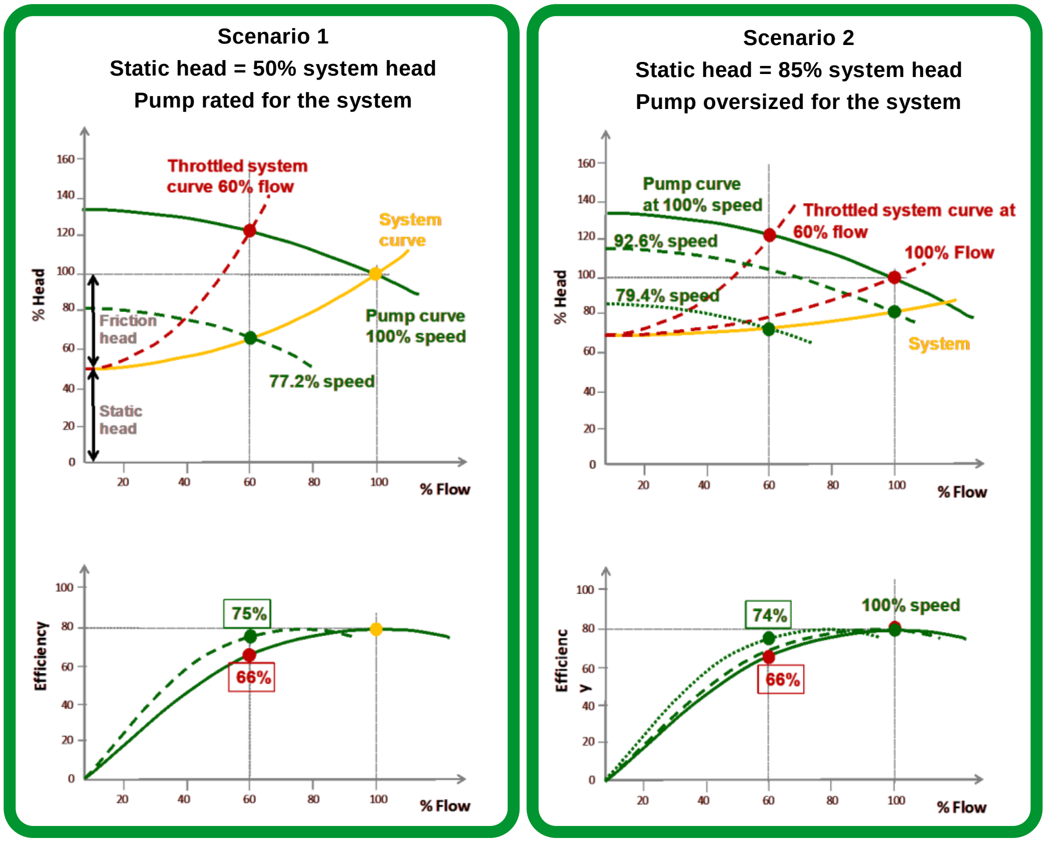
- Scenario 1 (**Figure 2**): the static head represents 50% of the system head, and the pump is rated for the head and flow of the system. At 100% flow, the power consumed by the pump is the same at both fixed speed and with a variable speed drive. At 60% flow, the energy savings resulting in the variable speed drive use is 46%.
- Scenario 2 (**Figure 2**): the static head represents 85% of the system head, and the pump is oversized by 20%. In real world scenarios, 75% of pumps are oversized (by 10% to 30%) in order to meet anticipated lifetime peak production, to anticipate future needs, or to rationalize spare parts inventory. Therefore, a variable speed drive saves 20% of energy at 100% flow and saves 36% energy at 60% flow.

Changing the operating point on the pump curve also changes the efficiency of the pump itself. The pump performs at maximum efficiency at its full capacity. This corresponds to what is referred to as the Best Efficiency Point (BEP). In terms of installation design and operation, the objective is to work as closely as possible to the BEP. By varying the speed, the pump efficiency remains roughly the same but is applied to a new flow rate. At fixed speed, reducing the flow rate quickly deteriorates the pump efficiency (because it works far from the BEP) while adjusting the speed keeps the efficiency close to the BEP (see **Figure 3**).

Determining pump efficiency is only a first step in identifying system performance levels. Monitoring efficiencies locally or remotely can detect operating points that are not suitable for the pump. Access to such data can improve both system energy efficiency and reliability.

Figure 3

Comparison of two efficiency scenarios at different flow rates: 8 to 9% more efficient with variable speed drives at 60% flow



Summary of pump energy efficiency management best practices

The energy efficiency of a pumping system can be improved by implementing the following simple actions:

- Replace traditional controllers with variable speed drives to boost the efficiency. Connected to a pump, a variable speed drive can control speed, pressure, and flow in conjunction with dynamic process and production requirements.
- Monitor production data and energy consumption data via software dashboards. Continuous tracking of the deviation between production output and energy consumed allows for rapid and cost effective decision-making. Intelligent Electronic Devices (IEDs) such as variable speed drives that are tied into the monitoring system, play a major role in reporting data related to operation, production, and energy in real time. Monitoring points should be close to the load because that is where most of the power is consumed. The closer the monitoring is to the load, the more insights can be acquired relative to cost savings.
- Monitor the operating point of the pump and its efficiency on a continual basis in order to visualize trends. Observance of the trends can then lead to sensible actions that improve efficiency, and verify the impact of improvements to the system.
- Use proper metrics to identify an increase or decrease in efficiency on particular systems and to compare efficiency performances of different pumps in multiple sites. A recommended key performance indicator (KPI) metric is the specific energy consumption, usually expressed as kWh/gallon of fluid flow.

Efficiency standards: Motors

In the realm of efficiency improvement, motors play an important role as part of the overall pumping system. In the US market, the National Electrical Manufacturer's Association (NEMA) and DOE/EPA have introduced standards regulating motor efficiency. Usually motors are required to meet either the government mandated EPAct standard or are specified to comply with NEMA Premium level. A list of common size open motor EPAct required minimum efficiencies can be found in **Table 1** (courtesy of NEMA standard MG-1-2009).

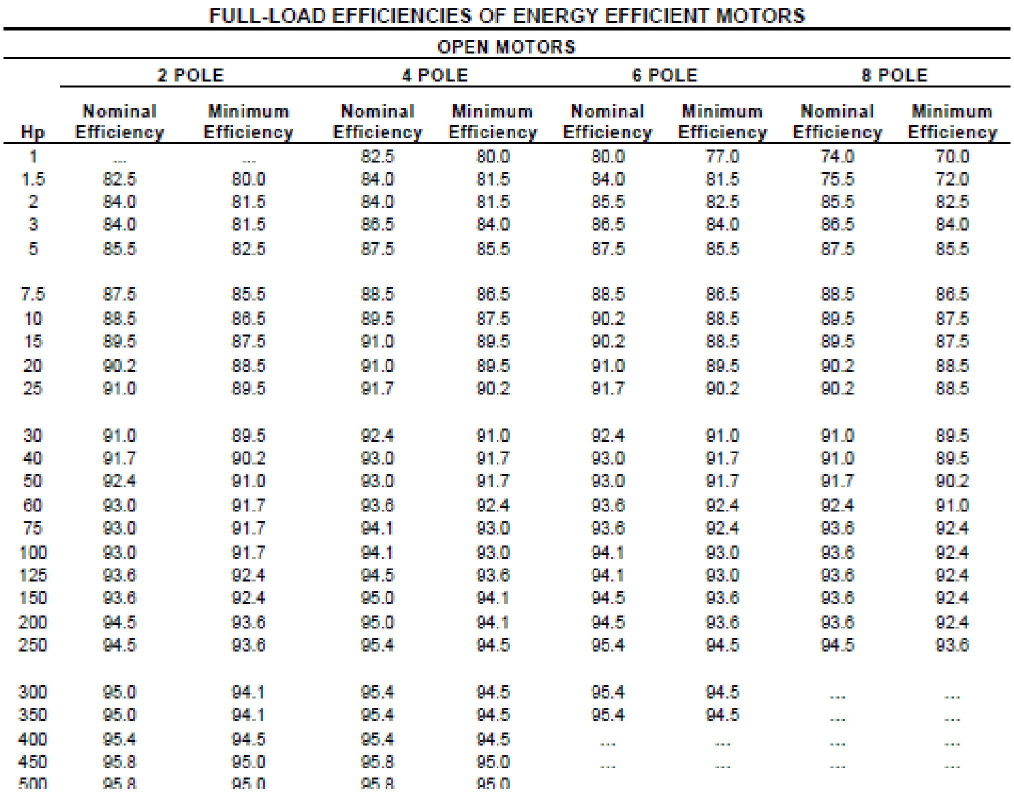


Table 1

EPAct minimum nominal and minimum induction motor efficiencies found in NEMA standard MG1 (Table 12-11). For a complete listing of all open and enclosed motor efficiency requirements, please refer to NEMA publications.

FULL-LOAD EFFICIENCIES OF ENERGY EFFICIENT MOTORS

OPEN MOTORS

	2 POLE		4 POLE		6 POLE		8 POLE	
Hp	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	...	...	82.5	80.0	80.0	77.0	74.0	70.0
1.5	82.5	80.0	84.0	81.5	84.0	81.5	75.5	72.0
2	84.0	81.5	84.0	81.5	85.5	82.5	85.5	82.5
3	84.0	81.5	86.5	84.0	86.5	84.0	86.5	84.0
5	85.5	82.5	87.5	85.5	87.5	85.5	87.5	85.5
7.5	87.5	85.5	88.5	86.5	88.5	86.5	88.5	86.5
10	88.5	86.5	89.5	87.5	90.2	88.5	89.5	87.5
15	89.5	87.5	91.0	89.5	90.2	88.5	89.5	87.5
20	90.2	88.5	91.0	89.5	91.0	89.5	90.2	88.5
25	91.0	89.5	91.7	90.2	91.7	90.2	90.2	88.5
30	91.0	89.5	92.4	91.0	92.4	91.0	91.0	89.5
40	91.7	90.2	93.0	91.7	93.0	91.7	91.0	89.5
50	92.4	91.0	93.0	91.7	93.0	91.7	91.7	90.2
60	93.0	91.7	93.6	92.4	93.6	92.4	92.4	91.0
75	93.0	91.7	94.1	93.0	93.6	92.4	93.6	92.4
100	93.0	91.7	94.1	93.0	94.1	93.0	93.6	92.4
125	93.6	92.4	94.5	93.6	94.1	93.0	93.6	92.4
150	93.6	92.4	95.0	94.1	94.5	93.6	93.6	92.4
200	94.5	93.6	95.0	94.1	94.5	93.6	93.6	92.4
250	94.5	93.6	95.4	94.5	95.4	94.5	94.5	93.6
300	95.0	94.1	95.4	94.5	95.4	94.5	...	...
350	95.0	94.1	95.4	94.5	95.4	94.5	...	...
400	95.4	94.5	95.4	94.5	...	...	...	...
450	95.8	95.0	95.8	95.0	...	...	...	...
500	95.8	95.0	95.8	95.0				

In addition to US standards, countries have published laws and regulations based on international standards and are increasingly requiring the usage of more efficient motors in order to reduce CO_2 emissions. **Table 2** aligns standards across different geographies.

Table 2

Alignment of motor efficiency categorization levels from the various global geographical regions

Motor efficiency class	Global	USA	EU (old)	EU (new)	China	Australia
Premium	IE3	NEMA premium	-	IE3	-	-
High	IE2	EPAct	Eff 1	IE2	Grade 1	AU2006 MEPS
Standard	IE1	-	Eff 2	IE1	Grade 2	AU2002 MEPS
Below standard	IE0	-	Eff 3	-	Grade 3	-

Efficiency standards: Pump Systems

While efficiency standards for pump systems do not yet exist in the United States, the DOE has issued a Notice of Intent for Federal Standards regarding the energy efficiency of commercial/ industrial pumps. The DOE has published a rulemaking framework and has shared documents regarding commercial and industrial pumps with manufacturers, consumer groups, federal agencies, and states in order to gather feedback.

European Regulation 547/2012 from European Union:

"As of January 1st 2015, pumps must attain an MEI of 0.4 or higher. That means that 40% of manufacturers' current inventory will be rendered obsolete."

However, the European Commission (EC) has already adopted regulation n°547/2012 under Directive 2009/125/EC in regard to eco-design requirements for water pumps. Some highlights include:

- Definition of a Minimum Efficiency Index (MEI) for affected pumps.
- As of January 1, 2013, pumps must have attained an MEI of higher than 0.1. This affects the manufacturers of pumps because 10% of their configurations have been rendered obsolete.
- As of January 1, 2015, new pumps being sold to end users must attain an MEI of 0.4 or higher. That means that 40% of manufacturers' current inventory will be rendered obsolete.
- In order to further expand efficiency gains, the European Union has requested a new directive which defines a broader view of the pumping system. Moving forward for efficiency measurement purposes, a pumping system will include the pump, the motor, the load profile, and the variable speed drives. This will result in a potential savings of 30% compared to 3.6% under the current "pump only" approach.
- The IEC regulation n°547/2012 does not yet include fire fighting pumps, self priming pumps, displacement pumps, pumps for private and public wastewater and for fluids with a high solids content, pumps for swimming pools, pumps for fountains, and clean water pumps larger than 150 kW.

The Hydraulic Institute is currently engaged with the European Pump Manufacturers Association (Europump), NEMA, and DOE representatives to harmonize pump system definitions for required efficiencies. Other regions of the world have defined their own minimum energy performance for pumps. The calculation method in Brazil is similar to the EU approach. In China, the regulation GB19762-2007 is applicable for clean water pumps. That regulation defines 3 grades where grade 1 is used for very high efficiency pumps. Grade 3 is the minimum efficiency authorized. The method of calculation used to define the grade is different from the method used by EU regulation.

Step 2: Asset management

Physical assets such as pumps need to be maintained on an ongoing basis. Maintenance costs represent 25% of TCO (see **Figure 1**) and therefore maintenance practices warrant examination in terms of contribution to energy-influenced savings. Maintenance costs are unavoidable due to the wear of components during system operation, and because the cost of downtime attributed to loss of production will impact overall business performance.

In pumping installations, many moving parts mean that proper maintenance of motors, drives, pumps, and associated pipes is crucial. Numerous steps can be taken to assure that maintenance costs are kept at a minimum while integrity of the systems is kept stable.

All pumps should be operated within the parameters of a given pump's specifications (referenced in the pump supplier's instruction manual / data sheet). As discussed, pump efficiency varies according to operational parameters. The pump is designed for optimal operation at the Best Efficiency Point (BEP) but 75% of the pumping systems are oversized by around 30%.

Figure 4 illustrates how pumps begin to waste significant energy when appropriate maintenance practices are neglected. For example, discharge recirculation can occur if the pump operates at 65% of the BEP flow rate, causing damage to the impeller, and a damaged impeller, even if not failed completely, will be less efficient.

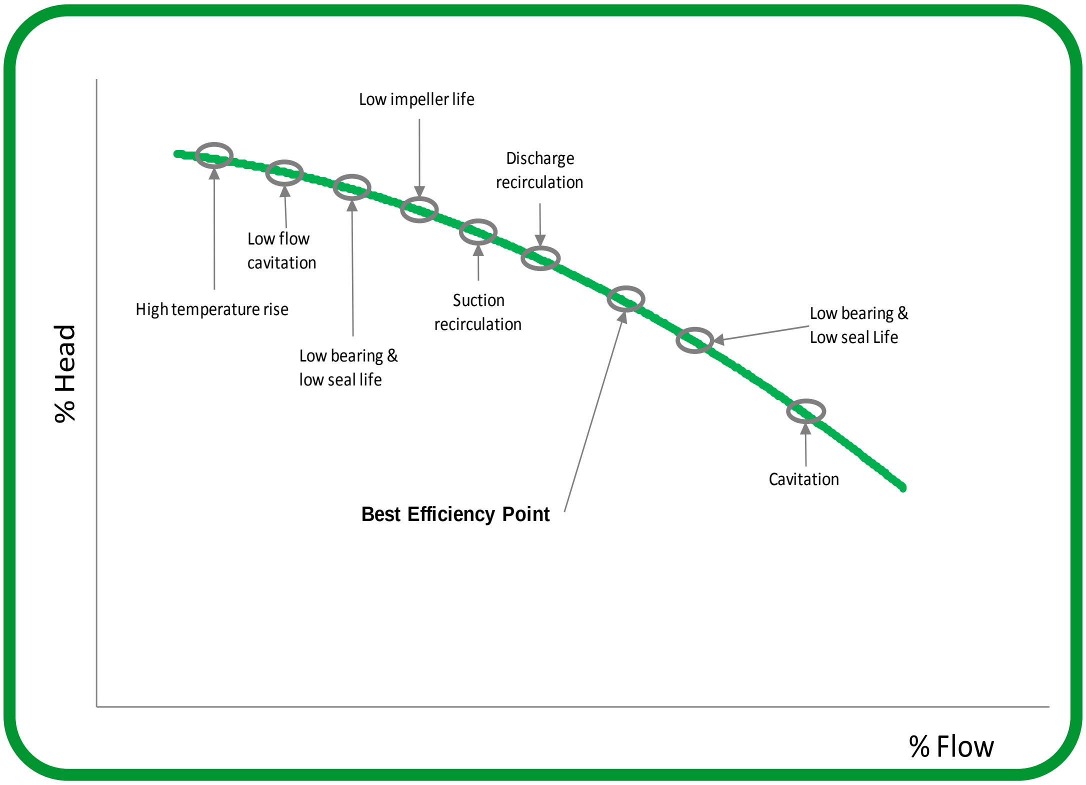


Figure 4
Maintenance related issues that impact pump performance (Courtesy of Barringer & Associates- "Pump practices & life")

Variable speed drives can help to keep the operating point close to the BEP and also protect the pump against destructive forces generated by inefficiencies. Extreme situations such as dry running, low flow operation, or cavitation (due to low net positive suction head) which can cause instantaneous damage are avoided. Monitoring the operating point of the pump and its efficiency provides diagnostics that help predict when potential system problems will occur.

Figure 5 illustrates how operating away from the BEP not only decreases the efficiency but speeds up the wear and tear on the pump thereby reducing reliability. For example, operating at 60% of BEP result in:

- 50% lifetime reduction of seals
- 20% lifetime reduction of bearings
- 25% lifetime reduction of casing and impeller
- Approximately 100% increase of maintenance cost

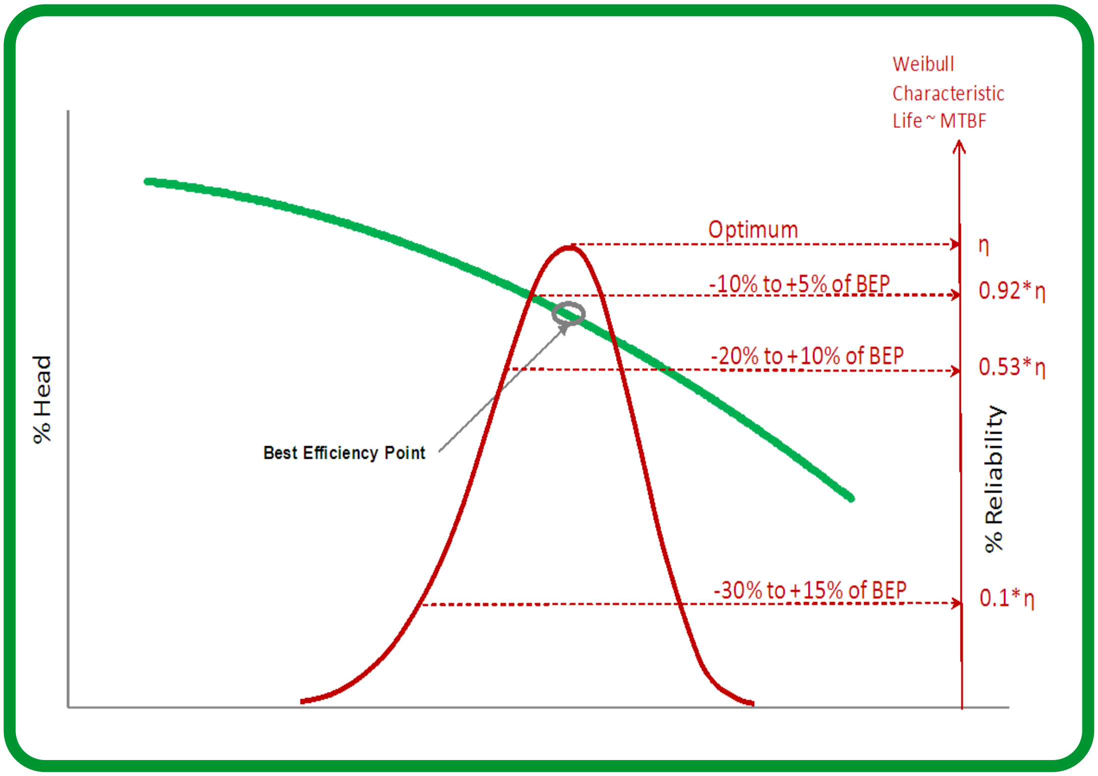


Figure 5

Effect of the distance from the BEP on reliability (Courtesy of Barringer & Associates – "Pump practices & life")

Wear is unavoidable due to mechanical parts that are moving and to the action of the fluid being pumped. Erosion is generated by the speed of fluid, and it could be increased by slurries (sand or bigger particles). Corrosion is due to chemical or electrochemical reaction that attacks the pump materials. Even treated drinking water causes corrosion in cast iron casings as a result of the catalytic effect of bacteria. Erosion and corrosion mostly impact the pipes, the impeller, and the case (which are critical operating components).

Efficiency drops by 10 to 15% for an unmaintained pump (see **Figure 6**). Moreover, the major loss in efficiency occurs in the first few years of the pump's life. Regular maintenance avoids losses in efficiency and capacity which can occur before the pump fails.

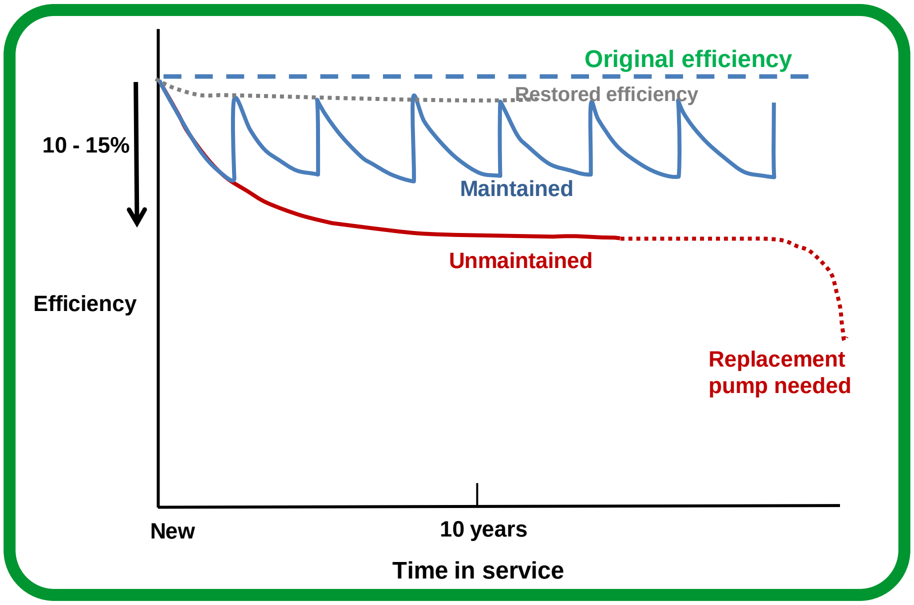


Figure 6

Average wear trends for maintained and unmaintained pumps (Courtesy of ETSU - Energy Savings in Industrial Water Pumping Systems)

Some of the factors that can damage a pump are quite visible. Others are not. For example, a worn seal is apparent. However, hydraulic wear is not. A problem that is not visible typically occurs before it is identified. This creates a potential situation of urgent corrective maintenance, and the defects may have affected other parts of the pump. Detection of these operating conditions is critical to keeping the system running as designed.

Maintenance practices

A number of approaches are available that can help to address the issue of maintenance in a cost effective manner. Preventive maintenance implies the systematic inspection and detection of potential failures before they occur. Condition-based maintenance is a type of preventive maintenance, which estimates and projects equipment condition over time, utilizing probability formulas to assess downtime risks. Corrective maintenance is a response to an unanticipated problem or emergency.

Figure 7 illustrates the cost curves of these three types of maintenance. Condition-based maintenance is the most cost effective of the three approaches.

Condition-based-maintenance monitors system data on an ongoing basis and provides an accurate assessment of the health, or status of components, devices, and / or the complete system.

As it relates to pumps, variables such as suction pressure, discharge pressure, pump speed, power, flow, and temperatures are monitored to detect a loss of efficiency. Identification of the potential problems is possible by combining the efficiency trends and process variables.

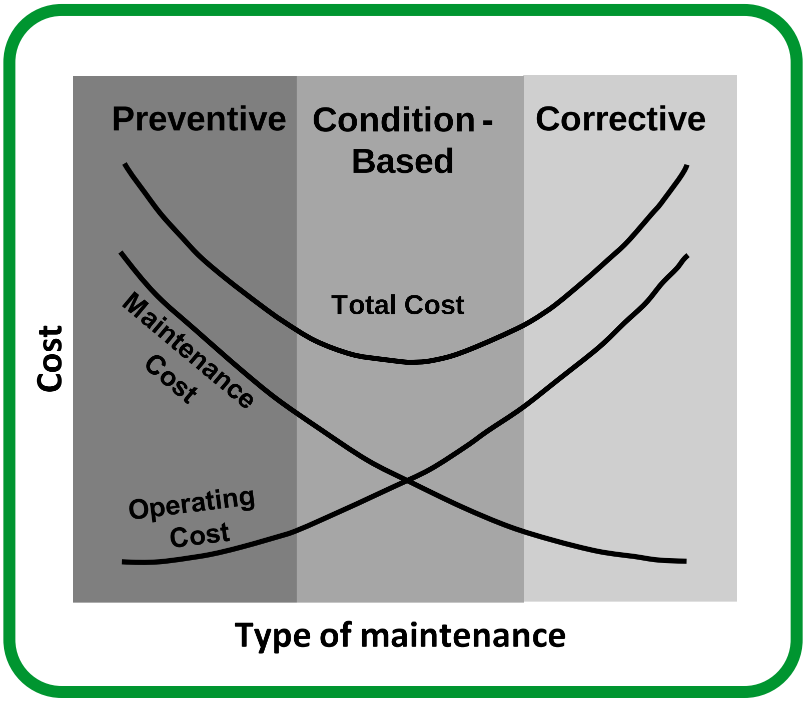


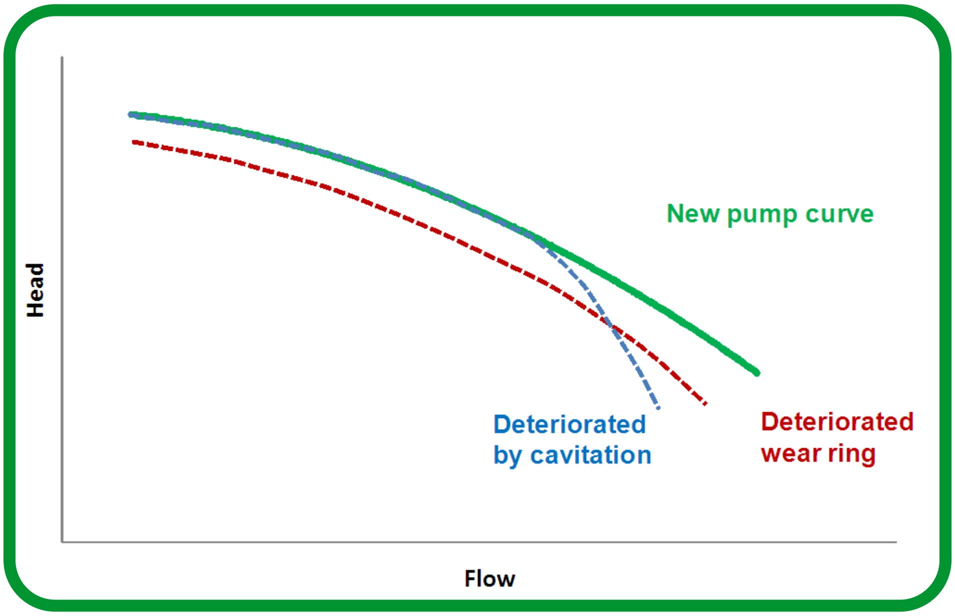
Figure 7
Cost curves of the different maintenance approaches (Courtesy of Penn State University / Applied Research Laboratory - "Open systems architecture for condition-based maintenance")

Variable speed drives have the capability of measuring process variables, temperature, and power with high accuracy and to assess the pump efficiency. If connected to the automation system or a web server, they can continuously monitor the health of the system and can indicate in a precise manner when proper maintenance is needed.

Figure 8 illustrates how a worn part can impact the pump efficiency curve.

Figure 8

Worn pump curve vs. new pump curve



Pipes

As part of the overall pumping system, pipes are also subject to issues such as overpressure, leakage, or pipe burst. An overpressure situation can be caused by poor pump control. A situation called “water hammer” can also occur. Water hammer is caused by a pressure or shock wave that travels through the pipes, generated by a sudden stop in the velocity of the water. This sudden acceleration and deceleration on the motor can be avoided with the help of a variable speed drive (sudden variation in flows is avoided). Leakage can also be reduced by automatic adjustments to pressure when appropriate.

Motors

Protection against input voltage and frequency fluctuations can help maintain the integrity and extend the lifetime of motors. In cases where motors are equipped with variable speed drives, those electrical disturbances are not transmitted to the motor.

Protection against high temperature conditions can also extend the life of the motor assets. Devices such as thermal relays, PTC or PT100 thermal sensors can help and are manageable through the variable speed drive.

In cases where long motor cables are used in conjunction with motors and variable speed drives, it is recommended that filters be installed in order to avoid the dv / dt and motor voltage surge effects (see the Schneider Electric white paper “*An Improved Approach for Connecting VSD and Electric Motors”* for more details on this subject). Note: For submersible bore hole pumps, it is recommended to verify the peak to peak voltage and the dv / dt at the motor terminals with the motor-pump supplier.

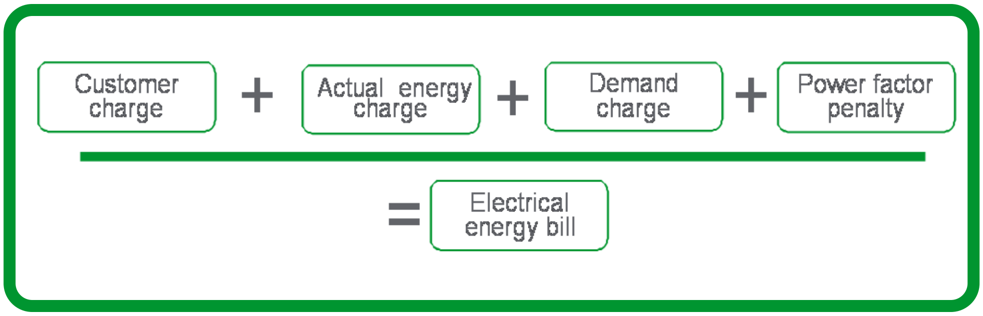
Step 3: Energy cost management

Buildings, water / wastewater, and oil and gas facility operators are presented with utility bills that have multiple components. These can include peak power demand charges, time-of-use charges, ratchet clauses, cost-of-fuel adjustments, power factor penalties, customer service charges and national, regional, and local taxes. A misinterpretation of utility rate structures can lead to poor management of electrical consumption and to higher costs. On the positive side, many utilities also offer rebate programs for installing energy efficient products like VSD's so it is equally important to consider the impact of a partial funding for a project using utility funding in the form of rebates.

Most energy bills cover similar basic elements (see **Figure 9**). Familiarity with the terms can assist in understanding where the opportunities for cost reductions exist.

Figure 9

Fundamental elements of a typical electrical utility bill



Below are some definitions for commonly used terms:

Customer charge – This is a fixed charge that depends upon the size of the connection that links the plant or building in question to the electrical utility network. The customer charge is calculated according to an anticipated power consumption range, and the price of the actual power that is consumed. Both of these elements are influenced by the type of contract that has been signed between the user and the utility.

Actual energy kWh charge – This charge corresponds to the consumed active energy, which is the cumulative energy consumed over a given period of time. The kilowatt hours (kWh) rate depends upon the time period the energy was consumed, and whether that consumption occurred during "peak" and / or "off peak" hours. Rates may also fluctuate depending on overall amount of power consumption and whether the facility is classified as a commercial, municipal, or industrial customer.

Demand charge – This charge typically represents the highest average power consumed within any 15 minute time period over the span of a month's time and is tracked by the utility. This number is then multiplied by the demand charge rate in order to produce the demand charge that appears on the electrical bill. That means consumers are charged for a peak demand even if this peak condition only happened briefly once during the month.

Power factor penalty - The power factor is the ratio between the active power (that generates work) and the apparent power (that could potentially be used to generate work). That means that a certain portion of the power that is delivered by the electrical utility to the site is not billed (because it did not generate work). If the power factor is less than a defined value mentioned in the contract (for example 0.9 lagging), the consumer is invoiced for not only the active power but also for the reactive power. Many devices have power factors lower than 1.0: Constant speed motors (especially at light loads); induction furnaces, transformers, variable speed drives, computers and fluorescent lighting are some examples that will impact imposed power factor penalties. Power factor correction capacitors are typically applied near the service entrance of a facility to increase power factor closer to 1.0 or unity.

Best practices for energy cost reduction through bill management

The electrical energy bill for the site can be reduced by implementing the following series of simple actions:

- Locate and review the utility contract itself to better understand the charges associated with the bill and how they can be controlled. Up to 10% savings without any capital investment could be achieved with the support of a company specialist in energy management.
- Adjust the timing of energy usage from the peak rate period to the off peak period as much as is possible (e.g., by reducing energy consumption during the day through pumping fixed requirements at night, like filling a tank).
- Reduce the monthly peak demand number in order to reduce the demand charge. In most cases, 75% of the applications are oversized. Variable speed drives, which are flexible enough to meet changing process demands and which are inherently soft start devices, can eliminate the need for 6X across-the-line starting current and then can reduce power consumption by 20% under normal operating conditions.
- Power factor penalties that are due to across-the-line operated motors can be upgraded to variable speed drives eliminating the requirement for Power Factor Correction Capacitors. VSD’s inherently provide high power factor regardless of motor/pump loads.
- Utilize harmonic analysis tools to determine distortion at critical points in the facility electrical distribution system. Usually these points are most critical where linear and non-linear loads connect electrically. Newer VSD technology can reduce the Total Harmonic Current Distortion THDi to fewer than 48% as measured at the input terminals for motors loaded down to 80% which usually represents an average operating point.
- Reduce the amount of consumed energy that is not linked with revenue generation. An active control of the process matching pump speed with process requirements or changing operating conditions will significantly reduce the operational cost.

Harmonics

Certain facilities can also be penalized by the utility if the installed electronics equipment generates a high level of harmonic distortion. With the increased application of VSD’s and other electronically switched power devices known as non-linear loads, utilities are now examining the quality of power back on feeder distribution lines to individual customer locations.

IEEE-519 is a nationally recognized Guideline that utilities use to establish limits for this non-linear load caused distortion. Care should be used when this is referenced in specifications since the guideline must be applied at certain electrical points on the overall distribution system defined as Points of Common Coupling (PCC). Limits vary depending on where these PCC’s are defined and mistakes are often made referencing a limit at the input terminals of a non-linear device that is meant for application on the utility transformer MV primary.

Many technical papers and tools are available from Schneider Electric on this subject. A mathematical analysis of specific power distribution systems is often required to determine impacts of harmonics and potential charges imposed by a utility for distorting the commercial grid feeding the facility.

Conclusion

By pursuing best practices in energy efficiency management, asset management, and energy cost management, the total cost of ownership for pumping systems can be reduced by up to 20%. One evolving technology, the Variable Speed Drive (VSD) with embedded energy management functionality, has the capability of being a major contributor to achieving reductions in TCO for the life of the pump system.

The VSD is now capable of being fully integrated into process systems and drastically impact users TCO. An energy management plan can be formulated by adopting energy efficient technologies, implementing condition-based maintenance practices, and optimizing cost control of the electrical utility costs. Using advanced VSD functions linked to pumping processes translates into improved business performance through better energy efficiency management and reduced maintenance costs.

To minimize unnecessary project delay, risk, and expense, organizations that are ill-equipped to jumpstart an energy efficiency program should seek the assistance of mission-critical subject matter experts who can take all aspects into account. Unseen variables like power factor, peak demand charges, pumping inefficiencies, and overall system performance can then be analyzed. A company that takes into account all these system variables can greatly assist in providing products and services to help design the most energy efficient facility.

To achieve operational sustainability, organizations must act quickly to assess their current programs. By building an operational methodology that emphasizes improvement in system efficiency, they can influence the Total Cost of Ownership of pumping systems.

About the authors

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