

Industrial Fan and Pump Systems: Capturing Large Savings through Improved System Design

Steven Nadel, American Council for an Energy-Efficient Economy
R. Neal Elliott, American Council for an Energy-Efficient Economy

ABSTRACT

Fans and pumps account for more than a quarter of industrial electricity consumption nationally. Six industries represent 84% of the potential industrial fan and pump energy savings. Optimizing the operation of fans and pumps can achieve electricity savings ranging from 20% to well over 50%.

While a range of efficiencies exist for fans and pumps, the opportunity is less with the efficiency inherent in the equipment and more with the application of the equipment. While fan and pump system optimization is not a complex engineering problem, it requires familiarity with both the facility processes, and fan and pump system design. Most optimization projects involve greater engineering costs than equipment costs. The average payback for a good optimization project is about 1.2 years, with a cost of saved energy on the order of \$0.012 per kilowatt-hour (kWh). These estimates do not account for productivity gains known to exist at many of the sites, which are sometimes as much as two to five times the energy savings.

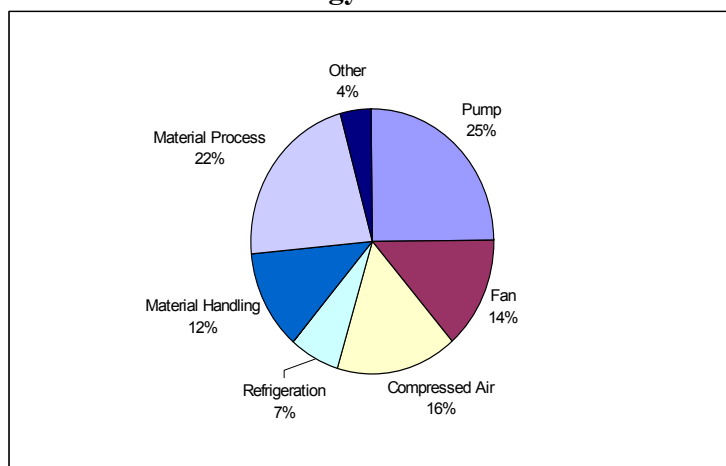
While the potential for fan and pump system efficiency has long been realized in the engineering community, attempts to design energy efficiency programs to capture this potential started just over a decade ago. To date, these programs have struggled to balance the needs for site-specific engineering services with program costs. This paper reviews existing program models and explores alternate program designs that may address the shortcomings of existing programs.

Market Analysis

Nationally, motor systems account for 50–60% of electricity use. Nearly half of this use is in the industrial sector, with the rest distributed among the residential, commercial, and utility sectors. In the industrial sector, about two-thirds of the electricity use is for motors (Nadel et al. 2002).

Fan and pump systems account for about 40% of industrial motor system energy use (see Figure 1), or more than a quarter of all industrial electricity use (Nadel et al. 2002).

**Figure 1. National Industrial Motor Systems
Energy End-Use**



Source: Nadel et al. 2002

Table 1. Characterization of Industrial Fan and Pump Load in the U.S.

NAICS	Industry	Electricity Demand 1997	Pumps	Fans and Blowers	Total Motors	Motor Electricity	Fans & Pumps Share of Electricity	Fans & Pumps Electricity Use
11	Agriculture	16,325	25%	20%	75%	12,244	45%	7,346
22	Mining	85,394	7%	21%	90%	76,854	29%	24,363
311	Food mfg.	66,166	11%	5%	81%	53,756	16%	10,809
314	Textile product mills	5,135	14%	15%	82%	4,221	30%	1,523
321	Wood product mfg.	21,884	4%	10%	80%	17,464	14%	3,064
322	Paper mfg.	119,627	28%	16%	84%	101,078	44%	52,636
324	Petroleum & Coal products mfg.	69,601	51%	13%	85%	59,369	63%	44,061
325	Chemical mfg.	212,709	18%	8%	73%	154,693	26%	54,797
326	Plastics & rubber mfg.	52,556	9%	4%	66%	34,847	13%	6,729
327	Nonmetallic minerals product mfg.	37,416	4%	4%	65%	24,328	8%	3,037
331	Primary metal mfg.	172,518	2%	4%	26%	44,855	6%	10,351
332	Fabricated metal product mfg.*	49,590	7%	5%	65%	32,462	12%	6,149
333	Machinery mfg.*	27,295	8%	4%	67%	18,391	12%	3,330
334	Computer & electronic product mfg.*	40,099	2%	3%	54%	21,783	4%	1,801
336	Transportation equipment mfg.*	54,282	4%	6%	64%	34,629	11%	5,753
Total		1,030,598	Fraction of total electricity			690,974	235,750	
						67%	23%	

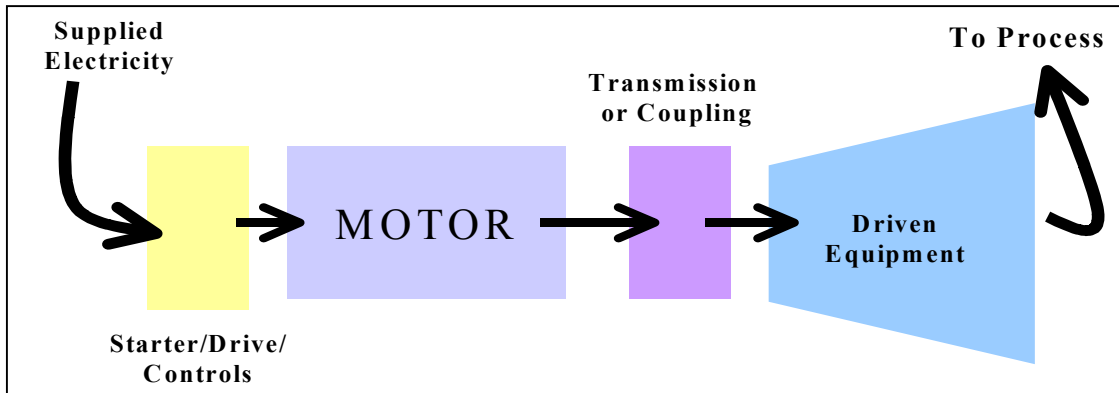
*Note: Greater uncertainty exists for these numbers than for other estimates, since they come from a single source, and in ACEEE's judgement may under-represent the fraction of electricity accounted for by fans and pumps in these industries.

Based on the American Council for an Energy-Efficient Economy's (ACEEE) analysis, six industries represent 84% of industrial fan and pump energy use: chemical manufacturing, paper manufacturing, petroleum and coal products manufacturing, mining, food manufacturing, and primary metal manufacturing. The electricity savings opportunity in these six industries would represent a 30% saving in national motor energy if this opportunity was fully realized. The share of motor system electricity use and the share represented by fan and pump systems vary by industry. Table 1 presents our estimates of the relative magnitude of electricity consumed by fan and pump systems for the important industries on a national basis.

Technology Description

Motor systems are comprised of a number of subsystems, as indicated in Figure 2. Efficiency opportunities exist in each subsystem, as has been described in many sources (e.g., Nadel et al. 2002). Much attention has been applied to the motor, where selecting

Figure 2. Components of a Motor System



efficient equipment is one significant opportunity. Many studies (Nadel et al. 2002; XENERGY 1998) have identified the process as the source of even greater energy savings potential. Motors play a key role in many of these processes, with fan and pump systems representing one of the most important.

While a range of efficiencies exist for fans and pumps, the opportunity is less with the efficiency inherent in the equipment and more with the application of the equipment (Friedman et al. 1996). Part of this potential results from the fact that fan and pump energy use varies as approximately the cube of motor speed. While small changes in motor speed have modest impacts on process flows, they can have large impacts on energy use. Thus the goal of system optimization is to match flow to the actual process requirements. Unfortunately, engineering practice tends to add margins of safety to capacity sizing, so most pump and fan systems tend to be oversized. Complicating the sizing issue is that fan and pumps have a range of optimal operating characteristics that must be matched to process flow and pressure requirements (Nadel et al. 2002). While these process requirements are constant in many applications, in some cases they may vary over a significant range (e.g., over a 1 to 3 range of flow). Several different optimums may exist for these different flow regimes.

In matching the pump and fan characteristics to the process requirements, the target is achieving the lowest flow, and thus the lowest energy usage. The easiest parameter to adjust is the fan or pumps speed. The speed can be changed by:

- Adjusting the drivetrain (e.g., different size belts and pulleys);
- Modification to the pump or fan (e.g., trimming of the pump impeller or substitution of the fan impeller);
- Staging of multiple fans or pumps; or
- Varying the motor speed using an adjustable speed drive (ASD) that includes variable frequency drive (VFD) as well as various mechanical speed controllers.

The choice of technology will be dictated by the particular circumstances. The application of an ASD allows for significant flexibility and is appropriate in a situation with varying load. However, an ASD increases equipment cost significantly and can actually increase energy use in systems where there is no significant variation in load. As a result, ASDs have proven to be the solution of choice in only a portion of the fan and pump system

applications. For the majority of applications, other lower-cost approaches represent the best solution (Nadel et al. 2002).

Knowing the process requirements is key to determining the correct speed of pumps and fans. Thus a system analysis is required, beginning at the load (at the right in Figure 2) and moving back through the system to ultimately the sizing of the motor, starter and electric supply. While this is not a complex engineering problem, it requires familiarity with both the facility processes, and fan and pump system design.

Market Players

The fan and pump industries represent a contrast in market structures. The industrial fan and blower market is fragmented and competitive, with no manufacturer accounting for more than a 12% market share (Friedman et al. 1996). Manufacturers sell fans and blowers through manufacturer representatives or to other original equipment manufacturers (including dust collection, oven, boiler, and pollution control equipment manufacturers, among others). Contractors install most fan and blower systems. Specifiers work with the contractor, end-user, and manufacturer representatives to design the system and select equipment. Finally, independent air balancing firms may be called upon to test the system after installation and certify that it meets design criteria.

In contrast, the industrial process pump market is more concentrated, but extremely competitive, with not every manufacturer serving each process market. Within a given market, there may be only a few players. As a result of recent industry consolidation, the largest of these is ITT Industries. Manufacturers sell pumps through manufacturers' representatives and distributors or, in some cases, directly to very large end-users. Many process pumps are engineered specifically for a particular end-use application and thus are sold directly to the end-user through the manufacturer. Manufacturers and their agents (internal sales staff, distributors, and manufacturers' representatives) exert strong influences on this market, as together they play a strong role in determining pump efficiency and selection.

Pump distributors vary widely in sophistication. Some provide design, repair, and maintenance services while others simply order and obtain pumps for the end-user or contractor. Distributors use manufacturer-provided manuals, pump curves, and software to help select pumps. The information provided by the manufacturers is adequate for proper pump selection. Pump distributors play an important role in determining which pump is chosen for a job; however, they have little stake in pump system efficiency.

Mechanical contractors install most process pumps. Consulting engineers design nearly all new green-field sites (i.e., new manufacturing facilities being constructed from the ground up) and may also get involved with system renovation or major retrofit situations. End-users often design smaller system renovations themselves. Larger end-users, particularly in the chemical and petroleum industries, often have internal process engineers who perform system design work.

Market Barriers

Fan and pump markets are beset with many of the afflictions that limit energy savings in other industrial markets. Industrial firms tend to be focused on first cost. This behavior is frequently associated with equipment cost, but market experience indicates that first cost

concerns may apply even more to engineering services (Nadel et al. 2002). In addition, because of engineers' tendency to include a margin of safety, system components tend to be oversized. This trend is further complicated because of changes that occur in the process since its initial design. As result, the equipment seldom operates under design conditions.

Since most industrial process loads are site specific, design of fan and pump systems requires good application-specific engineering, and cannot be obtained in a "cookie cutter" fashion. Most end-users (and even many of the consulting engineers they hire) often lack practical knowledge regarding how best to optimize systems. Furthermore, optimization can be a time-consuming process, and time is something most customers are short of. On the other hand, the equipment cost needed to realize the savings is frequently modest (Nadel et al. 2002).

Energy Savings Potential and Economics

Electricity savings come from optimization of fan and pumps systems. The cost and savings resulting from a project are site specific, reflecting the unique opportunities available at the site, and the engineering and equipment expenditures required.

Energy Savings

Based on past program experience, typical energy savings from fan, pump, or blower system upgrades vary from 20 to 50%, or even higher for systems identified as good candidates for optimization (Nadel et al. 2002). To be conservative, we assume an average 20% saving as did Martin et al. (2000) for their calculations (e.g., if two-thirds of customers achieve 30% savings, average savings across all customers will be approximately 20%).

Based on this rate of savings potential, we estimate an electricity savings potential of over 235,750 million kWh nationally in the industrial sector. These savings are concentrated in six industries with large electric energy consumption and significant pump and fan use, accounting for 84% of the savings potential (see Table 2 and Figure 3). In addition, there are significant savings opportunities in the commercial sector, particularly in water and wastewater plants (ASE 2002) and heating, ventilating and air conditioning systems.

Table 2. Potential Fan and Pump Energy Savings

NAICS	Industry	Potential Savings (Mill. kWh)	Share of Fan & Pump Savings Potential
11	Agriculture	1,469	3%
22	Mining	4,873	10%
311	Food mfg.	2,162	5%
314	Textile product mills	305	1%
321	Wood product mfg.	613	1%
322	Paper mfg.	10,527	22%
324	Petroleum & coal products mfg.	8,812	19%
325	Chemical mfg.	10,959	23%
326	Plastics & rubber mfg.	1,346	3%
327	Nonmetallic minerals product mfg.	607	1%
331	Primary metal mfg.	2,070	4%
332	Fabricated metal product mfg.	1,230	3%
333	Machinery mfg.	666	1%
334	Computer & electronic product mfg.	360	1%
336	Transportation equipment mfg.	1,151	2%
Total		47,150	

The concentration of energy savings in a few industries creates an important program design opportunity for program implementers, as will be discussed later in this paper. However, the key industries may vary somewhat from region to region and even utility to utility.

Incremental Costs

As noted earlier, most projects involve greater engineering costs relative to the cost of the equipment. Many of these costs are associated with collection of system data to allow for the estimation of actual process requirements. Based on known and estimated costs and energy savings for sites that are proceeding toward implementation, the average payback is 1.2 years. These results are discussed further below. Cost of saved energy is estimated to be on the order of \$0.012/kWh (Martin et al. 2000). These estimates do not account for productivity gains known to exist at many of the sites, which are sometimes as much as two to five times the energy savings. These non-energy benefits can include improved equipment reliability, increased productivity, and improved product quality. One frequently cited benefit is the elimination of plant bottlenecks that result in plant-wide productivity improvements (Nadel et al. 2002).

Pump and Fan Programs

While the potential for fan and pump system efficiency has long been realized in the engineering community, attempts to design energy efficiency programs to capture this potential started just over a decade ago. To date, these programs have struggled to balance the needs for site-specific engineering services with program costs, though interest remains high among mature industrial programs in developing program strategies.

Past Program Experiences

Programs focusing on fans and pumps began around 1990, starting in Canada but then progressing to several regions of the United States. Early programs were offered by B.C. Hydro and Ontario Hydro and focused on identifying good applications for ASDs. However, this focus proposed an answer before asking which technologies make the most sense for each customer. By 1993, the Canadian utilities began several pilot projects that used a systems approach to optimize the entire motor-driven system. Due to a shift in utility priorities, these programs were discontinued before they moved out of the pilot stage but many of the people working on these programs participated in the development of a Performance Optimization Service (POS) in Wisconsin.

The Wisconsin POS program began in 1993 and was operated by the Energy Center of Wisconsin (a nonprofit organization) in partnership with the state's utilities. Under the POS, utility customer service representatives identified candidates for POS services and a POS engineer was hired to provide the customer a quick, free, engineering "walk-through" analysis of their systems. If substantial savings were projected, a feasibility study proposal was prepared to cover work to determine what should be done to improve efficiency and performance, and how much it would save the customer. If the proposal was accepted, a POS engineer collected system-load and operating data, and prepared a feasibility study report,

which recommended a design strategy and detailed technical and economic impacts of the project. As the program evolved, these steps were streamlined and combined so that following the walk-through the customer was given preliminary cost and savings estimates, along with the proposal for the detailed study.

Utilities offered a range of incentives to customers to implement POS projects: partial reimbursement of feasibility study costs; customized rebates based on projected energy savings; low-interest loans; and shared-savings contracts through an independent financing organization. A training program was developed with support materials for utility representatives, consulting engineers, trade allies, and end-users, with training tailored toward specific needs of each of these groups (Wroblewski 1996).

The POS program provided initial audits to 36 sites and detailed feasibility studies to 11 sites. Ultimately, however, only six customers decided to implement projects; most of the others never made a decision. An evaluation of the program attributed the low implementation rate to several factors: (1) nothing was broken; (2) it was perceived that savings were risky or cost estimates unrealistic; (3) several plants got a second opinion from a fan vendor who told them not to do the project because of feasibility or reliability concerns; (4) reluctance on the part of plant personnel to acknowledge inefficiencies in their systems; (5) payback periods that exceeded company targets; and (6) expectation/desire for financial incentives (which Wisconsin utilities were phasing out as the POS program was beginning). The evaluation also found that those customers that did implement projects did so for two main reasons: the project solved an existing problem, and/or the project was low risk and had low or no capital costs. Interviews during the evaluation found that most companies preferred to consider process changes when existing systems fail or need to be expanded. Interviewees recommended greater utility involvement in the process, including presenting the POS concept to senior management (Bensch 1999; Sturiale 1999). Of the projects that were implemented, four were evaluated. These projects cost an average of \$48,000 and saved an average of \$40,500 annually, resulting in an average simple payback period of 1.2 years. Average project savings were reported as about 110 kW and 675,000 kWh per year (Sturiale 1999).

As a result of the low project implementation rate, as well as the high cost of marketing and engineering, the Energy Center decided to cancel the program. Program staff felt that the concept had a lot of merit, but more work was needed to streamline procedures so that costs could be kept in check and also so that projects were more contained and easier for customers to make decisions about. For example, several of the engineers involved in the program recommended development of improved pre-screening procedures so that inappropriate sites could be better screened out prior to any onsite assessments (Bensch 1999; Meadows 2000).

Recent and Current Efforts Focusing on Particular Industries

Building on these lessons, recent efforts to capture fan and pump efficiency savings have tended to focus on particular industries and the particular fan and pumping systems that are generic to an industry. Focusing on industries allows for knowledge from one project to be applied to other projects, cutting costs. Also, word-of-mouth and case studies within an industry can be very useful in building participation. Examples of programs focused on particular industries include: work in California, Vermont, and Wisconsin on municipal

water and wastewater systems; work in California on agricultural pumping systems; work in British Columbia, the Pacific Northwest, and North Carolina on lumber drying kilns; and work in the Northwest on refrigerated storage warehouses.

In 1995, the U.S. Department of Energy (DOE), the Electrical Apparatus Service Association (EASA), the Pacific Gas and Electric Company (PG&E), and local motor distributors identified water pumping at water and wastewater treatment facilities as a major energy-saving opportunity, based on several previous demonstration projects. Using three California Energy Commission (CEC) case studies at water and wastewater sites as a foundation, the organizations arranged operations and maintenance pumping workshops for Northern California Chapter of the American Water Works Association (AWWA) members. The workshops focused on how to choose motors and pumps, maintenance and operation practices, and motor and pump repair. These workshops were all standing room only. As a result, AWWA partnered with CEC and utilities throughout the state to offer workshops statewide. Based on this success, DOE, CEC, and AWWA, along with the Electric Power Research Institute (EPRI) and the utilities, brought the Pumping System Optimization training to California, which had previously been offered in Ontario, Canada. The success of the California initiative resulted in programs in other states, including New York, Arizona, and Iowa. The strength of the program has been its focus on a narrow market segment. Another inducement was that the sponsors worked with participating states to give Continuing Education Unit hours for the workshops, which was important to many of the water and wastewater operators who needed the hours to maintain certification (Oliver 1999).

More recently, the Vermont Energy Investment Corp. (VEIC) has been running water and wastewater energy efficiency programs for the Long Island Power Authority and Efficiency Vermont. Similarly, Wisconsin Focus on Energy has deployed a water and wastewater program based on a water and wastewater roadmap it developed (Focus on Energy 2002a). These programs provide a comprehensive assessment of efficiency opportunities. Among the measures included are process technology changes such as fine-bubble aeration. The implementation of these measures frequently incorporates pump and blower system optimization to take advantage of the process load reduction that result from the change in process technology. The Wisconsin program has retained industry experts that conduct assessments for municipalities on energy-saving opportunities. The program staff are particularly targeting smaller (5–10 million gallon per day) facilities because they have found greater replicability of recommendations and ease of implementation at these facilities than at larger systems that are more complex (Focus on Energy 2002b; Griffin 2002).

California utilities (e.g., PG&E and the Southern California Edison Company [SCE]) have also been promoting pump system improvements to agricultural customers for decades. The foundation of these programs has been a pump testing service that tests pumping systems to determine overall system efficiency, electrical motor performance, pump hydraulics, and water well characteristics. The result is a computerized report containing information on the testing results, and a recommendation on whether replacement or upgrading equipment is warranted. Where such changes are recommended, estimates of the capital and operating costs for the upgraded system are provided. In recent years, many of these programs have added additional services such as free or subsidized engineering feasibility studies on energy-saving measures, pump system design analysis, and incentives for installing energy-saving measures (Conlon & Weisbrod 1998; SCE 2000).

Market research by PG&E found that the major barriers inhibiting good pumping practices are the perception that efficiency measures have many hidden costs, concerns that measures will not perform as advertised, and lack of information and the time needed to find trustworthy information. This research found that the PG&E pumping program was addressing the information barrier to a significant extent and other barriers to a lesser extent (PG&E 1999). A 1998 evaluation of SCE's pumping program found similar program impacts and further found that pumping system efficiency gradually increased in the 1990s (due in part to the SCE program), that program participants saved energy relative to non-participants, and that the market share for high-efficiency pumps was much greater in California than in a neighboring state that did not have an agricultural pumping program (Conlon & Weisbrod 1998).

However, Conlon & Weisbrod also recommended developing additional intervention strategies to better address the remaining market barriers to high-efficiency pumps and good pumping system design, operation, and maintenance practices. These strategies include: improving access to financing and other tools to reduce the first cost of more efficient equipment; developing standards for defining and distinguishing high-efficiency pumping equipment; working with municipalities to improve bidding procedures so that efficient and inefficient equipment are no longer evaluated as "comparable;" encouraging dealers to improve stocking of efficient equipment; and offering training for pumping system consultants on the value of long-term payback from investing in the acquisition of higher-efficiency and longer-lasting equipment (Conlon & Weisbrod 1998).

Another example of a industry-focused program is the application of ASDs in hardwood lumber dry-kilns conducted by the N.C. Alternative Energy Corp.—now Advanced Energy (AE)—in cooperation with the furniture industry, North Carolina State University, and the state's electric utilities. The project's goals included: understanding the drying process for furniture-grade hardwood; developing a control strategy for the fans; and evaluating the potential for savings. In furniture-grade lumber, especially some hardwoods such as oak, the control of the drying process is critical for maintaining lumber quality. The AE study developed and demonstrated a control strategy based on the change in the humidity in the air immediately before and after it had passed through the lumber stack to vary the fan speed. The lumber quality was better with the variable air (particularly on difficult woods to dry, such as oak) though tests were not conclusive. The total energy required for a load of wood was reduced by about half (Nadel et al. 2002). Similar programs were run for softwood dry kilns by B.C. Hydro for several years (FERENCE Weicker & Company 1995) and by the Bonneville Power Administration in the 1990s at many wood product plants in the Northwest (Gordon 2000).

In the Northwest, a program operated from 1998–2001 to work with refrigerated fruit storage warehouses to encourage them to install ASDs on refrigeration system evaporator fans. The program centered on educating warehouse owners—as well as vendors, contractors, and systems operators—on the benefits of ASDs in refrigerated warehouses. As of November 2001, projects were implemented at 24 sites including 18 controlled atmosphere storage facilities, five cold-storage warehouses, and one distribution center. Evaluations of the program found that projects in the controlled atmosphere facilities reduced fan energy use from 24–78% and also reduced fruit mass loss by 0.19–0.58% (which is important since sales revenues depend on weight). About one-half the financial benefits came from energy savings and one-half from reduced mass loss. Overall simple paybacks on these

projects ranged from 1.1–3.6 years. At the other six sites, fan energy was reduced 62–86%, with simple paybacks based on energy savings ranging from 1.4–8.0 years. Probably even more importantly, surveys of field trial participants found that the experience convinced them to install more evaporator fan ASDs. The evaluation attributes the program’s influence to a significant regional presence in industrial refrigeration and person-to-person marketing by a highly experienced and respected program contractor (PEA 2002). While the program has ended due to market acceptance of ASDs in the industry, a number of follow-up activities are taking place (NEEA 2003).

Broad Programs

In addition to these industry-specific programs, a number of broader programs are being offered to promote fan and pump system energy savings. For example, DOE’s *Industrial Best Practices: Motors* program has developed and offered a series of Pumping System Optimization Workshops. These sessions present the fundamentals of optimizing pump systems and focus on the Pump System Assessment Tool (PSAT), which helps industrial users assess the efficiency of pumping system operations. PSAT uses achievable pump performance data from Hydraulic Institute (HI) standards to calculate potential energy and associated cost savings. In 1999, DOE began a training program on how to use the PSAT software (DOE 2002).

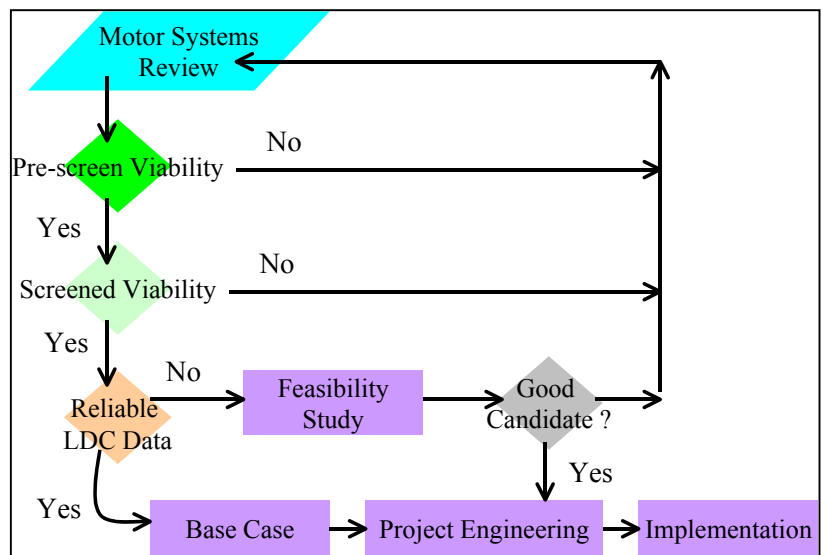
Many utilities offer incentives for installation of ASDs in fan and pump systems. Most of these programs offer “custom” incentives for ASDs and other energy-saving measures. In these custom programs, the customer or its consultants prepares a description of the measure, its costs, and its energy and demand savings. Based on this information, the utility will provide an incentive determined according to a formula (e.g., \$x per kWh saved). However, a few utilities offer pre-calculated incentives per unit horsepower controlled by the ASD, provided certain criteria are met. For example, National Grid USA offers incentives on a per horsepower basis for boiler water feed pumps; hydraulic pumps on injection molding machinery; chilled water distribution pumps employed in building HVAC systems; and supply, return, and building exhaust fans employed in variable air volume building HVAC distribution systems. For each of these applications, annual equipment operating hours must exceed eligibility levels set by the utility. National Grid offers pre-calculated incentives for these applications because it is confident that ASDs in these applications will provide cost-effective energy savings. For other potential applications of ASDs, National Grid accepts custom-measure applications but requires engineering calculations to verify that savings are significant and cost-effective. The National Grid ASD program has been popular with customers and ASD vendors because it is relatively simple to apply for and the amount of incentive is known in advance, making it easier for vendors to sell projects to customers. National Grid had been offering this program since the early 1990s, and as of 2000, had provided incentives to over 500 customers (McAteer 2000).

Program Strategies

An industrial fan and pump system program requires more thought than other programs because of the complex nature of the opportunity. The biggest challenge encountered by past programs has been high program cost for opportunity identification and solution design. It is important that the program quickly focus its efforts on sites likely to result in implemented savings. As a result, a program focused on a few specific industries appears most effective. In addition, past program experience indicates that systems that have a total installed fan or pump horsepower of greater than 100 hp are the best target or else the engineering cost will swamp the value of the energy savings.

FlowCare Engineering developed a screening methodology for Ontario Hydro that is graphically represented in Figure 3. This methodology assumes a familiarity by the program engineers with the opportunities that exist in the target industries, but does not require a design engineering level of expertise to accomplish initial screening. A technically oriented field representative with some limited training can do the prescreening. The viability screening may require a greater depth of understanding, but can frequently be accomplished by conference call, rather than requiring a site visit. If the facility has good process data, a load duration curve (LDC) can be constructed for the application, allowing a systems engineer to evaluate the project and undertake the design of a solution. If this data is not available, onsite monitoring will be required to construct the LDC to allow for final screening. This approach allows for different levels of expertise to be focused most effectively to minimize use of high-cost consultants (Martin 2001). Don Casada also developed a similar approach while at the Oak Ridge National Lab (Tutterow, Casada, and McKane 2000).

Figure 3. Fan & Pump Optimization Candidate Screening



Source: Martin 2001

The design of a full program requires up-front work to characterize the opportunity in the service region. The general approach is as follows:

- Analyze the pump and fan market in the service territory(ies);
- Identify key market sectors with significant opportunities;
- Conduct case studies at representative sites to identify key opportunities and solution strategies;

- Develop semi-prescriptive recommendations for target sectors based on the case studies;
- Identify and/or develop local technical assistance resources (preferably from the existing consulting engineering community) augmented by national experts;
- Develop and deploy an outreach effort to the target audience;
- Conduct preliminary screening at interested facilities using a screening process as discussed above; and
- Support solution development and deployment at the most promising sites.

The program will need to assemble a toolkit from the extensive existing materials developed by groups such as HI, DOE, and pump manufacturers. The toolkit should be deployed in a web format similar to that developed by the Consortium for Energy Efficiency for the Motor Decisions Matter (MDM) initiative (Jones 2003). In addition, the project should assemble a database of key North American consulting resources that could be used to assist programs.

With this approach, program costs can be contained. The program quickly focuses on high probability candidates, with the use of high-priced engineering services effectively targeted at facilities likely to yield the greatest savings. In this program approach there is limited need for equipment incentives because of the high benefit-cost ratio for most projects, although some equipment incentives may be useful in the early stages to help the program establish a track record in the service territory. The more important focus should be on incentivizing the engineering service, since once a project is designed the customer is likely to proceed with implementation if it can be shown to be profitable.

Conclusion and Recommendations

Programs, such as those with the water/wastewater, lumber drying, and refrigerated warehouse industries, indicate that substantial savings are possible with targeted fan and pumping programs. We recommend that utilities and other program implementers begin to develop programs based on these successful examples, but targeting key local industries with extensive fan and pump energy use. Typically a year will be needed for program development and a year for a pilot program targeted at a specific industrial sector, with large-scale deployment in subsequent years. We suggest that program development include preparation of an assessment of the industrial fan and pump market in the local area, identifying key local industries with opportunities for substantial fan and pump energy savings and also identifying regional industry experts and key trade allies. Concurrent with this survey, programs should assemble a toolkit to support marketing and provide tools to assist engineers. This toolkit should draw from available materials and be supplemented with some new materials. As part of this toolkit, several case studies should be developed for targeted industries.

References

- [ASE] Alliance to Save Energy. 2002. *Watergy*. Washington, D.C.: Alliance to Save Energy.
- Bensch, I. 1999. *POS Evaluation: Looking Back on the Performance Optimization Service Program*, Report Summary. Madison, Wis.: Energy Center of Wisconsin.
- Conlon, T. and G. Weisbrod. 1998. *Southern California Edison Hydraulic Services Program Market Effects Study*. Study ID #3507. Sonoma, Calif.: RLW Analytics.
- [DOE] U.S. Department of Energy. 2002. http://www.oit.doe.gov/bestpractices/software/psat_cert.shtml. Washington, D.C.: U.S. Department of Energy.
- Ference Weicker & Company. 1995. *Process Evaluation of B.C. Hydro's Fans, Pumps, and Compressed Air Programs*. Vancouver, B.C., Canada: Ference Weicker & Company.
- Focus on Energy. 2002a. *Roadmap for the Wisconsin Municipal Water and Wastewater Industry*. Madison, Wisc.: Focus on Energy.
- . 2002b. "Wisconsin Municipalities Turn to Focus on Energy." November 19 Press Release. <http://www.focusonenergy.com>. Madison, Wisc.: Focus on Energy.
- Friedman, R., C. Burrell, J. DeKorte, N. Elliott, and B. Meberg. 1996. *Electric Motor System Market Transformation*. Washington, D.C.: American Council for an Energy-Efficient Economy.
- Gordon, F. (Pacific Energy Associates). 2000. Personal communication to Steven Nadel. July.
- Griffin, T. (Science Applications International Corp.). 2002. Personal communication to Neal Elliott. September.
- Jones, T. (Consortium for Energy Efficiency). 2002. Personal communication to Neal Elliott. September.
- Martin, N., E. Worrell, M. Ruth, L. Price, R.N. Elliott, A.M. Shipley, and J. Thorne. 2000. *Emerging Energy-Efficient Industrial Technologies*. Washington, D.C.: American Council for an Energy-Efficient Economy.
- Martin, V. (FlowCare Engineering, Inc.). 2001. Personal communication to Neal Elliott. March.
- McAteer, M. (National Grid). 2000. Personal communication to Steven Nadel. April.
- Meadows, K. (Energy Center of Wisconsin). 2000. Personal communication to Steven Nadel. August.

- Nadel, S., R.N. Elliott, M. Shepard, S. Greenberg, G. Katz, and A.T. de Almeida. 2002. *Energy-Efficient Motor Systems, Second Edition*. Washington, D.C.: American Council for an Energy-Efficient Economy.
- [NEEA] Northwest Energy Efficiency Alliance. 2003. <http://www.nwalliance.org/projects/current/warehouse.html>. Portland, Oreg.: Northwest Energy Efficiency Alliance.
- Oliver, J. (U.S. Department of Energy). 1999. Personal communication to Neal Elliott. March.
- [PEA] Pacific Energy Associates and MetaResource Group. 2002. *Market Progress Evaluation Report: Evaporator Fan VFD Initiative, No. 3*. Report #E02-102. Prepared for the Northwest Energy Efficiency Alliance. Portland, Ore.: Pacific Energy Associates and MetaResource Group.
- [PG&E] Pacific Gas and Electric Company. 1999. *PY97 Agricultural Energy Efficiency Incentives: Pumping and Related Market Effects Study*. Study ID #335A. San Francisco, CA: Pacific Gas and Electric Company.
- [SCE] Southern California Edison. 2000. "SCE Business Advisor: Pump Tests." <http://www.scebiz.com/solutionscc/services/pumptest.htm>. Rancho Cucamonga, Calif.: Southern California Edison.
- Sturiale, J. 1999. *POS Evaluation*. Prepared for the Energy Center of Wisconsin. Madison, Wis.: Sturiale & Company.
- Tutterow, V., D. Casada, and A. McKane. 2000. "Profiting From Your Pumping System." In *Proceedings of the Pump Users Expo 2000*. Louisville, Ky.: Pumps & Systems Magazine and Randall Publishing Company.
- Wroblewski, R. (Energy Center of Wisconsin). 1996. Personal communication to Steven Nadel.
- XENERGY. 1998. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Washington, D.C.: U.S. Department of Energy, Office of Industrial Technologies.