Pumping Systems – Low Hanging Fruit in Saving Energy

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Abstract

Pumping systems absorb in the neighbourhood of 20% of all motor driven electrical energy usage in the United States. However, established efficiency incentive programs only contribute a small proportion of incentive dollars to save energy in pumping systems. The programs today are mostly centred around the use of high efficiency motors, which only result in small energy savings. The addition of variable speed often saves far less than envisioned. The programs centre on component efficiency as opposed to a complete system approach which has the opportunity to save substantially more energy. Custom incentive programs for pumping energy savings are cumbersome, under resourced, and their usage is small.

This paper highlights a number of case studies where substantial pumping energy savings were obtained. The projects were eligible for incentives from subsidy programs. However, the major driver of the upgrades was not an energy incentive program or even energy efficiency itself. The projects proceeded for other reasons. An environment is needed where energy upgrades of pumping systems are the norm in the industry and not just a by-product of the few pumping system upgrade projects which proceed for other reasons. Revamped national or regional energy incentive programs could mean that the majority of these opportunities could progress and a huge amount of energy could be saved.

The paper outlines suggested prescriptive incentives, measures, validation programs, and tools, which would propel the majority of these process upgrades to proceed. The resulting savings from these programs have the potential to reduce the electrical energy consumption in North America by 5% or even more.

Introduction

Pumping systems account for nearly 20% of the world's energy used by electric motors and 25% to50% of the total electrical usage in certain industrial facilities.[1] Clearly, pumping systems consume a significant amount of the total electrical energy. The combined total of United States and Canadian energy efficiency program budgets for ratepayer funded electric and gas programs reached nearly $6.2 billion in 2009.

Electric Programs (Commercial and Industrial unless indicated as Residential)			
Lamps	92%	Residential: Clothes Washers	42%
Ballasts	91	Residential: Existing Home	42
Motors	82	Residential: Quality Installation	41
Residential: Compact Fluorescent Lamps	82	Any Data/IT	38
Packaged Units	80	Residential: Room A/C's	36
Unitary Heat Pumps	78	Residential: Dishwashers	33
Drives	76		
Unitary A/C	73	Quality Installation	31
Residential: Heat Pumps	67	Residential: Solar Thermal Water Heaters	24
Solid State Lighting	66	Residential: Heat Pump Water Heaters	23
Residential: A/C	66	Residential: Solid State Lighting	23
New Building	59	Any Agriculture	22
Residential: New Home	57	Residential: Computers	10
Residential: Refrigerators	56	Residential: TVs	7
Existing Building	51	Residential: Set-Top Boxes	6
Heat Pump Water Heaters	45		

Table 1. The product categories listed above are by percentage of respondents that responded "yes" to the question, "Is this product included in your program?" The results are for U.S. and Canadian programs combined, and are listed in descending order of percent coverage by programs. Note that heat pumps refer to a refrigeration technology and not fluid pumping systems.

Table 1 above lists the percentage of times that energy incentive program administrators indicated a product is included in the program.[2] Not once in the list are pumping systems referenced even though pumps account for 20% of energy in electric motor systems. One could argue that mentioning the word motor or variable speed drive (VSD) is sufficient, as motors and variable speed drives (VSDs) indicate the greatest energy saving opportunity in a pumping system. Figure 1 illustrates some of the opportunity in pumping systems by looking at the system as a whole instead of just its component parts. A typical component part look may say the motor is 89.5% efficient, and there is an opportunity to gain 4.7% by switching to a high efficiency motor. 89.5% is the average efficiency and 4.7 percentage points is the average efficiency increase between DOE 1998 pre-Epact motor efficiency and the current NEMA standard [12-12] known as NEMA Premium today.[3] Correspondingly, addition of a VSD may save 20%, based solely on the author's observation in the field, and a more efficient pump could save energy by improving the pump operation from the efficiency figure of 74% to the efficiency of 78% (i.e., a fairly aggressive pump end efficiency gain of 4 percentage points). This approach yields an efficiency gain of 4.7 percentage points on the motor, plus 20% overall savings% for the VSD, plus 4 percentage points for the pump resulting in a power savings of 28.4% for the pumping system.

In this scenario, the industry considers changing the motor very easy as the higher and lower efficiency motors are interchangeable physically, the difference in apparent energy efficiency is readily readable from the nameplate and any millwright and electrician can take one motor out and put the other motor in. Adding a VSD is a little more difficult but still relatively easy. The VSD must be checked for compatibility with motor, and often this reinforces that the motor be changed as well. Most motors supplied today are generally compatible with variable speed VSDs whereas even 5 years ago this was not the case. Also it must be determined how the VSD is to be controlled. How will the VSD know what reduced speed and power level to run at? The easy mode of reducing speed is simply manually setting a lower speed by determining the system still operates successfully or ideally opening a throttling valve and setting the lower speed to maintain the same flow after the valve is opened. The next level up would be decreasing the speed in relation to an easy control that can be installed. An example of an easy control is having the pumping unit maintain a set pressure. This means the control components are all set close to the pump in the mechanical room and installation costs and required system control thought is minimal. Finally, installing the VSD is relatively easy and any electrician can place the VSD on the wall and run the motor power through the VSD before going to the motor. The relatively easy installation described saves 28% of energy costs on average. The utility and the owner can feel quite happy that their work has saved 28% of energy with only a little effort.

In this description usually the owner would not change out the pump as there is only 4 percentage points of additional energy to be saved, and changing the pump can be quite involved. Usually the pump is not interchangeable physically, and changing the pump can mean necessary foundation and pipe modification work, which is not considered worth the effort. The real savings, however, is in the rest of the system, pipe design, valves and control type in conjunction with the pump, VSD and motor.

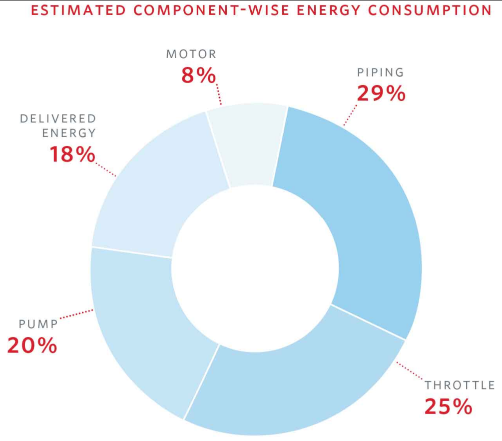

Figure 1. Energy use in a typical system. Source: www.worldpumps.com

Figure 1 illustrates the energy use in a typical pumping system. From the energy use, the opportunity to save energy is illustrated by the size of the percentage. The figure says that only 8% of the energy produces valuable work. The remaining 92% is wasted energy and available for more efficient operation. The motor accounts for only 8% of the energy loss, and yet that is the main target for energy reduction in systems today through a history of both utility incentives as well as legislation. The second target is VSDs in pumping systems, which however can only contribute limited reduction in the energy consumption of a pumping system on their own. The true opportunity of 92 % can only be seen by finding an optimum pumping system with minimum hydraulic pipe losses combined with the proper size and energy efficient control of the pumping system.

Opportunity Potential

OPPORTUNITY POTENTIAL

		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%

CUMULATIVE ENERGY SAVINGS

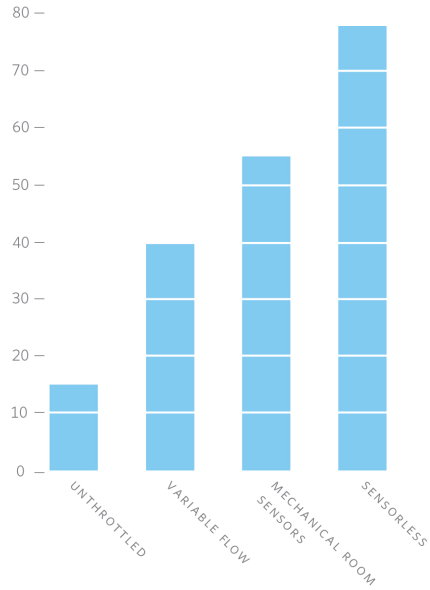

Figure 2. Four opportunity steps in a typical cooling secondary pumping system in a heating or cooling loop in a commercial building.

Figure 2 illustrates four opportunity steps in a typical cooling secondary pumping system in a heating or cooling loop in a commercial building. It starts with a 3-way constant flow pumping system which any system installed prior to 1995 (perhaps 50% of the installed base today) probably employed. The first step in the energy saving opportunity is the installation of a VSD, opening the throttling valve in the system where a typical system would have a throttling valve dissipating a percentage of pressure estimated at 15% of the pumping power of the system. Many systems operate today with the variable speed set at a constant reduced speed. It definitely saves energy. However, only 15%. The second step of the energy reduction is changing the system from constant flow system to a variable flow system in a simpler situation. This can be done by closing the bypass line of each three way control valve.[4] In this mode, the pump “rides” its performance curve to provide the flow needed by the system and an additional 29% energy is saved.

The next step of opportunity is to change the variable speed VSD control from constant speed setting to a variable speed and control it by maintaining a constant pressure across the pump. This is considered by the heating and cooling industry as the easiest method to control a variable speed VSD in a pumping system as the control sensors and wiring are all contained in the mechanical room. It is an easy system to install and troubleshoot. It saves an additional 26% in energy.

A final opportunity is to have the system controlled to the true pumping demand of the system. This can be done by either placing the control sensor out into the system itself which raises the cost of the control system and makes trouble shooting more difficult. Or, by using integrated pump controls available in the marketplace in the last decade only, which sense the true system requirement through electronics present in the pump itself. This final step of improvement increases the energy savings by an incremental 49% to a total system savings in energy of 77%. It should also be noted that a number of other energy saving opportunities have not even been included in the above example such as the opportunity to change the motor to a higher efficiency motor available today, the opportunity to right size the pump and optimize the selection against load profile to optimize energy use, in a retrofit installation an upgrade of the pump for wear can increase pump efficiency an additional 1 to 5%. Offsetting these additional opportunities not mentioned could be other factor which discount the above energy savings referenced. The above description does not allow for the power loss through the variable speed VSD control as these devices are not 100% efficient even at full load and are less efficient at part load and reduced speed. The same statement applies to motors as the motor efficiency is reduced as it runs at reduced load and reduced speed.

There are two major points in the above description. The first is by looking at the whole pumping system as opposed to one component, the savings in efficiency can be increased from 15% or less, to 77% or more! The second point is that most programs today, as referenced from Figure 2 above, look only at the change out of the motor for an average energy savings in the neighbourhood of less than 5% or the addition of the variable speed VSD for a savings of perhaps 20%, missing the overall 77% or more opportunity available!

The above speaks to the circumstance where any component in a pumping system is even considered. The number one referenced product in Table 1 was lighting. The author has attempted to quantify what percentage of the $6.2 billion in energy incentive programs has gone to pumping systems and has been unable to dimension the number as it is so small and generally therefore not recorded. When the author asked a utility representative this question the answer was “We give away a lot of light bulbs”. Figure 3 below illustrates the potential savings between pumping systems and lighting. To convert from a T12 to T8 lighting system saves in the neighbourhood of 30% and with a payback of 1 to 3 years after utility rebates.[5] Lighting was the number one referenced product in the programs and probably the area where most of the utility incentive dollars have been directed. If we compare this to a pumping system opportunities where saving can be in the neighbour of 75% and payback less than a year, it does make one ask why pumping does not receive more attention and incentive.

Need for Incentives

From here we should move to the question whether incentives are needed to ensure the upgrade of pumping systems.

A report by the US Department of Energy recorded the success of a motor challenge program. The program documented over a dozen major upgrade programs that had an average energy savings of 33% with some as high as 60 per cent. They found, however, that despite the success of a few companies and the relative maturity of the technologies used to achieve motor system efficiency, the level of knowledge and adoption of system efficiency measures among facility managers is very low. They found that only the largest plants had implemented the most common kinds of system improvements in the past two years to any great extent, and the pattern of knowledge and implementation, even among the largest companies was inconsistent. Among all manufacturing facilities, 24 per cent reported that they had not implemented any of the long lists of potential system efficiency measures over the past 2 years.

It was found that industrial facility managers face significant barriers to capturing the financial and operating benefits of motor system energy improvements. The most important were:

- Low priority of energy efficiency improvements among objectives. Motor systems were less than 1% of operating costs.
- Lack of awareness of energy saving opportunities— was this a function of the importance of the objective? Why take the time to learn if it is not important>
- Low staffing – Staff is rationed, and there are no resources to implement efficiency programs.
- Conflicting incentives among suppliers. Do salesmen spend time on an efficiency improvement project for $20,000 or a new construction project for $250,000?

Data Centres are a major user of pumping systems due to their need for large cooling systems. They are also heavy user of electrical power. A recent conversation with a major player in the data centre industry indicated key factors in priority in the design and construction of a data centre were:

1. Performance reliability (does what it says on the tin)
2. Uptime / availability (always working)

3. Speed to availability (shortest time between project launch and revenue coming in)
4. Service support (it will be fixed quickly if something goes wrong)
5. Quality / longevity (will continue working in the way that it was commissioned)
6. Impact on PUE (life cost, including energy consumption)

Note that energy consumption is part of the sixth and last priority only. This was not a US based observation but actually an observation from a European industry leader where energy costs are even higher than in the United States.

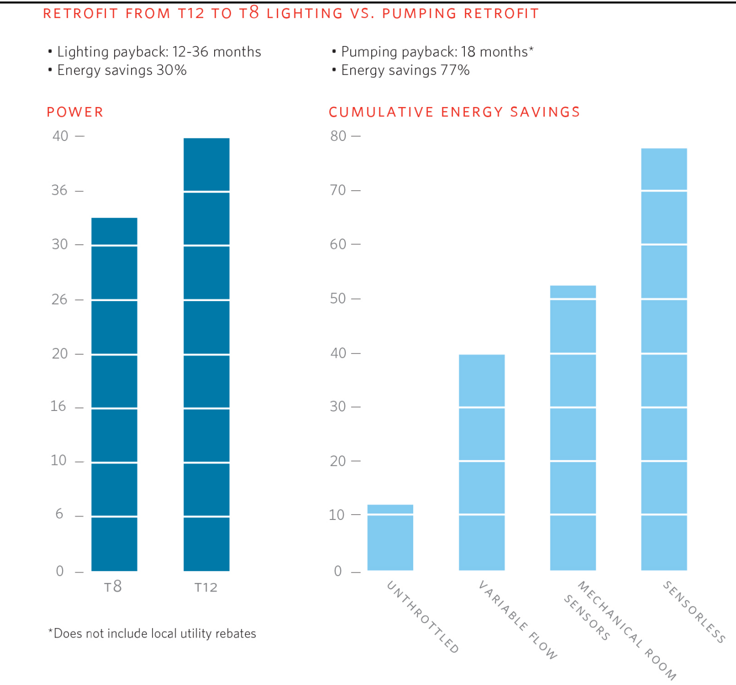

Figure 3. Payback and energy savings estimates of a lighting retrofit vs. variable speed pump retrofit

Unfortunately much of the equipment we ship today and systems we install are energy obsolete as it does not include the best practices and technologies available. Certainly most of the equipment shipped and systems installed before 2005 are energy obsolete. There exists a great opportunity to upgrade these plants and save substantial energy!

Case Studies

Three case studies that illustrate the opportunity and perhaps reinforce some the themes introduced above follow.

Case Study 1: Domestic Booster System

This is a case study of a domestic water pressure booster system. It is a system which pressurizes water in the basement of a building from a city main water supply so that it reaches the top of a building. These systems typically include pumps, valves, pipe and controls all mounted on a skid and delivered as a pumping system from the supplier. In this installation the project was initiated as the existing system needed repair.

The municipal offices of a city of 149,000 people are located in a nine-story commercial building in the downtown area. When the city first began investigating opportunities for an upgrade, the building was using an old pressure booster system that was not functioning properly.

The existing constant speed booster system was energy obsolete. It produced 140 psi of pressure regardless of the changing needs of the system. It also included pressure reducing valves, which throttled and wasted pressure within the system. When the system overheated from low flow or excess pressure, a valve opened to dump the water either to a drain or back through the pump.

The new booster system operates using a demand-based control methodology. The system monitors pressure and operates the pump to boost system pressure only as needed. The system does not rely on pressure reducing valves, but instead maintains pressure through integrated controls. In low flow situations, the pressure setback feature reduces system pressure, further reducing energy usage. When no flow is required, the unit switches into "sleep mode" instead of wasting water through a valve.

A booster system that optimizes energy usage and operates at reduced speeds was installed. The combination of low-speed operation, no flow shutdown and soft fill startup features also reduce wear. Reduced wear leads to reduced maintenance and extended system life.

Commenting on the performance of the new booster system, the Manager, Operations and Maintenance, said “The new pumps are working great. We’ve dropped our system pressure from 140psi to 85psi with no complaints. The operating pump runs at 50% speed, so electrical savings will be noticeable.” The reduction in system pressure means that the energy savings would exceed 40%.”[6]

The new system consumes about 35 per cent of the energy of the installed system due to the demand based controls utilized. The project went ahead as the old system was in desperate need of repair. It did not proceed on the basis of the energy savings. It was only considered an advantage. Although readily available, to the author’s knowledge, the installation never applied for the rebate available for variable speed VSD installation or a custom program installation as the paperwork was considered too time consuming!

Case Study 2: Sewage Pumping System

The next case study has been highlighted as a US Department of Energy – Energy Efficiency and Renewable Energy Technology program best practices.[7]

A Town of in North Eastern USA was looking for a way to increase the energy and operating efficiency of its Reservoir Avenue sewage pump station.

Located in southwestern Connecticut, the town has a population of 32,000, with ten sewage pumping stations, a total raw sewage handling capacity of 3.3 million gallons per day. Each of the stations pump sewage to a main lift station where it is then pumped to a sewage treatment plant.

Built in 1971, the Pump Station consisted of twin sewage handling pumps vertically mounted approximately 17 feet below the ground. The pumps were each equipped with a 40-hp direct drive, wound-rotor motor. Running at reduced speed, the pumps operated at a system duty point of approximately 850 gallons per minute (GPM) at 50.3 feet of total dynamic head (TDH). A control system using a wound rotor and variable resistance circuit technology was used to reduce pump speed to a constant 1320 rpm. To turn the pumps on and off based on the level of liquid in the sump, a bubbler-type level control system was used. The system used two continuously running compressors which supplied a small amount of air through a dip tube into the wet well. A pressure transducer mounted on the air supply line measured the pressure needed to overcome the wet well level.

The pump station handles approximately 0.34 million gallons of raw sewage per day. The original pumping processes consumed approximately 72,500 kWh of electricity annually, costing the Town $5,495.

To identify potential energy saving opportunities at the pump station, a test plan was undertaken by team engineers. A systems approach was used to determine how to increase the efficiency of the entire sewage pumping station. Rather than focusing on the individual elements and functions of the pumping system, total system performance was the focal point of the analysis. Following a thorough investigation of the pumping system, engineers decided to add a smaller pump that could handle the same volume as the original pumps during non-peak periods. The lower outflow rate reduces friction in the piping system, lowering the required head and energy consumption.

The sizing of the pumps in the original system was designed to allow one pump to handle the entire peak inflow to the station under normal operation, which is usually less than 800 GPM. Both pumps were inactive until the level meter reached 57 inches. At that time, the primary pump would begin operating and would pump until the water level fell to 32 inches. The second pump was designed only to be used during extreme flood conditions. If the water level reached 60 inches on the level meter, the second pump would begin to operate. In flood conditions, both pumps would remain running until the water level fell to 32 inches, at which time both pumps would simultaneously shut down. Each pump rarely operated for more than five minutes at a time.

Test data for the original system indicated a normal operating point of 850 GPM at 50.3 TDH for the single operating pump. With an overall pump efficiency level of 74 percent, the pump's efficiency was not a problem. Years of use, however, had begun to take its toll on the system, resulting in frequent breakdowns, occasional flooding, and sewage spills.

Engineers categorized four energy use sources in the original system: the bubbler level control system, lights, circulating pumps for the motor control system cooling water, and miscellaneous station energy use. Analysis of the pump system determined that much of the overall energy use consisted of auxiliary electrical system loads and miscellaneous point loads. Engineers found that the existing speed control system did not vary the pumps' flow handling capacity. As a result, the pumps were operating at a reduced constant speed. In addition to reducing the efficiency of the pumps' electric motors, the inefficient control system also required the constant operation of two circulating cooling water pumps. The level control system was also equipped with two continuously running compressors, further increasing electricity consumption. Finally, because of a broken automatic light switch, the three 200-watt light fixtures were constantly on.

To increase energy efficiency of the pump station, engineers installed an additional 10-hp pump with direct on-line motor starters and a level control system with float switches. The new pump handles the same volume as the original pumps during non-peak periods, but runs for longer periods of time. The lower outflow rate reduces friction and shock losses in the piping system, which lowers the required head and energy consumption.

In addition, the ineffective existing pump speed control was eliminated and the motors were wired for direct on-line start. Because the speed control was eliminated, the motors powering the existing pumps ran at 1750 RPM instead of 1320 RPM, so their impellers were trimmed from 11.25 inches in diameter to 10 inches. The existing pumps are still used for the infrequent peak flows that the new smaller pump can't handle. The two compressors for the bubbler level control system and the two circulating pumps for the old motor control system were also eliminated.

Under normal conditions, the operating point for the new pump is 450 GPM at 40.7 TDH, compared to 850 GPM at 50.3 TDH for the pumps in the original system. The specific energy of the optimized system was measured at 325 kWh/MG, a 255 kWh/MG decrease from the original system. In addition to the 17,643 kWh of energy savings achieved by modifying the pump unit, significant energy savings also resulted from changes made to other energy use sources in the station. Annual energy consumption by the lighting system was reduced by 5148 kWh, while energy consumption of the bubbler level control (7,300 kWh/yr) and the cooling water pumps (1,752 kWh) was entirely eliminated. In all, 31,875 kWh was saved, a reduction of almost 44 percent, resulting in $2,614 in annual energy savings.

In summary, the town altered the existing pump system by adding a smaller pump and modifying the system control scheme. The changes reduced annual electricity consumption by almost 44 percent, or nearly 31,900 kWh, saving more than $2,600 per year. This Motor Challenge Showcase Demonstration project, which cost $12,000, has a simple payback of 4.6 years. The project demonstrates that an innovative pump selection and operating scheme can significantly reduce the operational costs of a sewage pumping station. The lessons learned from this successful project can be applied to the city's other sewage pumping stations, further reducing the town's electricity consumption and costs, and to similar pumping stations throughout the United States.

Several lessons were learned from this Showcase Demonstration project which can be applied to other similar energy efficiency projects in the future: (1) rethinking the pump selection and operating methodology for pumping equipment can result in significant savings; (2) in systems with static head, stepping of pump sizes for variable flow rate applications can decrease energy consumption; (3) a "systems approach" can identify sources of energy consumption other than pumps that can be modified to save energy.[1]

What is interesting about this case study is that the existing installation incorporated speed reduction whereas the improved installation removed the variable speed controls and instead operated the pumps at full speed! So the initial installation would probably have easily qualified for a utility rebate for the installation of VSDs however the new installation which removed the VSDs would have perhaps qualified only after an intensive engineering study application and a verification audit. Second interesting point is a lighting upgrade was also done at the site and the lighting reduced power by 5,148 kWh compared to the pumping system reduction of 17,643 kWh.

Case Study 3: High Lift Pumping System

A third case study involved a High Lift Pumping Station Upgrade. This is the largest water pumping station servicing a city of over 500,000 people. The connected load was over 10,000 HP and a mix of 13.8kV and 2.4kV. The city needed to replace the motors and switchgear, which were at the end of their asset life. They didn't have quantitative data, but felt that the station was operating at low energy efficiency. An assessment determined that the City was paying significantly more money per year on energy than necessary. This project was also given priority status, as the City has determined it was a project that would qualify for infrastructure stimulus funding.

The team proposed completing an energy analysis model, considering all variables, to determine how to design a station that operated with high energy efficiency over a broad range of discharge flows and pressures.

The following data tools were developed and used:

A station system discharge curve which indicated the discharge flow versus pressure for the normal and abnormal operating ranges. There were actually multiple curves depending upon what downstream pumps were running. This was also taken into consideration. Five years of SCADA operational data were utilized to create a “real life” curve versus theory.

- Real, actual pump curves for all 6 existing pumps, of difference sizes, but utilizing the 5 years of SCADA data. This provided quantitative data that showed the pump impellers had been trimmed many years ago, which no one knew for sure, and defined that the pump efficiency was less than 65%.
- A review of water plant flows to determine what low, medium, and high flows allow the entire plant to operate at high efficiency. These three values were then used to select new pumps that operated at high efficiency at the same target flows.

The potential solutions had to address the following areas for optimization:

- How to run the water plant, and the downstream pump station at optimum efficiency
- How to select the best combination of pumps to meet the pumping needs
- What new voltage and motors are most efficient
- How many and what size VFDs could reduce energy costs

For each an analysis of the problem was reviewed and the cost/benefit for each area was established. Regarding the plant operation, it was identified that three key flows could provide a high plant operating performance and energy efficiency.

This established the pumping target values of 160 Million Liters per Day (MLD), 220 MLD, and 360 MLD. For the pump options, a computer model was developed for a six pump station model. This included the target flow, forecasted discharge pressure, pump efficiency for each pump under those conditions, cost of energy during different times of day, total energy used for a year, and the forecasted annual total cost of pumping. Using the pump curves for various pump sizes, in combination with various VFD configurations, it was determined that the optimum solution was to replace the various sized pumps with six identical size pumps and four VFDs, constructed in a split electrical bus that enables half the station to stay in operation while the other half is down for maintenance. The new mechanical arrangement is forecasted to reduce the energy costs by 30% per year, for an annual energy cost savings of over $500,000. [2]

It is interesting that the driver for the above pump retrofit was that the motors and switch gear equipment were near the end of their operating life and what made it a priority project, which was completed, was the availability of Stimulus money for this infrastructure project.

Conclusions from the Case Studies

The three case studies above highlight savings to pumping systems of 65%, 44% and 30% respectively. The first installation was undertaken because the old pumping system was in need of repair; the second was was undertaken to demonstrate that improvements could be made by using a systems approach under the Motor Challenge Showcase Demonstration. There were no incentives involved; the third installation was undertaken because the motors and switch gear equipment were near the end of their operating life, and one time Stimulus money was available. How can we encourage proceeding with projects where energy reductions are available?

The search by the author for pumping system energy saving case studies has not been easy and in the end the author only had 20 or so from throughout North America to choose to highlight in this paper. This paper also wishes to request more pumping system case studies so that information can be amalgamated and communicated to help promote energy savings through pumping systems. The author would request that any organizations or individuals with pumping system case studies they are willing to share to forward them to kdoran@pumps.org.

General Conclusions

- Utility programs total $6.2b in North America. Very little of this is allocated towards pumping systems;
- Pumping systems make up 20% of the energy consumed by electrical motor systems;
- Pumping system upgrades can have higher energy savings than lighting. Lighting is the main subsidized area in utility rebates;
- The private sector has many priorities ahead of saving energy in pumping systems.

Pumping system upgrades are an excellent way for the utilities and society to achieve their energy reduction goals and yet so few pumping systems are upgraded. What is the solution?

Very few prescriptive utility energy incentive programs exist for the upgrade of pumping systems. Previously, utility rebate programs have existed for motor efficiency level improvements and today legal minimums ensure higher motor efficiency levels. However this, although a highly publicized and traditionally funded opportunity, only contributes a small percentage to energy reduction. Prescriptive rebates exist in many locations for the installation of VSDs. However, their installation —because the whole system is the important issue—also produce only a percentage of the energy savings possible.

The author, after having been part of a North American wide search for pumping system rebate programs, is aware of only a few prescriptive pump system initiatives. [3] The few prescriptive programs found include:

- A flat dollar amount rebate varying by pump horsepower for the installation of pumps which incorporate integrated controls. [4]
- A flat dollar amount for installation of variable speed or 2 speed pool pumps[5]

- A flat dollar amount per HP for booster pump systems HP reduction[6]

These are the type of easy to understand and apply for energy incentive rebates which are needed to ensure low hanging energy saving opportunities in pumping systems progress.

A summary of ideas for prescriptive incentives are:

- A utility rebate system based on pumping system application upgrades and calculators. There are relatively standardized pumping systems. For example, in cooling plant systems for buildings, the following pumping system options exist. These are listed from the highest energy consumption to the lowest with an estimate for illustration purposes on comparative pumping energy consumption.
    - Constant speed, constant flow primary and secondary cooling pumping systems (the norm for systems over 30 years old) Energy = 100
    - constant speed variable flow primary and secondary cooling systems (the norm for systems over 20 years old) Energy = 80
    - variable flow and variable speed secondary cooling systems controlled by maintaining pump pressure (the norm for systems over 10 years old) Energy = 70
    - variable flow and variable speed secondary cooling systems controlled based on the demand of the system (the norm for system over 3 years old) Energy = 55
    - Variable primary pumping (present in 25% of new systems installed today) Energy = 40

The above energy estimates are strictly for illustrative purposes. It is suggested that prescriptive incentives could be developed to incentivise upgrades of systems either strictly based on a factor of system type and installed horsepower before and after or calculators could be developed where system type and quite basic information is inputted for the before and after systems with incentives defined from the output from the calculator. The calculators could be developed in conjunction with trade organizations and then published and used by utilities for prescriptive incentives. Of course the utility would wish to audit a sample of the installations to confirm the energy savings generated from the calculators. The above example is for different standard types of cooling pumping systems used in buildings. Standard types of pumping systems with defined energy consumption levels can be developed for each industry such as irrigation, pulp and paper, municipal fresh and sewage water, petrochemical etc. and prescriptive rebate programs developed.

- More conservative programs could require power meters recording consumed power before and after the retrofits. The problem with this type of arrangement is often system load and therefore consumed power could vary seasonally or are process load based and measurements can vary widely. Quite sophisticated factors must be defined to calculate this variation which moves a prescriptive program to one with risk and complexity.

- Rebates paid based on the invoice value for pumping units incorporating integrated controls, rebated at a set dollar amount based on the unit's power. If an owner of an installation buys such a unit it is an easy application procedure to obtain the corresponding rebate. These units are available today from various manufacturers in sizes from 30 watts to 325-hp.

- Rebate system based on installed rated horse power. Prescriptive schemes based simply on installed nominal horsepower before and after are possible. Although they carry risk in that actual consumed horsepower can vary from that nominally installed overall energy savings will be achieved on the average installation. Prescriptive rebates based on this would be simple and straightforward to apply.

- Energy savings result from trimming impellers, upgrading pump clearances, sealing and bearing systems. These could be rebated in a prescriptive manner based on the type of upgrade and the total horsepower installed.

- A prescriptive rebate based on a reduced discharge at constant suction pressure or differential pressure requirement at a set flow. Any pumping system change which reduces the pressure requirement at a given flow reduces the energy requirement.

Clearly there is a large opportunity to save energy in pumping systems. Today's custom programs just are not incentivizing systems owners and operators to reduce this energy. What is needed is a combination of an increase in the amount of incentive but probably more importantly a simplification of the incentive programs to make them prescriptive, easy to understand and access and the removal of risk that the incentive may not be paid after an owner has made upfront investments in money and time. A quotation cited in this paper was "Our utility gives away a lot of light bulbs". It is time that the industry opens the doors on the tremendous savings and low hanging fruit available by upgrading pumping systems.

[1] Variable Speed Pumping, p 1, Hydraulic Institute, Europump, US Department of Energy, DOE/GO-102004-1913, April 2004. p. 1. http://www1.eere.energy.gov/industry/bestpractices/pdfs/variable_speed_pumping.pdf

[2] The State of the Efficiency Program Industry Budgets, Expenditures, and Impacts 2009, Consortium for Energy Efficiency. p13. http://www.cee1.org/files/StateofEEIndustry2009.pdf

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