Industrial DSM - What Works and What Doesn't

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The industrial sector has long been a mystery to many DSM professionals especially in the area of industrial process conservation technologies. Because the industrial customer's primary interest is manufacturing a product, views of energy efficiency and DSM project viability vary widely from the commercial sector. End uses and technologies for the industrial sector are different, and therefore DSM programs must acknowledge and promote conservation using a modified approach. This paper will examine the successful and unsuccessful aspects of typical DSM program criteria for the typical industrial customer. In particular, the author will draw on over three years of firsthand experience working with over 120 industrial clients totaling 32 million square feet and $50 million of DSM investment in a Northeast DSM program. Statistics as well as anecdotal comments will be presented on the industrial customer's response to DSM program rule changes intended to encourage greater participation. A wide variety of typical industrial (but uncommon to commercial sector) energy conservation measures (ECM) recommended and installed will be reviewed for savings potential as will the willingness of an industrial customer to implement them. End-use metering validation results are presented on one type of ECM.

Introduction

The industrial customer's priorities and view of the world differ from those of the typical commercial building owner or an electric utility sponsoring a limited or comprehensive DSM program. This is partly due to the industry's purpose of manufacturing a product in a competitive marketplace worldwide. In this environment, energy cost reduction can be an activity which is of interest to the cost-sensitive industrial customer. For the typical electric utility DSM program, however, energy reduction (or load shifting) in a cost-effective manner is often a mandated regulatory activity. Sometimes the interaction of these two views (industry and utility) does not meet with the success that DSM professionals have expected, especially in terms of the level and timing of actual implemented conservation measures. This paper will examine the author's experiences over a three-year period within the context of a comprehensive DSM program sponsored by a major US electric utility in New England.

Results

When discussing the potential for DSM with an industrial customer within the context of an electric utility's implementation programs, the author likes to present the concept of a "Venn Diagram." On the one hand, "circle A" is all the potential electrical conservation measures (ECMS) - the utility's bag of tricks. On the other hand, "circle B" is all the cost-reduction measures that the industrial customer would like to do. There is a subset of ECMs both parties are willing to study and implement, and often, it is the job of a consultant to study, guide, and help implement these common ECMS.

From the electric utility's perspective, of interest are those ECMs that save either kilowatt-hours or kilowatts (or both) while meeting some cost-effectiveness test. Reliability and persistency of the savings in energy units (kWh) are sometimes more important to the utility than cost reduction to the end-user. On the other hand, the industrial customer is less interested in saving electricity for its own sake, but is aggressively interested in reducing operating costs and the cost of manufacturing a unit or product. The customer is by nature, therefore, interested in a "new piece of equipment" which can save money. Cost of energy per unit of production is the industrial customer's gauge. Fuel source is often immaterial. This view of the industrial customer is generally not well embraced in many electrical DSM programs.

Many electrical DSM programs set limitations on the definition of "comprehensiveness;" limitations that often do not make sense to the industrial customer. For instance, cogeneration and fuel switching are usually not allowed. Except for the industrials with large and continuous steam loads, cogeneration is usually not cost-effective. When there is a useful thermal load, cogeneration is potentially a very effective DSM option. Since cogeneration competes directly with the utility, most industries do realize the obvious reluctance to fund this ECM with rate payer's money. The reasoning behind fuel switching restrictions, especially when presented as part of a heat recovery ECM, is less clear. Often only heat recovery from electric to electric process is allowed. Since there are very few such opportunities, heat recovery is generally neglected in DSM programs.

Finally, depending on the industrial processes involved, thermal energy use could be the largest source of energy use at a particular facility. When the management finally decides to spend time looking at the energy use at the plant, it can be somewhat discouraging to examine in detail only the electrical end-uses. Despite electricity's high cost relative to fossil fuels, the total fossil fuel dollar cost can be the largest part of the industrial customer's energy bill. It would be quite a boon to coordinate in one DSM program, all fuels -- the electric and otherwise -- at a particular site. The door to fuel switching and cogeneration would obviously have to be open.

ECM Applicability

The following discussion of results is based on a sampling of industrial customers that the author has personally visited for either a preliminary walk-through audit or a detailed energy study.

Probably the most striking aspect of industrial DSM is the list of applicable ECMs for this sector. The author has surveyed a wide variety of industries, and the following table could be said to be representative of the industrial sector in that it draws from a large number of SIC types, including textile, wire drawing, printing, foundries, aluminum anodizing, metal fabrication, paper machinery, spring manufacturing, sports equipment, medical equipment, metal forging, metal assembly, paper making, chemical, explosives, food processing, defense manufacturing, aerospace, dairy, cable manufacturing, plating, plastics molding, jet engine manufacturing, elastomers, fabric printing, gun manufacturing, household chemicals, electronic equipment, automotive parts.

A number of points emerge from this table. First, all industrial customers are able to improve their lighting systems and install high efficiency AC motors. As shown later, lighting is the area where most of the electrical energy savings can be found. The industrials have

Table 1. Applicability of Common Industrial ECMs

ECM Description	Percent of Facilities With at Least One ECM
Improve Lighting Efficiency	100
High Efficiency AC Motors	100
Replace Screw Air Compressor with Reciprocating Type	40
Variable Speed Drives on Pumps	27
Energy Management System	20
Replace Motor Generator Sets with SCR	13
Compressed Air Demand Management	13
Wet-Side Economizer	7
High Efficiency Chiller Replacement	7
Exotic Metal Plating Anodes	7
Variable Speed Drives on Fans	<3
Air-Side Economizer	<3
Variable Voltage Lighting Controls	<3

fluorescent lighting, primarily, but they also have high intensity discharge (HID), thus differing from many commercial customers. Any DSM program for industrials must not neglect lighting, especially its cost-effectiveness to the industrial customer.

Second, replacement of air compressors is in high third place with 40 percent of the customers having the potential for air compressor replacement. Generally speaking, this ECM replaces the less expensive (and less efficient) screw-type air compressor with a longer life reciprocating type. Most industrials have purchased the cheapest unit (screw) on the basis of first cost. Usually these units have to be replaced within 10 years. Electrical savings and excellent persistency are possible by changing the air compressor to the reciprocating type. The industrials like this since it is a new piece of equipment which is tangibly improving their plant; further, it is big enough to measure and the resulting savings appear immediately on the bill. (It should be noted the leak prevention and other potentially low cost measures have been considered by DSM programs to be operation and maintenance expenses and thus not applicable for subsidy but included in recommendations.)

Figures 1 graphically shows the savings potential of the replacement of the air compressor from screw to reciprocating type. Figure 1 shows a before and after comparison of the screw and reciprocating type under similar loading conditions for a typical production day at the same facility. The amperage is shown for both (power has a similar curve). The reciprocating electrical current (and also power) is roughly half that of the screw for the same total horsepower installed. This is an example of how the potential for dramatic savings in one ECM is able to excite the management of industrial customers. It is interesting to note that the short-term metering of results (about two weeks total time) indicated that actual savings were larger than predicted, but still within the bounds of accuracy typical of engineering estimates.

Third, variable speed drives (VSD) are less universally applicable than some DSM professionals think. In the author's experience, he has found that only 27 percent of the industrial customers have any VSD applications, and these are usually on pumps. Facilities where VSD on fans are appropriate (and cost-effective) are less then 3 percent! (This does not mean, however that in some industries, VSDs are not excellent measures.) Essentially,

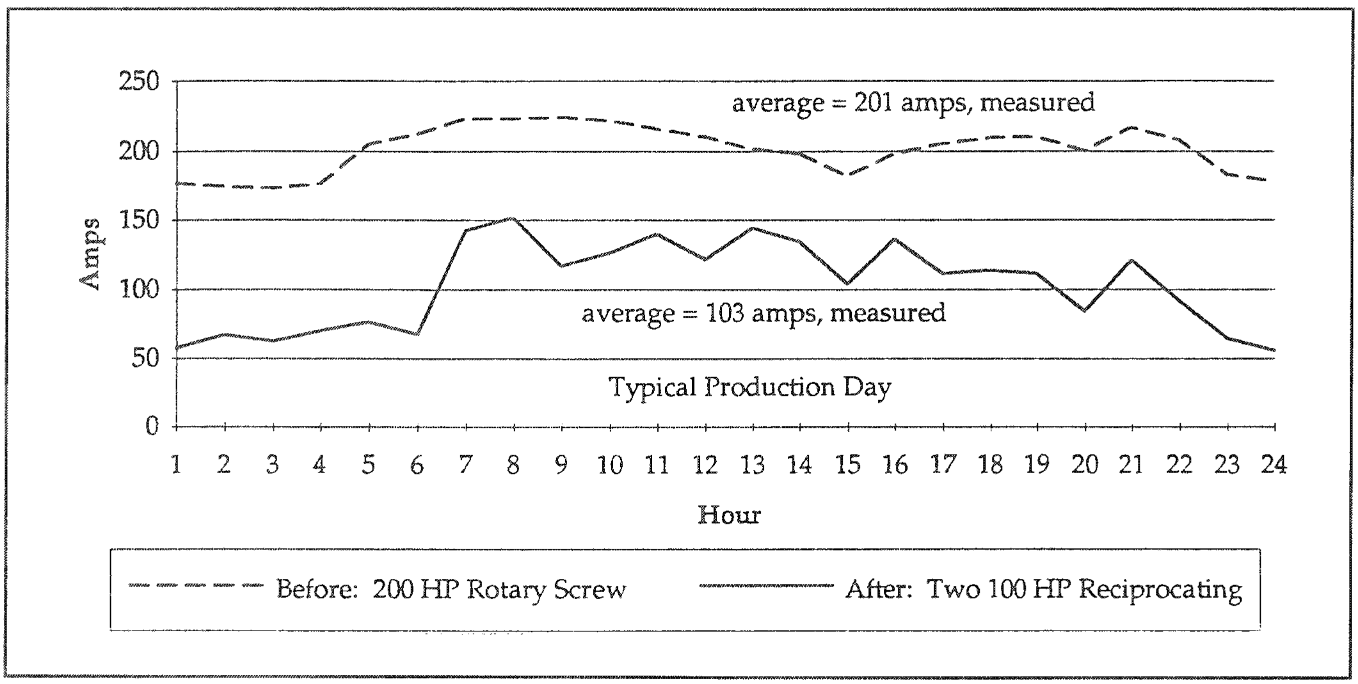

Figure 1. Typical Industrial Compressor Replacement--Old Rotary Screw to Reciprocating

the appropriate VSD applications are at times where there is a variable load, but the customer is bypassing (for convenience or ignorance) this load during the month or day or part thereof. Since processes and production change over time, these situations can arise, but not as often as one would think. When they are present, savings are usually substantial.

Fourth, all the other ECMs listed in Table 1 are available as appropriate for the DSM program manager. These ECMs are obviously not present in the commercial sector (except energy management systems and VSDs on fans), but are present in enough industrial facilities to warrant inclusion in any comprehensive program. It is also possible to simplify the approach by making the top four ECMs categories (lighting, motors, VSD pumps, and air compressors) prescriptive. On all four categories, savings are essentially driven by total hours of use (or run-hours). Short-term end-use metering for a period of one to two production weeks is sufficient to accurately estimate savings.

Finally, the author has not listed the various "new" electro-technologies such as radio frequency, microwave, and infrared drying because often these technologies do not qualify under the cost-effectiveness tests. These electro-technologies work very well. They reduce the customer's per unit production cost of electrical energy. Typically, they are so efficient they allow the customer to reduce a process from three shifts to one, thus eliminating two shifts of labor in the process (or they allow the customer to increase production by 200 percent). Unfortunately for the DSM program, either the cost of these technologies is too high to justify the electrical savings generated or there are not enough electrical savings as the installed demand may increase from the base case because of the continuous operation of the new equipment. These are still good ECMs for the customer, but under the current DSM program definitions, they are not eligible for partial funding.

What Is the DSM Potential for the Typical Industrial Customer?

Based on the admittedly small sampling of detailed energy studies performed by the author, the author has estimated the mean and standard deviation of the electrical energy savings both as a percent of total facility electrical costs (%) and as an electrical cost savings per square foot ($/sf). It should be noted that the author has not included savings from customers in the food processing industry with large process refrigeration loads. These facilities are all unique and customized and do not lend themselves easily to "standard" ECMS. Savings are most often much higher than for other industries since the electrical use density (and load factor) is so high.

The author has estimated that the typical industrial customer has the DSM potential of 12.80% ± 5.13%. Expressed another way, the average industrial customer can save (in 1991 dollars) about $0.49/sf ± $0.21 /sf. The estimated total cost to implement these ECMs is $2.28/sf ± $0.90/sf. These costs include materials, labor, sales tax if any, contingencies, and engineering. On average, therefore, the simple payback of these DSM measures to the customer is 4.65 years ($2.28/$0.49). Currently, a monetary incentive is offered to help implement these ECMS. Depending on the type and amount of savings from each ECM, this incentive is high enough to reduce the final simple payback to between one and three years. In the DSM program on which the author works, most industrial process ECMs are reduced to a one year simple payback. At these levels, the mean incentive for the industrial customer is $1.38/sf ± $0.63.

Figure 2 graphically shows the distribution of the end-use types of savings for the typical industrial facility. Surprisingly to some, lighting represents the largest area for electrical savings with nearly 59 percent of total recommended savings (kWh). The high efficiency motors includes process and HVAC motors. Roughly half would

Table 2. What Is the DSM Potential?

	Percent of Savings	Savings ($/sf)	Costs ($/sf)	Incentive ($/sf)
Mean	12.80%	$0.49	$2.28	$1.38
SD	5.13%	$0.21	$0.90	$0.63

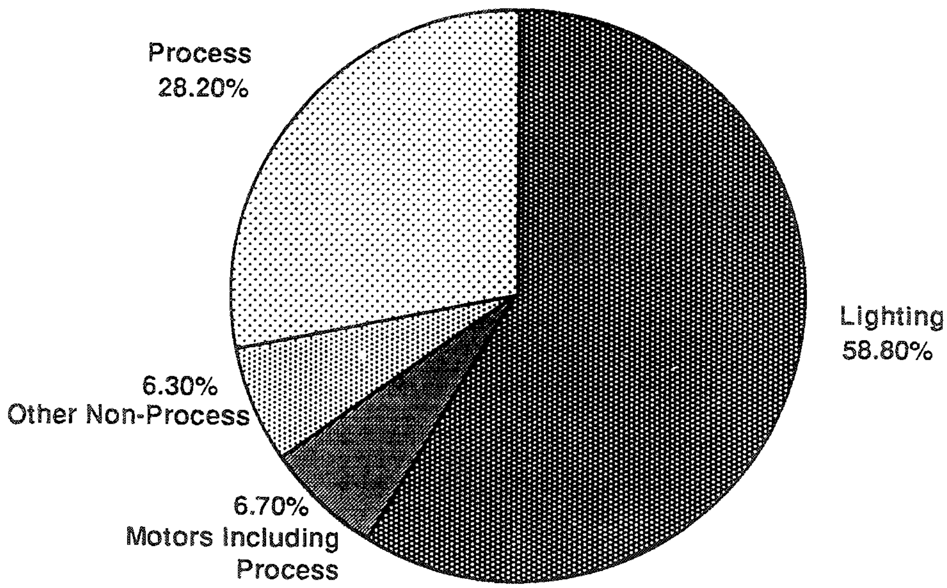

Figure 2. End Use Mean of Savings as Percent of Total

be considered process. If that is added to other process, the total percent of savings for the process end-use would be about 32%. Clearly, this is a big enough "slice of the electrical pie" to address.

How Long Does It Take to See Results?

One of the most discouraging aspects of any comprehensive DSM program is the time it takes before anything is installed. The interval between the typical industrial customer entering a comprehensive DSM program to finishing of the first milestone or finishing construction is a startling 25 months! It is the author's belief that this fact, more than any other, is the single most damaging aspect to high implementation rates among the industrial customer.

Before incentives are offered, the customer has to be recruited in a marketing phase, usually through an initial screening by the utility and a preliminary facility walk-through audit by a contractor. After a formal presentation of results, the customer chooses to continue in the program and enters into a detailed energy study phase. Finally, the results of this study (which are reviewed and approved by a quality assurance contractor) are presented to the customer and paperwork offering the incentive prepared. This process takes about 13 months ± 3.4 months.

After the offer letter, it is still time consuming to have the ECMs installed. As the table indicates, about 12 months ± 3.6 elapse from offer to incentive payment after construction. The longest period is during planning by the

Table 3. How Long Does It Take to Get Results?

	Time of Lead to Offer (Months)	Time of Offer to Incentive (Months)	Total Time (Months)
Mean	12.90	1.21	24.0
SD	3.4	7.6	8.5

customer to have the construction budgeted in his capital appropriations for the current or future fiscal years. After a decision to go ahead is made by the customer, engineering design (if needed) and the general construction process together are a lengthy process, followed at the end, by housekeeping issues such as final quality assurance inspections and "cutting" of the incentive check. All in all, a deliberate procedure, but unnecessarily long for the typical industry.

Three events that tend to hamper implementation typically occur during this process. First, a new contact is often named to "take over" the program details at the industrial plant. This is quite normal since capable people are either promoted, transferred, or move on to other organizations. Consequently, the project may see a second or third contact. Each time, confusion exists and sometimes what was desired initially is now no longer a priority.

Second, the corporation in general (top management, financial, engineering, and facilities) loses interest as the process wears on. People just naturally are involved in other concerns at the business, which reduces or diffuses their interest in the program. If there is no interest, then there will be no force to implement, even if the ECM is "free" or almost free (one-year payback).

Finally, the level of business activity can change in time and/or the process can be altered or eliminated. If these changes require another evaluation, the typical customer response is that the ECM is just too difficult to implement. They recall the length of time taken before and basically stop all forward progress.

Profile of an Industrial Customer

The typical industrial customer is not concerned with saving electrical energy for its own sake. Saving electricity is usually a minor chore compared with the major activity of facilities personnel making a product. Depending on the industry, the total cost of electrical energy is usually low, from 2 percent to 6 percent of sales (a few can be much larger) and is already reflected in the cost of production.

Industrials operate in a competitive environment. This competition is between companies not only regionally, but nationally and internationally. Larger industrial customers also compete within their division with other "sister" plants. It is typical for these customers to calculate and track on a monthly and weekly basis the cost of electricity per unit of production (case of product shipped, for instance). Some are extremely cost sensitive here, although not necessarily electrical usage (kW or kWh) sensitive. They further calculate (and evaluate themselves) and compare the unit cost of production versus the cost to transport the goods to the market. Aspects of production or entire production lines (and subsequent electrical use) can and are moved periodically to a "sister" plant when the mix of costs between production and shipping change are to the customer's advantage.

Within this environment, a comprehensive DSM program can serve as an effective management tool to help the industrial plant compete and thereby remain a full requirements customer of the utility. DSM can be used by the industrial plant for focusing an effort on systematically reducing energy costs as a component of overhead. An electrical cost saving of 13% $\pm$ 5% is big enough to attract top management's attention. It should be noted, however, that the author has fielded a number of very observant questions by industrial customer's noting that, due to the lack of timeliness of the program, the electrical cost savings will be diluted by rate increases before full implementation. Nor does, the source of funding go unnoticed. Some would rather have a discount on their electric bill than have to implement the DSM options. This is especially true of the largest users.

Most of these people are used to negotiating with customer and supplier as conditions change. They would like the same options when they consider their electricity supply. To the extent that a comprehensive DSM program is an option for these customers, then at least the program represents a good bridge for bettering customer relations. To this end, it is very important that the DSM program "rules" change as little as possible.

Other than the length of time it takes for implementation, the second largest barrier for a successful DSM program is confusion and complaints about the complexity of the program and variations in the rules. The average time between rule changes is about 8 months. In a program that takes over 25 months to completion of the first milestone of construction, multiple rules changes are devastating to customer confidence. Most industrial customers do not believe that they will be ultimately paid the incentive.

In terms of economic criteria to motivate the industrial customer, a two year simple payback is still the most common threshold time horizon. Above this threshold, they lose interest quickly. Acceptance of a longer payback period is an indication to the author that the customer was planning on implementing the measure anyway and was just looking for the proper time to do it. A small incentive (say a three-year payback) finally convinces him to do it. In some sense, this could be considered a "free rider", although the customer had heretofore not done anything. It was the offer of an incentive that "pushed him over."

For ECMs that the industrial customer is not normally thinking about (paybacks between three and 10 years), an incentive of one year is enough to get the process into motion. Even at that level, some customers may not implement. When they do not, it is usually related to cash flow. It is important for these customers to always have a positive cash flow. Any ECMs presented must address this positively to have a chance of implementation.

Conclusions

After working with a complicated but basically good comprehensive DSM program for over three years, the author has come to one conclusion - prescriptive incentives are better than "buy downs." Although this may be against the trend, it makes for a more "honest" distribution of incentive. To keep the amount of the incentive a mystery to all (including the customer) until the final cost and savings are in, is in itself a significant barrier to implementation. The typical industrial customer does not want to accept much risk for ECMS. Unless the incentive is fixed early in the construction process, the customer has little reason to hold down costs (provided the entire ECM still meet the cost-effectiveness test). As each customer, and particularly the vendors, learn the details of the DSM program and how the utility handles rule variations, costs have a tendency to increase beyond what they otherwise might be. If the incentives are fixed early in the process, the project becomes less extravagant. In this situation, the quality level of the final products installed is somewhat lower but the energy savings usually are the same. In the long run, the author believes that this will make DSM programs more cost effective by allowing incentives to be paid in proportion to the energy savings.