Market Potential for Operations and Maintenance Programs in the Northeast

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ABSTRACT

Utilities have always had a vested interest in understanding the power needs of their customers and regional industries. In the past several years, utilities have turned a curious ear towards facility operations and maintenance (O&M) as a potential target for energy services. Currently, a consortium of eight electric and gas utilities is sponsoring a study to characterize the commercial and industrial O&M market in their service territories in Massachusetts, Rhode Island, Connecticut, and New Jersey. This paper will describe work being conducted by this consortium to identify key O&M markets, baseline practices, and electric and gas savings potential in the Northeast. An ultimate goal of this effort is to make recommendations on O&M program marketing and design.

The authors have identified the following two key implementation issues for operations and maintenance programs while evaluating the only two O&M programs in the Northeast.

1. Influence Customer Behavior. Operations and maintenance programs are inherently different from most other utility programs. While other programs offer incentives to upgrade or replace equipment, O&M programs strive to change how the customers operate and maintain their equipment. Those responsible for program delivery need to realize that O&M has a substantial behavioral component. There are two requirements for a successful O&M implementation: (1) the customer must clearly exhibit substandard regular operating or maintenance procedures, and (2) the program must influence *lasting* improvements to these procedures. An O&M measure which provides a one-time improvement of equipment operating condition is unsuccessful from the standpoint of program delivery. This program can only meet its goals with the cooperation of the customer and the commitment to better facility management.

2. Establish Quality Control Procedures. Unlike standard retrofit or replacement measures, the energy impacts of O&M measures are not well established. Literature on the subject is fragmented and often based on individual case studies. As such, there can be great disparity in the quality of analysis and reporting provided by firms on O&M projects. It is strongly recommended that utilities establish quality control procedures to provide a framework to reevaluate the quality of work delivered by all involved firms to improve future program delivery.

Based upon data from the two aforementioned program evaluations, four O&M measures exhibited high implementation rates. In addition to being the most frequent O&M

installations, these measures also proved to be amongst the most successful in terms of energy savings. This paper will reveal the key industrial O&M markets in the Northeast, as well as describing the most and least successful O&M measures via savings realization and detailed case studies.

Defining O&M

It is useful to begin by developing a working definition of O&M measures for the study. The following multi-faceted definition of O&M has appeared in several sources, although it most likely has its origins at Pacific Northwest National Laboratory (Parker et al. 1993). According to this definition, an item or activity can be considered O&M if it meets one or more of the following criteria:

- Any item or activity that will bring equipment back into its original design and specification,
- A repetitive activity,
- A low cost item that can be installed or performed by the O&M staff, although it may be contracted,
- An activity that is financed as an expense rather than capital,
- An item or activity that has a simple payback of less than one year, and
- An activity affecting the operation of equipment: set points, schedules, control settings, and procedures.

This useful definition reflects the essential characteristics of O&M without unnecessarily excluding non-traditional examples.

It is equally important to understand how utility staff and O&M contractors define O&M, as well as how O&M measures differ from traditional energy conservation measures. In a broad sense, O&M measures are usually defined as energy savings measures that are free or inexpensive to implement. These measures include the proper maintenance of existing equipment or the installation of new controls. Some consider O&M as providing information to help customers operate more efficiently, while others differentiate O&M and traditional energy conservation measures based on the source of funding for the improvements.

Northeastern O&M Market Assessment

RLW Analytics, Inc. (RLW) is currently conducting a market assessment of O&M practice in the Northeastern United States via a study sponsored by a consortium of eight electric and gas utilities. RLW will assess the commercial and industrial O&M market in the service territories of these eight utilities, covering Massachusetts, Rhode Island, Connecticut, and New Jersey.

The key to the success of this project is identifying the market segments with the greatest opportunities for O&M savings and the means to overcoming barriers to adopting O&M practices in these segments. Of critical importance to these challenges is a strong awareness and technical understanding of which O&M practices are most effective for the technologies and end-uses predominate in the target segments. The strength of the approach is its marriage of effective market segmentation methods with technical analysis of O&M measures.

The ultimate goals of this comprehensive, staged data collection are fourfold:

1. *Key O&M Markets*: Describe the O&M market and current practices in a way that will help the sponsoring utilities develop coherent strategies for addressing the markets with both good market transformation potential and substantial energy savings opportunities.
2. *Baseline Practice*: Assess baseline O&M practices by end-use type and state, laying the foundation for assessing measures to be offered and, to the extent possible, estimating their potential energy savings.
3. *Measure Offerings and Potential Savings*: Assess O&M measures to be offered and, to the extent possible, estimate potential energy savings associated with these measures by segment and state.
4. *Program Design*: Make recommendations on overall program marketing and design. The assessment of market transformation potential will provide the initial estimates of potential program effects.

Key O&M Markets

In order to identify key industrial O&M markets in the Northeast, we researched a number of data sources. The U.S. Department of Energy's (DOE) Office of Industrial Technologies (OIT) sponsors the Industrial Assessment Centers (IAC) program which conducts assessments and provides recommendations to manufacturers to help them identify opportunities to improve productivity, reduce waste, and save energy. Other resources permitted researchers to estimate the size of the industrial market with regards to number of facilities and energy consumption. An American Business Information (ABI) database provided data on the number of industrial facilities by two-digit Standard Industrial Classification (SIC) code. The Energy Information Administration (EIA), the independent statistical and analytical agency within the DOE, gathers industrial energy consumption data via the Manufacturing Energy Consumption Survey (MECS), the only comprehensive source of information on energy use by U.S. manufacturers. Researchers used MECS data to quantify the level of energy usage in the Northeast census region. Data provided by a New England utility also was utilized to characterize electric usage intensities and end-use consumption for industrial customers in their service territory.

Number of Facilities. The ABI database provided data on the number of industrial facility types in the Northeast by two-digit SIC code. The following states were selected because this is how MECS represent the Northeast region: Maine, Vermont, New Hampshire, Connecticut, Massachusetts, Rhode Island, New York, New Jersey, and Pennsylvania. Based on the ABI data, the five most numerous industrial facility types in the Northeastern United States are: *Printing & Publishing*, *Industrial Machinery*, *Fabricated Metals*, *Miscellaneous Manufacturing*, and *Electronics*.

Industry Energy Usage. The Manufacturing Energy Consumption Survey (EIA 1994) provided estimates of net electricity consumption by census region and industry group. The electrical usage in the Northeast region was analyzed for all major industries and sorted by energy consumption. Based on this data, the five industrial categories in the Northeastern United States with the highest electrical usage are: *Primary Metals*, *Chemicals & Allied*, *Paper & Allied*, *Electronics*, and *Rubber & Plastics*.

Data provided by a New England utility was used to depict industrial energy usage in their service territory by end-use. The inclusion of electrical end-use in this data provides some useful insight on potential areas for O&M in this territory. In no way do we suggest that this particular service territory may be used to represent the entire Northeast. Rather, this data simply highlights some key end-uses within the specific industries.

Figure 1 displays the relative energy usage (the percent consumption of each industry relative to the consumption of the largest industry) by major SIC code across six end-use categories. As evidenced in the figure, the more prominent end-uses include motors in the *Rubber & Plastics* and *Paper & Allied* industries, and process equipment at *Rubber & Plastics* and *Industrial Machinery* facilities. The inset figure shows a pie-chart of the end-uses that comprise the bars. Motors are by far the largest industrial end-use in this territory, consuming 43% of the total facility electrical usage, followed by lighting (16%) and process equipment (14%). This data suggests that there might be a good opportunity for motor maintenance and both lighting and process time control at industrial facilities in the Northeast.

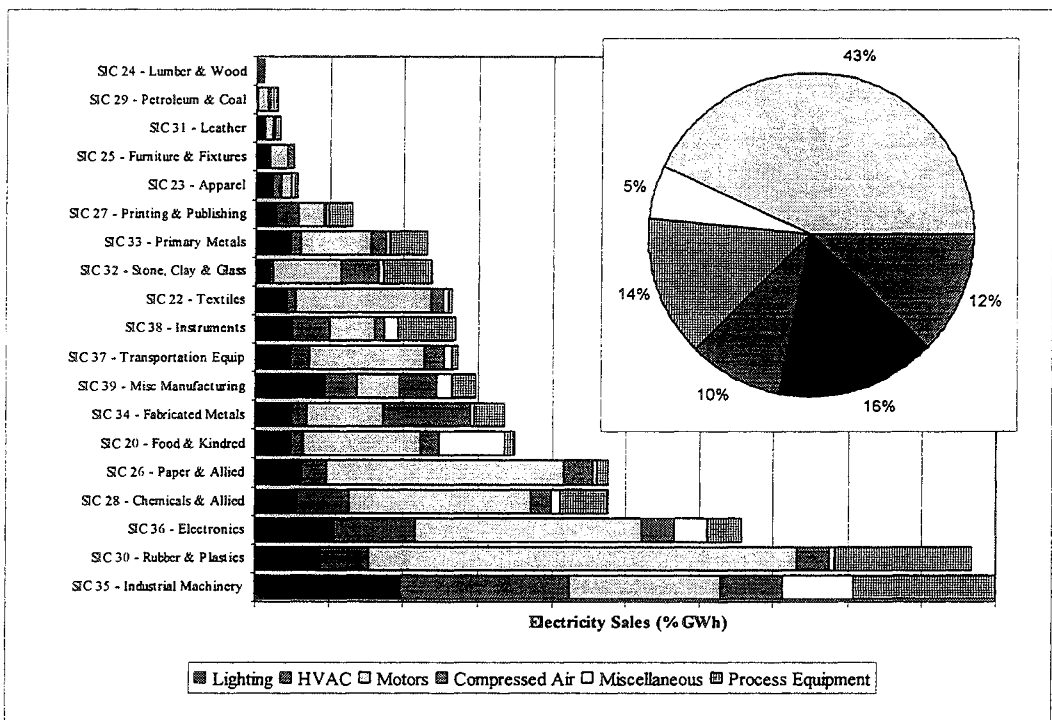

Figure 1. Relative Energy Usage for Industrial Customers in a New England Service Territory (Utility Data)

Energy Utilization Intensity. Based upon similar data, Figure 2 presents the Electric Energy Utilization Intensity (EUI) for each of the major SIC groups in the same utility territory. This figure shows that the industries with the highest EUIs in this region are *Food & Kindred*, *Textiles*, *Apparel*, *Lumber & Wood*, and *Furniture & Fixtures*. Note that most industrial customers have EUIs above 15. For comparison, most commercial buildings have EUIs below fifteen (EIA 1995), with the exception of in-patient health care facilities, refrigerated markets or warehouses, and restaurants. It is important to note the limitations in using high EUIs to select target O&M segments, as high EUIs might indicate unique characteristics of a business type, as opposed to poorly operated or maintained equipment.

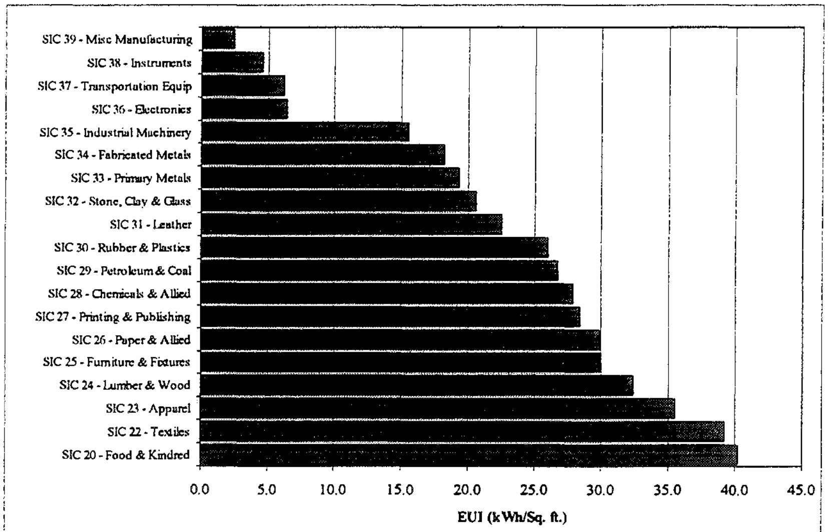

Figure 2. Electric EUIs for Industrial Customers in a New England Service Territory (Utility Data)

Potential O&M Savings. The last source that was examined was the database from the Industrial Assessment Center (IAC) program that contains records from thousands of industrial assessments across the country. In brief, we analyzed the total electrical consumption of these customers as compared to their savings recommendations. Researchers reviewed all of the recommendations, which included energy efficiency enhancements, waste minimization, and manufacturing productivity, and selected those which qualified as O&M measures under the aforementioned definition.

Table 1 summarizes some of the data collected to this point and introduces the IAC research. As seen in the table, all analysis has been performed with respect to each of the 20 major industries or SIC groups. The number of facilities in the Northeast (Column A) comes from the ABI database, and northeastern electrical usage (Column B) comes from the MECS database. Since the data acquired from the New England utility only represented 5% of total consumption in the Northeast census region, this information was not deemed sufficiently representative to present in this table. The remaining data used in this table are from the IAC database, which provided estimates of total facility electrical usage (Column C) and recommended O&M savings (Column D) for a large sample of industrial customers across the United States. Although this data was not provided in electrical units, the IAC data simply was used to calculate a percentage of recommended O&M savings (Column E). It should be noted that researchers thought it reasonable to utilize all national IAC data to develop percent savings estimates rather than restricting this data to the Northeast and reducing the sample size substantially. This decision is supported by the finding that HVAC, a temperature-dependent and hence regionally-influential electrical end-use, only represents 5% of industrial energy consumption at a New England utility.

Table 1. Relative Rank of Industries Based on Three Key Parameters

	A	B	C	D	E	F	G
Major Industry Description	Number of Facilities in Northeast (#)	Northeastern Electrical Usage (GWh)	Total Facility Electrical Usage (MMBtu)	Recommended O&M Savings (MMBtu)	Estimated O&M Savings Potential (%)	Potential Northeast O&M Savings (GWh)	Potential Savings per Northeast Facility (MWh)
Data Source:	ABI	MECS	IAC	IAC	= D / C	= B x E	= F / A * 1,000
SIC 36 - Electronics	7,667	7,358	2,492,814	126,471	5.1%	373.3	48.69
SIC 34 - Fabricated Metals	14,290	5,072	3,022,988	152,590	5.0%	256.0	17.92
SIC 35 - Industrial Machinery	20,951	4,525	2,540,382	125,905	5.0%	224.3	10.70
SIC 27 - Printing & Publishing	29,559	3,156	1,192,850	59,486	5.0%	157.4	5.32
SIC 26 - Paper & Allied	3,843	9,397	2,221,183	109,930	4.9%	465.1	121.02
SIC 28 - Chemicals & Allied	4,942	11,230	1,630,779	50,834	3.1%	350.1	70.83
SIC 30 - Rubber & Plastics	5,411	6,474	4,367,274	180,126	4.1%	267.0	49.35
SIC 33 - Primary Metals	3,363	17,781	2,485,395	67,858	2.7%	485.5	144.36
SIC 38 - Instruments	5,456	3,757	620,330	38,871	6.3%	235.4	43.15
SIC 20 - Food & Kindred	5,658	6,215	3,932,664	117,271	3.0%	185.3	32.76
SIC 23 - Apparel	7,492	2,035	370,790	33,376	9.0%	183.2	24.45
SIC 39 - Misc Manufacturing	13,426	1,673	239,425	15,351	6.4%	107.3	7.99
SIC 24 - Lumber & Wood	5,951	1,198	1,637,069	77,389	4.7%	56.6	9.52
SIC 37 - Transportation Equip	3,324	3,524	1,487,091	77,535	5.2%	183.7	55.28
SIC 32 - Stone, Clay & Glass	4,689	5,271	3,194,551	73,973	2.3%	122.1	26.03
SIC 29 - Petroleum & Coal	743	2,990	110,067	5,364	4.9%	145.7	196.12
SIC 22 - Textiles	2,969	1,666	2,498,282	82,561	3.3%	55.1	18.54
SIC 25 - Furniture & Fixtures	2,905	421	571,718	32,829	5.7%	24.2	8.32
SIC 31 - Leather	1,112	243	99,296	5,450	5.5%	13.3	11.99
SIC 21 - Tobacco	222	20	52,669	354	0.7%	0.1	0.61

	Relative Rank			
Major Industry Description	Northeast Facility Presence	Potential O&M Savings	Potential Savings per Facility	Average Overall Rank
Data Source:	Rank of A	Rank of F	Rank of G	Rank A,F,G
SIC 36 - Electronics	5	3	7	4.0
SIC 34 - Fabricated Metals	3	6	13	4.5
SIC 35 - Industrial Machinery	2	8	15	5.0
SIC 27 - Printing & Publishing	1	12	19	6.5
SIC 26 - Paper & Allied	13	2	3	7.5
SIC 28 - Chemicals & Allied	11	4	4	7.5
SIC 30 - Rubber & Plastics	10	5	6	7.5
SIC 33 - Primary Metals	14	1	2	7.5
SIC 38 - Instruments	9	7	8	8.0
SIC 20 - Food & Kindred	8	9	9	8.5
SIC 23 - Apparel	6	11	11	8.5
SIC 39 - Misc Manufacturing	4	15	18	9.5
SIC 24 - Lumber & Wood	7	16	16	11.5
SIC 37 - Transportation Equip	15	10	5	12.5
SIC 32 - Stone, Clay & Glass	12	14	10	13.0
SIC 29 - Petroleum & Coal	19	13	1	16.0
SIC 22 - Textiles	16	17	12	16.5
SIC 25 - Furniture & Fixtures	17	18	17	17.5
SIC 31 - Leather	18	19	14	18.5
SIC 21 - Tobacco	20	20	20	20.0

Weighted Average Estimated O&M Savings Potential per Northeast Facility
27.02 MWh

Total Estimated O&M Savings Potential in the Northeast
3,891 GWh

Researchers proceeded on the premise that regional O&M potential may be based upon three key parameters: 1) the number of industrial facilities in the region, 2) potential savings for the specific industrial market, and 3) potential savings *per facility* within the market. By selecting these three parameters, researchers feel that they can answer the following key questions:

- Are there many facilities within this industry in my region? (Column A)
- Does this industry have strong savings potential in my region? (Column F)
- Will O&M improvements at individual industrial facilities have much impact in my region (Column G)?

By ranking the answers to these questions and combining into an average overall score, researchers identified *Electronics*, *Fabricated Metals*, *Industrial Machinery*, *Printing & Publishing*, and *Paper & Allied* as five industries which have a significant presence on the electrical grid in the Northeastern United States.

Market Barriers. In assessing O&M measure offerings and savings, the likelihood of customers to implement practices on their own and barriers to this implementation is critical to the analysis. For example, if the analysis revealed barriers to capital investments in control measures for small manufacturing facilities, these barriers would inform the economic potential for control measure savings in this segment. The analysis will consider what barriers exist to adopting specific O&M practices in specific segments and how and whether or not these barriers can be addressed.

As part of the Northeastern O&M Market Assessment, interviews were performed with twenty utility employees. One of the most frequently mentioned barriers was that of O&M budgets. There were two significant findings here. First, the O&M budget is typically developed by personnel in companies that do not completely understand the importance of effective O&M. Second, O&M for many sectors is not viewed as particularly important compared to other needs. Those who oversee and develop budgets are apt to cut O&M costs, e.g., downsizing maintenance staff, in lieu of other needs.

Another barrier was the challenge of convincing the maintenance people of a particular O&M need, but understanding they will in turn have to present the change to their superior. This may be undesirable because suggesting improvements to their superior may make it appear to their superior that they are not doing their job appropriately. It is easier for a Facility Manager to get by day-to-day then to make significant O&M changes. One interviewee commented that avoiding this scenario requires careful work and sensitivity to the position of the facility manager in the improvement process.

Education. One of the most commonly suggested resources that respondents mentioned was that of education. Consistently, it was commented that to really impact O&M, it is not effective to just give money to the customer. It was emphasized that education and training in how to properly perform O&M on equipment and systems is paramount to a successful O&M program whose goal is to diminish its intervention over time. Some related suggestions included holding seminars, conducting breakfast training sessions, or generating a customer O&M newsletter. Some respondents suggested offering training courses at local colleges on O&M, or holding O&M certification classes or seminars at the utility. Literature or brochures specifying maintenance schedules or other specific equipment maintenance issues may be an effective way of educating others also. Getting maintenance staff to implement improved O&M on their own is a critical part of any market transformation effort, and education and training is a necessary component of that program design. Finally, this education must span both maintenance and management staff so that O&M value can be proved, understood, and respected at all levels.

Baseline Practice

Interviewees were asked to forecast what would happen to O&M in the next two years if there were no utility intervention. Most reported that O&M would not get much better or would be minimal without utility intervention. One respondent said the status quo would continue until intervention occurred. Three people reported that it would be based upon the economy and how much money customers had to budget with, indicating that customers will only do what they can afford to do. Some reported that O&M would degrade to the point where most companies would go into a "fix it when it breaks" mode. Generally, the O&M prognosis without utility intervention was not good from the interviewees' perspective.

When asked which industries have the most potential to transform on their own, several interviewees indicated that hospitals are more likely to transform on their own due to the criticality of O&M to their mission. A similar argument was posed for computer and electronics companies, where working environments demand specific conditions. Others indicated that manufacturing and industrial customers are relatively more likely to change as a result of their constant monitoring of the bottom line expenses, including energy use, in their performance and productivity.

When asked about the current state of O&M in the Northeast, "Not Good", "Rather Poor", and "Improvements Needed" were common responses. Two interviewees indicated that the current state of O&M was good, and four indicated that O&M varied greatly from customer to customer. From all indications, there is a general belief that there is room for improvement within the current O&M marketplace, and that without utility intervention in the next two years, O&M practices are more likely to get worse rather than better.

Measure Offerings and Potential Savings

There is a great diversity of possible O&M measures, ranging from simple and inexpensive equipment retrofits to far reaching behavior modification. Table 2 shows the estimated percent savings impact of a variety of O&M measures, based on an extensive literature review (Thumann 1996). Multiple listings for a single measure type represent data from different sources. 'Percent savings' is the percent of consumption for the end-use category listed in the third column. The percent savings potential for these measures range from a high of 30% to a low of 0.1%. Total energy management programs, air conditioning O&M, and compressed air leak reduction are the three highest impact measures listed in this table.

Table 2. Industrial O&M Electric Energy Measures and Savings Potential

O&M Energy Measure	Estimated Percentage Savings	Industrial End-Use Category	Potential U.S. Energy Savings (million kWh/yr)
Total energy management program	30.0%	All	253,110
General proper maintenance of electromechanical systems	12.5%	All	105,463
Employee participation program	19.0%	All	160,303
General air compressor O&M	12.6%	Compressors	8,720
Reduce compressed-air leaks	27.5%	Compressors	19,046
Reduce compressed-air leaks	5.0%	Compressors	3,463
Relocate compressed-air intake to outside	3.5%	Compressors	2,424
General air conditioning O&M	30.0%	Chillers	13,786
Clean A/C filters	8.0%	Chillers	3,676
Install industrial refrigeration controls	10.0%	Refrigeration	201
Install fast controllers on compressors	20.0%	Compressors	13,852
Install sequential lead/lag controllers	20.0%	Compressors	13,852
Install sequential lead/lag controllers	10.0%	Pumps	12,406
Use improved lubricant	3.3%	Motors	19,344
Use improved lubricant	5.0%	Motors	29,045
Do not over-lubricate motors	0.4%	Motors	2,178
Improve bearings, lubricant and lube maintenance	0.6%	Motors	3,631
Use premium lubricants	11.5%	Motors	66,804
Use improved lubricants in gearboxes	10.0%	Motors	11,618
Improved lubricant-wire drawing process	9.0%	unknown	n/a
Replace v-belts with cogged v-belts	2.7%	Motors	5,333
Replace v-belts with synchronous belts	3.8%	Motors	7,505
Improve maintenance on v-belt drives	3.0%	Motors	5,929
Correct voltage imbalance	1.7%	Motors	9,875
Apply correct voltage to motors	3.3%	Motors	19,170
Reduce operating voltage 1%	0.4%	Motors	2,382
Electrical tune up of motor systems	8.0%	Motors	46,472
Improved motor use and scheduling	3.5%	Motors	20,332
Turn off motor heaters during operation	0.1%	Motors	505
Turn off idling motors	0.4%	Motors	2,498
Provide better motor cooling	0.1%	Motors	505

Another important source of information for program practice is the experience of existing utility programs. RLW has performed two evaluations of O&M programs in New England in 1998. Both O&M programs addressed relatively equal numbers of commercial and industrial customers. Based upon the data obtained in these studies, four measures exhibited high O&M program implementation: HVAC Maintenance, HVAC Control, Lighting Control, and Compressed Air system maintenance. In addition to being the most frequent O&M installations, these measures also proved to be amongst the most successful in terms of energy savings.

HVAC maintenance. While compressed air may have greater savings potential for manufacturing facilities, the analysis of the NEES and NU program data suggests HVAC maintenance is the most common O&M measure in the Northeast. This measure includes a variety of system repairs targeted at restoring the optimal operating efficiency of HVAC units. A key obstacle to overcome in O&M program delivery is the disparity of methods employed to estimate the savings impact of HVAC maintenance. To improve future O&M savings estimates, the evaluation team recommends that utilities adhere to a single set of maintenance-based savings factors for assessing savings due to HVAC equipment maintenance (Agboatwala 1981). Coil and filter conditions may be qualified as light, moderate, or heavy fouling, and system components such as belts, dampers, and refrigerant charge ought to have similar standard condition qualifiers. Existing research could be compiled and supplemented with more extensive performance-based measurements for use in developing reliable maintenance-based impact factors for HVAC equipment.

HVAC control. In concert with HVAC maintenance, optimized system control can result in vastly improved HVAC system performance. Many operational measures can be implemented with existing control equipment, such as energy management systems or programmable thermostats. As variable-speed drive (VSD) usage increases in building mechanical systems, engineers often can find opportunities to tune the control of these drives towards optimizing energy consumption.

Lighting control. Lighting is a significant end use at most commercial and industrial facilities. While energy-efficient lighting such as T8 lamps, electronic ballasts, compact fluorescent lamps, and high-pressure sodium lamps has already yielded substantial energy savings for many customers, considerable savings potential remains in more widespread use of lighting control systems. As with any piece of electrical equipment, the greatest savings is achieved by simply eliminating the electrical load when it is not needed. Whether by individual occupancy sensors or centralized EMS lighting control systems, most facilities still have yet to maximize the savings potential of the lighting end use.

Compressed air system maintenance. Compressed air is a significant electrical end-use at many manufacturing facilities. Unfortunately, it is often a significant source of wasted energy. Compressed air leakage totaling 10% of total compressed air capacity is not uncommon, and leakage rates upwards of 40% have been observed (Talbot 1993). As such, energy savings from repairing compressed air leaks can be substantial, but accurately estimating the savings can be very challenging. Unfortunately, energy savings estimates for compressed air systems often are based upon arbitrary savings assumptions and simple calculations. More than any other measure type, it is imperative to accurately quantify either the actual leak reduction or the pre- and post-retrofit CFM rates for compressed air systems. Several evaluation measures could have benefited from more extensive preliminary measurements, such as flow and pressure metering. Though more costly up-front, it would have permitted quantification of pre- and post-retrofit system CFM, as well as a better assessment of the customer's compressed air needs.

Other O&M measures include insulating ducts and pipes, disconnecting unused lighting fixtures and ballasts, pipe and duct insulation, and process control improvements. Note that process control measures can have extremely high savings impact, but must be thoroughly examined on a case-by-case basis to ensure that the process needs of the customer are not lost in the quest for energy savings.

Targeting Specific End-Uses or Technologies. Many interviewees suggested targeting customers with a particular end-use or technology. One interviewee, a project manager who has overseen several dozen O&M projects, indicated that customers who use refrigeration and large chillers are particularly strong candidates for O&M programs. In his opinion, a program for chillers would be easier to implement, as chillers have fixed operating parameters, while refrigeration may have greater potential for savings. Refrigeration systems operate all the time, have flat loads, and are often mission-critical. One interviewee characterized the maintenance of some refrigeration-dependant facilities in his experience: "Most maintenance staff are wizards at keeping systems going, so as long as the system is keeping the ice cream hard, no one cares how efficient it is, only the end product matters. They will do anything to keep the ice cream hard." Manufacturing owners often do business on a tight margin with high costs; a situation where saving less than twenty percent of the energy bill for one piece of equipment can still be a strong motivator.

Interviewees also suggested air compression systems as an end-use that can benefit from improved O&M. One subject referred to a compressor project that saved ten thousand dollars a month through plugged air leaks. Because of the large potential saving possible from this end-use, several of the sponsoring utilities are also sponsoring a more detailed baseline study of compressed air O&M.

Another technology that has been suggested are Energy Management Systems (EMS). An EMS is one of the most powerful conservation measures possible. An integrated EMS can control lights, HVAC, motors, variable speed drives (VSD), and almost any other end-use, all while providing useful data that can be used to continuously monitor system operation and flag maintenance needs. While some facilities may be ideal candidates for the installation of a new EMS, at other facilities an adequate EMS may already be in place but operating improperly. Measures based on ensuring that previously installed EMS systems are fully utilized offer the potential for very significant savings with little material cost.

Steam traps were also mentioned in several interviews. Steam traps permit the passage of condensate, air, and non-condensable gas from the piping and equipment while preventing the loss of steam. Poorly functioning traps cause steam to be wasted and account for a very sizable energy loss, often at large multi-building facilities. These types of heating systems are typically employed at large facilities, and are frequently overlooked as a significant source of energy savings.

Most respondents supported manufacturing as a major segment worth targeting. In addition, manufacturing was identified as having an interest in O&M due to the high cost of operation in the Northeast as opposed to other parts of the country. These customers are looking for ways to reduce their operating costs, of which energy comprises a significant portion. In fact, one respondent estimated that 15-20% of a manufacturer's budget is energy costs. Manufacturing was described as a market that regularly looks at O&M as an integral part of increasing profits through reduced energy costs and potentially increased or enhanced production.

On the other hand, some interviewees felt that many manufacturers have a production focus instead of an efficiency focus, which tends to inhibit O&M procedures. Manufacturers were nearly universally described as being primarily interested in manufacturing a product, with energy conservation or any other business considerations secondary to that goal. While this indeed is a barrier against O&M in manufacturing facilities, it may also be viewed as a significant opportunity. Several interviewees suggested that the challenge in the manufacturing segment is to focus O&M on items that ultimately will increase the performance of their production and positively impact their core business.

Other Factors Influencing Savings Potential. In addition to technology and industry type, interviewees raised many other characteristics that would affect O&M potential. One such factor noted in multiple interviews was customer size. According to interviewees, size of customers tends to dictate 1) the presence and size of O&M budgets, 2) the sophistication of the O&M staff, and 3) the understanding of the economics regarding improved O&M. Several interviewees characterized larger companies as more up to date with O&M, while smaller companies were described as lagging a little, and having little or no O&M staff and less money and focus on O&M in their company. In addition, several respondents generalized that large customers tend to act on O&M changes before small ones. This was most evident in the manufacturing segment, where plants and companies can vary from small family style operations to Fortune 500 corporations.

There was disagreement, however, on whether small or large customers had the best potential for savings. One interviewee mentioned that the greatest impacts were always from the greatest users. Another subject mentioned that large customers were likely to have reaped most simple O&M savings. Medium sized customers were mentioned by some as a promising target because they offer significant impact, while lacking the sophistication of the largest customers. Another interview suggested small commercial customers, who have little or no sophistication with respect to O&M practices, as a promising target.

End-uses were also mentioned as an important factor. End-uses suggested as indicators of savings opportunities include customers with large or mission-critical HVAC loads, customers with central steam plants, low-rise construction relying upon roof top units, customers who consume large amounts of hot water, and dual fuel customers.

In addition to customer size and end-uses, other factors dictating the aggressiveness of O&M practices included the following:

- Existence of 24-hour operation,
- Level of energy use,
- The energy used per square foot (EUI),
- Use of O&M contractor staff,
- Amount and sophistication of facility management staff,
- Value of O&M to the core business,
- Equipment types,
- Age of the building,
- Whether it is owner-occupied, and
- Whether the occupant pays the utility bills.

While some of these factors are influenced by business type, customers with these factors do cross over many markets. From this perspective, while there is merit to characterizing O&M practices within business types, there is also a need to identify within and across business types those critical factors that will influence customers participation in an O&M program.

Program Design Recommendations

Two key implementation issues were identified in reviewing the existing NU and NEES O&M program offerings:

1. Influencing Improved Maintenance Procedures. Operations and maintenance programs are inherently different from most other utility programs. While other programs offer incentives to upgrade or replace equipment, O&M programs strive to change how the customers operate and maintain their equipment. Those responsible for program delivery need to realize that O&M has a substantial behavioral component. There ought to be at least two requirements for a successful O&M implementation: 1) the customer must clearly exhibit substandard regular operating or maintenance procedures, and 2) the program must influence *lasting* improvements to these procedures through changes to the organization's attitudes, training and culture related to O&M. Sustainable O&M efficiency can be achieved only with the cooperation of the customer and the commitment to better facility management.

2. Quality Control. Unlike standard retrofit measures, the energy impacts of O&M measures are not well established. Literature on the subject is fragmented and often based on individual case studies. As such, there can be great disparity in the quality of analysis and reporting provided by engineering firms on O&M projects. It is strongly recommended that utilities establish quality control procedures to provide a framework to reevaluate the quality of work delivered by all audit firms to improve future program delivery.

Potential design and delivery systems include:

- Technical Information Programs: This type of program involves the promotion of O&M measures through technical information on measure specifics and savings provided directly to consumers.
- Technical Assistance Programs: This type of program goes a step beyond informational programs in assisting the customer through the implementation stages.
- Performance Contracting or Shared Savings Programs. This involves a third party contractor that will implement the O&M measures for a portion of the reduction of the participant's bills.
- Contractor Selection: Utilities can provide their assistance in the contractor selection process by (1) developing a list of pre-approved bidders, (2) assisting in the development of RFP's for O&M measure analysis and/or implementation, and (3) working with the customer to approve and finalize vendor projects.
- Training Programs: Training programs can range from workshops to in-house seminars to one-on-one training at customer facilities.
- Certification Programs: Many management barriers can be overcome through the use of certification programs to establish a mark of quality amongst maintenance staff.

An additional challenge not truly addressed involves bringing O&M training and knowledge into the management and culture of organizations. There is much more to quality O&M above and beyond fixing leaks and turning off lights. Good O&M is much like good housekeeping or good book-keeping, it involves a web of inter-related actions, priorities and attitudes, all integrated into the customers larger goals and actions.

Sometimes the most valuable lessons are learned through failure, as illustrated by the following example, albeit in the commercial sector. During the Texas LoanSTAR program, it was discovered that 104 previously installed energy management control systems at 104 schools in one large district were completely or partially disabled. Thirty of 47 rooftop units (RTU) that were supposedly connected to the system were disconnected. One particular RTU had been disconnected from the system at three points. In this case, re-commissioning of the energy management system (EMS) led to 27% savings, or more than 1.6 million dollars per year. This was not a failure of an EMS or an RTU; it was a failure of management and organization; those who were culpable did not even suspect there was a problem (Claridge et al. 1994).

The most important O&M measures are the transformation of the organization and management at the site in question. Once this measure has been implemented and energy efficient O&M is a priority, other measures should motivate themselves.

Conclusions

This paper attempted to cover a lot of ground by identifying key industrial O&M markets and baseline practices as well as potential O&M program offerings. The consortium of eight utilities in the Northeast has identified a handful of industrial sub-segments that are abundant in the region and offer strong O&M savings potential. The most important thing that we have learned so far in this study is that O&M is highly behavioral, thus education and training in how to properly perform O&M on equipment and systems are paramount to successful programs. By encouraging energy-efficient practices in industry now, we have an opportunity to take the quality, efficiency, and competitiveness of American industry to the next level in the coming millennium.

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