Wisconsin's Performance Optimization Service: Utilities and Trade Allies Delivering a Service to Improve Industrial Motor-Driven System Performance

Edward M. Carroll, Barbara J. McKellar, and Ronald G. Wroblewski,
Wisconsin Demand-Side Demonstrations, Inc.

Wisconsin Demand-Side Demonstrations, Inc. (WDSD), is developing a new approach to increase industrial electric demand-side savings by learning to leverage and enhance the skills of trade allies who work with industrial fans, pumps and blowers. Through a comprehensive marketing and technical training curriculum, the Performance Optimization Service (POS) project provides a repeatable *systems* engineering approach to identify, assess and optimize the performance of large fan, pump and blower systems.

WDSD designed its POS approach to address both technical and market barriers that presently hinder greater industrial energy efficiency. From a technical perspective, under POS, engineers perform a systematic engineering assessment and optimization of customers' fan, pump and blower *systems.* From a marketing standpoint, POS is designed to bring trade allies from a variety of applications together to identify and participate in system optimization projects.

The objective of this paper is to outline the evolution of this approach to motor-driven system efficiency, describe techniques involved with POS, and explain how the project is being fielded in Wisconsin during 1994 and 1995. The POS project's long term goal is to: a) increase the number of industrial customers presently participating in utility energy-efficiency services; b) move from a component- to system-based program design; and c) improve industrial customer process efficiency while meeting customer needs.

Introduction

Through Wisconsin-Demand-Side Demonstrations, Inc., several Wisconsin utilities are sponsoring a Performance Optimization Service (POS) demonstration project. This demonstration project operates under the umbrella program for motor and motor systems known as Responsible Power Management (RPM). POS is a service that a team of professionals-consisting of electric utility staff, consulting engineers, service contractors and equipment manufacturers-provides to optimize industrial customers' turbomachinery systems. The objective of this service is to improve system performance and increase industrial energy efficiency. POS accomplishes this task through an assessment that looks at how the entire system is presently operating, and proceeds to match system output (flow, pressure, temperature, etc.) to the actual demands of a given process.[1]

The near-term objectives for the 1994 POS demonstration project are to: 1) begin establishing POS knowledge within the Wisconsin engineering community by conducting two training sessions in 1994; and 2) demonstrate the structured, systems approach of POS by having engineers who complete the POS training conduct POS feasibility studies and system optimization retrofits with industrial customer facilities throughout the state.

Project Evolution

WDSD is building on the work of Ontario Hydro and the other coordinated Canadian utilities' Performance Optimization program. In both Ontario and Wisconsin, approximately 70 percent of industrial electricity is consumed by motors (Stonehouse and Braithwait 1992).2 In order to tap into this motor efficiency potential, both Ontario Hydro and the Wisconsin utilities initially concentrated their industrial motor-driven system efficiency efforts on Adjustable Speed Drive (ASD) applications. Wisconsin utilities focused research on identifying appropriate ASD

application procedures, monitoring existing applications for energy savings and power quality impacts (ADM 1994). This information was to be used to provide guidelines for Wisconsin utilities to use in creating demand-side management programs addressing industrial motor-driven systems.

During working group meetings coordinated through Wisconsin Demand-Side Demonstrations, Ontario Hydro staff shared their experiences in developing and fielding an ASD program. After completing an ASD demonstration program, Ontario Hydro found the program to be too narrowly focused; the component-based approach provides an answer before truly asking the right questions. ASDs are appropriate for only a portion of all motor-driven systems due to technical and market barriers, such as application considerations, system pressure requirements and lengthy payback periods. Made aware of this limitation, WDSD and Wisconsin utilities decided to reposition the motor system program and build on the idea of a Performance Optimization Service, which includes a variety of techniques to better match turbomachine output to process requirements.

POS Techniques

Industrial customers have realized fan, pump or blower system electrical savings of 20 to 50 percent through POS techniques such as trimming impellers, utilizing ASDs, and reducing piping or duct transfer system pressure losses.

Fans, pumps and blower systems are physically governed by a set of equations known as the affinity laws. The affinity laws define the operation and energy usage of these systems.[3] Reducing flow in instances where the process does not require as much fluid flow as the turbomachine generates can save considerable energy. According to Nadel, a modest reduction in flow can result in significant reduction in energy requirements with the use of speed modulation technology such as an ASD (Nadel et al.).

A pump optimization completed with an Ontario customer provides a good example. At this particular facility, pumps were producing 6,400 gallons per minute (gpm) when the process only required 4,400 gpm; the balance was being bypassed back to the pump inlet through a throttling valve. A more accurate matching of pump size to current process requirements reduced the horsepower (hp) required from 1,233 hp to 443 hp, thereby saving the customer $219,000 per year in electric costs (5, 140,000 kWh/yr) (Ontario Hydro 1992). Similarly, an Ontario cement factory was able to replace four fans totaling 900 hp with four new fans totaling 700 hp by replacing the throttling damper control system with an ASD control system, resulting in cost savings over $100,000 per year (2,350,000 kWh/yr) (Ontario Hydro 1992).

Over time, fan, pump and blower systems may gradually drift from their optimal operating points for a variety of reasons. Changes in equipment, quantity of product produced, operating environment and maintenance intervals all may cause systems to operate at points that are less than optimal, which wastes energy, resources and money. The performance of many of these existing systems can be improved through a POS feasibility study and retrofit. Some POS energy-saving techniques include:

- replacing throttling valves and dampers with speed-regulating devices such as Adjustable Speed Drives;
- eliminating excess flow through bypass valves;
- use of better motor and equipment sizing to meet current process demands;
- modifying flow at inlets and outlets to enhance system performance; and
- redesigning pipe/ductwork to reduce or eliminate excessive fluid pressure losses.

The POS approach requires engineers to look *beyond* ASD applications; in some cases, other system modification options can result in equal or greater savings and lower first cost than the installation of an ASD.

As previously mentioned, in a typical Wisconsin industrial facility, motors account for approximately 70 percent of the electricity consumed. A large number of these motors drive fans, pumps, and blowers, so Wisconsin utilities are targeting these systems for the initial 1994 POS project. The technical potential estimate for a POS targeting fan, pump and blower systems is 3,100 GWh and 236 MW.[4]

Benefits

Ultimately, POS is designed to benefit the industrial customer by increasing system performance and energy efficiency. However, this service also offers benefits to utilities, consulting engineers and turbomachine trade allies. Some specific benefits the Wisconsin utilities hope to achieve and offer to customers and trade allies from POS include the following:

Industrial Customers. As documented by Ontario Hydro, POS offers customers a way to match turbomachine performance to actual process requirements leading to reduced operating and maintenance costs, greater production control and equipment reliability (Ontario

Hydro Case Study). WDSD is designing POS to allow industrial customer operating and management staff to: 1) easily understand the feasibility study process, and 2) provide the engineer "reality checks" during the study process to ensure the technical options being considered are both technically and financially feasible for the company. Also, through the training provided by Wisconsin Demand-Side Demonstrations, industrial customers are offered a pool of local engineering expertise to draw from to conduct system studies and complete the retrofit work.

Engineering Community. POS offers consulting and industrial in-house engineers a repeatable method to identify saving opportunities, undertake studies and facilitate the implementation of study recommendations. Wisconsin Demand-Side Demonstrations and supporting utilities believe the POS method streamlines the process of identifying POS opportunities and undertaking studies while creating new business opportunities for engineers.

Equipment Manufacturers, Service Firms and Distributors. Turbomachine manufacturers, distributors and firms installing equipment can increase their sales through cooperative work with utilities and the engineering community. Information sharing between these groups can help identify specific customers to target for study and new, energy-efficient equipment sales and application opportunities.

Utilities. POS can assist electric utilities in saving energy and reducing demand in a more cost-effective manner. In Ontario Hydro's pump optimization example cited above, the utility incentive divided into the project's life cycle savings provides the utility with an approximate cost of $.0004/kWh. Assuming the utility's avoided cost of $.04/kWh and a 30-percent administrative cost, this project provides a benefit/cost ratio of 7.

Utilities also benefit by creating a partnership with industrial trade allies to help serve customers. Wisconsin Demand-Side Demonstrations anticipates the standardized POS method will streamline the review of feasibility study proposals.

POS Concept - Project Elements

Various stakeholders-including utilities, energy service companies (ESCOs), equipment manufacturers, engineers, service contractors and state government-coordinate their activities using the POS project elements. As explained below, these project elements include: 1) Systems Approach and Method, 2) Engineering Training and Project Support, 3) Project Incentives, 4) Trade Ally Partnerships, and 5) Technology - influencing the design of fan, pump and blower equipment for new and retrofit installations.

The POS Systems Approach and Method

Candidate systems are screened for savings opportunities, then tested to establish the actual operating characteristics of the fan, pump or blower system. Thus, recommended system improvements are based on the actual in-plant operating conditions. This differs from the traditional approach utilized in many industrial energy management studies, which calculates savings based on engineering assumptions of equipment loading, efficiency, hours of operation, etc.

Performing a formal test of a fan, pump or blower to accurately establish the flow, pressure, and energy use of the current system means that the engineer has much better information available to asses the system and upon which to base recommendations. For example, without a field performance test, an experienced engineer may be able to identify that a system currently being controlled with a throttling device is substantially oversized. However, only with test results that prove the pressure is three times what is required can the engineer confidently recommend opening the throttling device, and replacing the old, inefficient unit with a new, highly efficient unit that is one-third the size. [3]

Substantiated field performance testing data also allows the engineer to more accurately assess the condition of the turbomachine, its distribution system and its inlet and outlet conditions. For instance, poor inlet conditions cause the air flow generated by a fan to be substantially less than what the manufacturer's fan curve would predict, while power consumption remains high. In other instances, the inlet and outlet conditions may be fine, but the machine may be malfunctioning, or operating away from its peak efficiency point.

Often, industries are using systems that were installed long ago for a condition that no longer exists. In order to adapt the system to current conditions, the maintenance and engineering staff may have been required to modify machinery (a valve on piping, a damper on an air duct or a flow bypass) to meet short term needs, but resulting in substantial energy waste. If the production requirements for flow and pressure are not time varying, it may be more cost effective to modify or replace the equipment rather than install an ASD.

This example illustrates the limitations of a utility ASD rebate program. ASD programs specify the answer, leaving the participant to figure out the question. The POS approach, on the other hand, looks at the production

requirements and suggests modifications to the system to meet these needs while reducing energy costs.

A key element of the POS systems assessment is the formal delivery method. The POS assessment method guides the engineer, utility representative and industrial customer from the identification of system optimization opportunities through to the final recommendation on how an industrial customer can optimize a given system. The POS method is designed to make the feasibility study process more understandable for all involved and to answer questions; for example, why a particular system is a good candidate, how the energy saving calculations are determined and how to factor the industrial customer's decision-making criteria directly into the analysis. This method involves the following steps:

Prescreening. Utility or consulting engineers identify industrial customers who may be candidates for a POS feasibility study, based on equipment type and age, hours of operation, planned system upgrades, additions or other changes in operation.

Customer Screening. Based on prescreening information, a utility or consulting engineer interviews the customer to collect fan, pump or blower system information, including equipment specifications and operating parameters, during an on-site visit. The engineer then completes a preliminary energy and production savings estimate to determine if further investigation will yield cost-effective optimization and energy saving opportunities.

Feasibility Study Proposal. If the energy savings estimates or the potential operating improvements prove substantial, the consulting engineer then collates the customer screening information into a standardized POS study proposal and presents it to the customer. In this proposal, the engineer provides an energy savings estimate along with the cost to undertake a POS feasibility study.

Field Performance Testing. Once a proposal is accepted by the customer, consulting engineers complete equipment inspections, determine system operating points, gather load data and other information necessary to complete the system energy and economic analyses. While each study will be unique, a set of standard POS field testing techniques are used to collect actual system performance data.[3]

Feasibility Study Report. Engineers analyze the field data and incorporate it into a standardized POS feasibility report. This brief 10-15 page document is designed to facilitate customer decision making. It presents a prioritized list of technical options for the customer to pursue, including energy and production cost-saving estimates, applicable capital costs, paybacks and financial incentives.

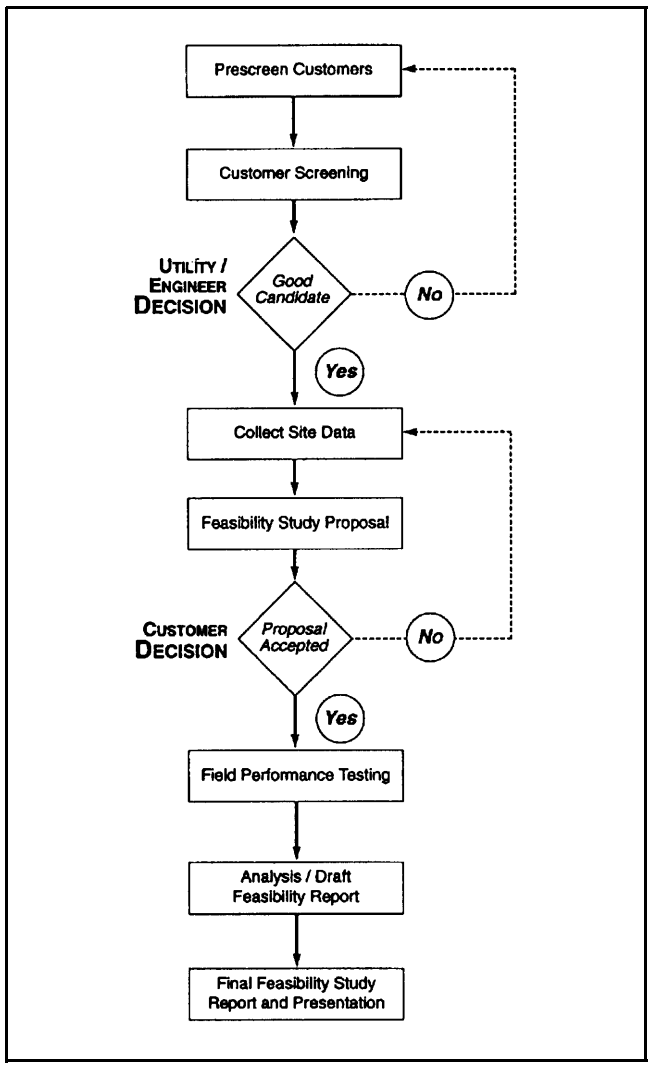

Figure 1. POS Study Process

Engineering Training and Project Support

POS is a service that involves people who can offer a combination of expertise from a variety of fields. In order to identify a POS opportunity and carry a project through to implementation, engineers are required to be familiar with:

- energy management studies;
- fan, pump and blower equipment;
- systems analysis and field testing of equipment; and
- selling the implementation of study recommendations.

While there are many individuals who possess background in one or two of the above listed elements, few individuals or firms are fluent with them all. As part of the POS

project, Wisconsin Demand-Side Demonstrations is providing formal training and project support to successfully market and complete POS system studies and retrofits. Through these efforts, we can begin building a network of Wisconsin professionals well versed in the POS method.

The detailed, four-day POS training session enables engineers to identify optimization opportunities, conduct field performance testing to determine actual system operation, estimate production and energy efficiency improvements and prepare a POS feasibility report. To practice principles taught in the classroom, engineers conduct field performance testing on a large chilled-water pump and forced-draft boiler fan system located at a university's heating plant. This plant serves as a field "laboratory" for engineers to identify opportunities for fan, pump and blower system improvements and understand field testing techniques. Students are then stepped through the process of analyzing the lab site's fan and pump operating data and incorporating this information into a standardized POS feasibility study report, which would then be presented to a customer. At the end of this training, engineers complete a test that reviews information from the four days of training, and receive accreditation to perform POS feasibility studies with participating Wisconsin utilities. The major emphasis is to provide a repeatable and transferable method for engineers to identify and complete POS studies, while providing industrial customers with information in a clear and consistent reporting format.

To provide complete information to all participants involved with a POS study, support materials are available to assist engineers in identifying fan, pump or blower system optimization opportunities and to complete a POS feasibility study. WDSD has developed a Performance Optimization Training Manual that serves as the central support source for WDSD's 1994 POS project (Stonehouse & Associates et al.). The manual guides the reader through the POS systems method, from the prescreening of system optimization opportunities to the final report and presentation to the customer. This POS Project Training Manual will be used as a key reference for participating engineers, customers and utility field representatives to consult for answers to technical and process-related questions.

Project Financing

In relation to POS, participating Wisconsin utilities offer financial assistance for conducting approved feasibility studies and for energy-efficiency projects on a customized basis. Custom rebates are calculated based on the amount of energy a particular project saves the utility in generation, transmission and distribution costs. Utilities also offer or coordinate low-interest loans and guaranteed-performance (i.e., shared-savings) arrangements. Under a shared-saving contract, independent organizations will cover the up-front capital costs associated with a project. The customer's energy cost savings then repays that loan over the time period.

Trade Ally Partnership

The long term success of POS depends on a cooperative effort involving many players from industry and the utilities. The key players from industry include consulting and industrial in-house engineers, equipment manufacturers and specifiers, distributors and service contractors and financial institutions. These individuals play vital roles in the implementation of POS projects.

As an initial step in working with trade allies, WDSD conducted a workshop in February 1993 to determine interest in a POS, outline barriers, and broadly define elements of a service to address these problems. Ideas from this workshop have been incorporated into the 1994 POS project (Carroll 1993). In October 1993, WDSD surveyed a broader group of fan, pump and blower trade allies serving Wisconsin customers to determine their interest in POS, Results indicate that manufacturers and consultants are enthusiastic about the POS concept. The initial respondents all believe a POS systems approach is greatly superior to the "component rebate" approach.

During 1994 WDSD will conduct individual meetings with 10 to 12 interested trade allies to better understand their particular needs in joining with other trades to support a Wisconsin POS. Proactive equipment manufacturers, engineers, and service contractors will then be brought together in a workshop format designed to address the concerns raised individually. This will allow them to incorporate the POS concept into trade allies' day-to-day business practices and move the program forward with their support. The objective is to develop utility and trade ally relationships, and determine how trade allies can support and promote POS over the long term.

Technology Transfer

Besides focusing on fan, pump and blower system optimization opportunities, the POS systems approach lends itself to the identification and assessment of other types of industrial systems, including compressed air, refrigeration and effluent treatment.

A POS also could be developed to influence the design of new industrial systems. While the present program focuses primarily on influencing the consulting engineering community, a POS targeted at the new equipment market would focus on equipment manufacturers with the intent of influencing manufacturers to build energy-efficiency

into equipment from the design stage. Pilot results from trade ally partnership interviews and meetings will help guide WDSD and utilities' future efforts in this area.

POS Pilot Projects

WDSD and supporting utilities are interested in applying the POS techniques presented in the training to several pilot customer sites during 1994. Based on a set of pre-screening criteria, Wisconsin utilities have selected several industrial customer candidates to undertake a POS feasibility study and retrofit. Benefits from pilot customer studies are threefold: customers benefit from energy and other potential production cost savings, while engineers participating in the pilot studies will be able to apply the POS techniques and enhance their expertise, and utilities have the opportunity to market-test the POS approach.

During the 1994 pilot project, WDSD will evaluate the effectiveness of this new service and how the classroom and field laboratory training relates to field implementation. Case studies will be developed documenting the study, technical option recommendations regarding retrofit and design, and available energy and production benefits realized.

Conclusions

The authors are excited about the potential for POS and believe that this service offers a potential win-win situation for utilities and their customers. As facilitators of this service, we believe utilities have an opportunity to strengthen their relationships with their large commercial/industrial customers while customers save money through energy savings and potential improvements in their overall production processes.

POS concentrates on saving energy using a motor drive *systems* approach and on overall production benefits that together drive customers' financial bottom lines. Through the evaluation of our pilot projects, we expect to learn about a) marketing this service actively using trade allies, b) the intricacies of measuring system impacts and c) focusing our technical training to best meet customer, trade ally and utility requirements.

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Endnotes

1. In this instance, and throughout this paper, a system is defined as that portion of the process associated with a fan, pump or blower. A blower is defined as a fan that generates very high static pressure.

2. Wisconsin information derived from personal conversation with Dick Kliebenstein, Public Service Commission of Wisconsin staff member, and from the Wisconsin Energy Bureau's 1994 electricity end-use consumption forecasts.

3. Field performance testing techniques are in accordance with standards established by the Air Movement and Control Association (AMCA Fan Application Manual) and Hydraulic Institute (Standards for Centrifugal, Rotary and Reciprocating Pumps manual). Affinity laws can be found in both of these publications.

4. POS technical potential estimate derived from the Wisconsin Statewide Technical & Economic Potential - Draft Report, November 2, 1993. WI Center For Demand-Side Research.

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